إقــرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

الجسيمات المنبعثة من كسارات الحصى وتأثيراتها الصحية علي العمال، المحافظة الوسطي – غزة – فلسطين

Particulate Matter Emitted from Gravel Crushers and Their Health Impacts on Workers, Middle Governorate - Gaza, Palestine.

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Master of Environmental science - Env. Health

Particulate Matter Emitted from Gravel Crushers and Their Health Impacts on Workers, Middle Governorate - Gaza, Palestine.

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بسم الله الرحمن الرحيم

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نتيجة الحكم على أطروحة ماجستير

بناءً على موافقة شئون البحث العلمي والدراسات العليا بالجامعة الإسلامية بغزة على تشكيل لجنة الحكم على أطروحة الباحث/ **أحمد عمر حسين أبو شقة** لنيل درجة الماجستير في **كلية *العلوم*** قسم **علوم بيئية – صحة بيئية** وموضوعها:

(الجسيمات المنبعثة من كسارات الحصى وتأثيراتها الصحية على العمال، المحافظة الوسطي – غزة – فلسطين)

(Particulate Matters Emitted from Gravel Crushers and their Health Impacts on Workers, Middle Governorate - Gaza, Palestine)

وبعد المناقشة العلنية التي تمت اليوم الأحد 7 جمادي الأولى 1435هـ، الموافق 2014/03/09 الساعة الثامنة والنصف صباحاً بمبنى طيبة، اجتمعت لجنة الحكم على الأطروحة والمكونة من:

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وبعد المداولة أوصت اللجنة بمنح الباحث درجة الماجستير في **كلية *العلوم*/** قسم **علوم بيئية – صحة بيئية**.

واللجنة إذ تمنحه هذه الدرجة فإنها توصيه بتقوى الله ولزوم طاعته وأن يسخر علمه في خدمة دينه ووطنه.

والله ولي التوفيق ،،،

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ABSTRACT

Background: Particulate matter (PM) refers to discrete particles in ambient air that exist as either solid or liquid droplets. A crusher is a machine designed to crush and grind rocks or rubble resulting from construction waste, and convert it to materials can be re-used in the building and construction.

Aim: To evaluate the level of PM_{10} air pollution in crushers plants, and their impacts on respiratory system health, vital signs and complete blood count for crushers workers.

Material and Methods: Case-control study was conducted during the period from April to August 2013 on all gravel crushers at Middle Gaza Governorates. 87 individuals participated, case (exposed) and control (non exposed) groups contain 40, 47 respectively. Pm_{10} concentration level was measured in the six crushers, and all participants were subjected to questionnaire, vital signs measuring, and complete blood counts

Results: Results showed that an average of particulate matter contributions is 15153 $\mu g/m^3$, which is about 100 times higher than PM_{10} existing standard of 150 $\mu g/m^3$. As well as, it showed clear links between PM10 exposure and respiratory health, vital signs, and white blood cells among exposed group. Cough, dyspnea and sputum buildup were more common among the exposed group 100%, 97.5%, and 82,5% respectively, the non exposed group 14.9%, 31,9%, and 28.6%, respectively. Increasing in white blood cells count and Vital signs disturbances (Increasing systolic and diastolic blood pressure, increasing pulse rate, increasing respiratory rate and temperature) reported significantly among the exposed workers.

Conclusions: PM10 concentration level in crushers plants were much higher than the existing standard. Occupational exposure to PM10 leads to higher prevalence of respiratory symptoms, vital signs disturbance, and increasing WBCs.

Recommendations: Environmental and engineering control of PM10 emissions, protective techniques, procedures, measures and equipment and periodic medical examinations.

Key Words: PM10. Respiratory symptoms. Vital signs. Crushers. Complete blood counts. White blood cells.

الملخص

خلفيـة: المـواد العالقـة عبـارة عـن الجسـيمات المتطـايرة الحـرة فـي الهـواء الجـوي ، تكـون علـى عـدة أشكال منها صلبة وسائلة .

الكسـارة هـي آلـة صـممت لسـحق وطحـن الصـخور أو الأنقـاض الناتجـة عـن مخلفـات البنـاء ، وتحويلهـا إلى مواد يمكن إعادة استخدامها في البناء والتشييد .

الهـدف: لتقيـيم مسـتوى تلـوث الهـواء بـالمواد العالقـة فـي محطـات الكسـارات، وتأثيراتهـا علـى صـحة الجهاز التنفسي ، و العلامات الحيوية و تعداد الدم الكامل لعمال الكسارة.

المـواد و الطـرق: أجريـت دراسـة الحـالات والشـواهد هـذه خـلال الفتـرة مـن أبريـل إلـى أغسـطس 2013 علـى جميـع الكسـارات فـي المحافظـة الوسـطى - غـزة – فلسـطين ، والبـالغ عـددها 6 كسـارات. وقـد أجريـت الدراسـة علـى 87 شـخص مـوزعين علـى مجمـوعتين وهمـا، مجموعـة الحالـة (المتعرضـين) مكونـة مـن 40 شـخص والمجموعـة الضـابطة (غيـر المتعرضـين) مكونـة مـن 47 شـخص. تـم قيـاس تركيـز المـواد العالقـة فـي مواقـع الكسـارات السـتة وتعـرض جميـع المشـاركين لمـلء الاسـتبيان ، و قيـاس العلامات الحيوية ، و فحص الدم الكامل .

النتـائج: أظهـرت النتـائج أن متوسـط تركيـز الجسـيمات هـو µg/m3 15153 ، وهـي أكبـر بــ 100 مـرة مـن المعـايير القياسـية العالميـة وهـي µg/m3 150 . وأظهـرت كـذلك علاقـات واضـحة بـين التعـرض للمـواد العالقـة (PM10) و صـحة الجهـاز التنفسـي ، العلامـات الحيويـة ، وخلايـا الـدم البيضـاء للمجموعـة المعرضـة. السـعال و ضـيق التـنفس و تـراكم الـبلغم كانـت أكثـر شـيوعا بـين الأشـخاص المعرضـين 100 ٪ ، 97.5 ٪ ، 82.5 ٪ علـى التـوالي ، أمـا غيـر المعرضـين فكانـت 14.9 ٪ ، 31،9 ٪ ، و 28.6 ٪ ، علـى التـوالي . زيـادة فـي تعـداد الخلايـا البيضـاء و اضـطراب العلامات الحيوية لوحظت بشكل هام في مجموعة الحالات .

الاسـتنتاجات: مسـتويات تركيـز المـواد العالقـة فـي محطـات الكسـارات أعلـى بكثيـر مـن المعيـار العـالمي الحـالي . كـذلك التعـرض المهنـي للعالقـة يـؤدي إلـى ارتفـاع معـدل انتشـار أعـراض الجهـاز التنفسـي ، واضطراب العلامات الحيوية ، و زيادة كريات الدم البيضاء .

التوصـيات: المراقبـة البيئيـة والهندسـية لانبعـاث المـواد العالقـة ، فـرض إجـراءات و تقنيـات وقائيـة وكذلك الفحوص الطبية الدورية.

الكلمـات المفتاحيـة: PM10 . أعـراض الجهـاز التنفسـي. العلامـات الحيويـة . كسـارات . تعـداد الـدم الكامل. خلايا الدم البيضاء .

DEDICATION

I dedicate this thesis to my parents who have always been my nearest and reverse neighbors, and have been so close to me whenever I needed. It is their unconditional love that motivates me to set higher targets.

Also, I dedicate this thesis to my sisters (Dalia, Dina, Doaa, and Eman) and brothers (Mahmoud and Mohammed) who are my nearest surrenders and have provided me with a strong love shield that always surrounds me and never lets any sadness enter inside.

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IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

All praise to Allah, the One to whom all dignity, honor, and glory are due, the Unique with perfect attributes, who begets not, nor is He begotten. He has no equal but He is the Almighty Omnipotent. Peace and blessings of Allah be upon the last prophet, Muhammad, and on all who follow him in righteousness until the Day of Judgment. All Praise be to Allah for enabling me to finish this paper. As the prophet Muhammad, peace be upon him, said, " He who is thankless to people, is thankless to Allah." I therefore gratefully acknowledge the many people who so graciously helped and supported me so as to successfully complete this thesis. First, I would like to thank my supervisors, Prof. Muhammad Al-Agha and Prof. Yousef Al-Jeesh for thier support, advice and encouragement throughout this study; I am really grateful for their willingness to help in reviewing the study to come out to light. Their useful comments were truly a tremendous help at every stage. My appreciation is paid to the referees' committee, who guided and enriched the study to help put my tools in the best form. Once again, I would like to express my sincere appreciation to my father , mother, brothers and sisters for their patience and assistance. Finally, I reiterate my endless acknowledgement and high appreciation to all who helped.

MAY ALLAH BLESS THEM ALL

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LIST OF ABBREVIATIONS

Abbreviation	Meaning
ACS	American cancer society.
ANOVA	Analysis of Variance.
APHEA	Air Pollution and Health: A European Approach.
BP	Blood Pressure.
CBC	Complete Blood Count.
COMEAP	Committee on the Medical Effects of Air Pollutants.
DBP	Diastolic Blood Pressure.
EPA	Environment Protection Agency.
EU	European Union.
HGB	Hemoglobin.
NMMAPS	National Morbidity, Mortality, and Air Pollution Study.
PM	Particulate Matters.
PM_{10}	PM_{10} is particulate matter with an aerodynamic diameter of 10 µm or less.
$PM_{2.5}$	$PM_{2.5}$ is particulate matter with an aerodynamic diameter of 2.5 µm or less.
PR	Pulse Rate.
RBCs	Red Blood Cells.
RR	Respiratory Rate.
RSPM	Respirable Suspended Particulate Matter.
SBP	Systolic Blood Pressure.
SPM	Suspended Particulate Matter.
SPSS	Software Package used for Statistical Analysis.
T	Temperature.
WBCs	White Blood Cells.
WHO	World Health Organization.

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CHAPTER 1

Introduction

1.1. Background

1.1.1. Air Pollution

Air pollution is defined as the presence of undesirable levels of physical or chemical impurities. Many organizations such as the World Health Organization (WHO, 1999) recognized particulate matter (PM), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone(O_3), lead (Pb) and sulfur dioxide (SO_2), as classical pollutants presenting a hazard to sensitive populations (Sherman, 2003).

People in developed countries are spending more and more of their time in various indoor and outdoor environments (Farrow et al., 1997). Pollution is any addition of matter or energy that degrades the environment for humans and other organisms.

Air pollutants may exist in gaseous or particulate form. The former include substances such as sulfur dioxide and ozone. Concentrations are commonly expressed either in mass per unit volume ($\mu g/m^3$ of air) or as a volume mixing ratio (1 ppm = 10^{-6} v/v; 1 ppb = 10^{-9} v/v). Particulate air pollutants are highly diverse in chemical composition and size. They include both solid particle and liquid droplets and range in size from a few nanometers to hundreds of micrometers in diameter; concentrations are expressed in $\mu g/m^3$. (Harrison, 1983).

Air pollution is one of the major problems facing the world as a whole, whether developed countries or developing countries. Palestine facing the problem of air pollution, both in the West Bank or Gaza Strip (kareem, 2010).

The main sources of air pollution in Palestine are the various means of transportation, the smoke rising from the chimneys of factories, the heavy dust from crushers, the burning of solid wastes, and the effects of water treatment projects. The industries in the West Bank, Gaza Strip, and the Israeli industries inside the part of Palestine occupied in 1948 are the biggest cause of air pollution in Palestine (Kareem, 2010).

1.1.2. Suspended Particulate Matter (SPM)

Suspended particulate matter (SPM) is the term used for a mixture of solid and liquid particles in air. Particle matter (PM) can be released from diverse sources ranging from anthropogenic to natural sources such as industries, volcanoes, crushing, grinding etc. It can also be formed by chemical transformation of gaseous emissions. PM has been classified according to the size. Particles, having a lower size limit of the order of 10–3 μm in aerodynamic diameter and an upper limit of 100 μm are termed as Suspended Particulate Matter (SPM), whereas PM that is 10 μm or less in aerodynamic diameter is called as respirable suspended particulate matter (RSPM) or PM_{10} because it penetrates the respiratory system. RSPM is again classified as: ultra fine (size range less than 0.1μm), fine (0.7–1 μm) and coarse (1–10 μm) (Fenger, 1999).

Fine particles are basically formed by chemical transformation of gases or by condensation of high temperature vapors during combustion. Particles can be organic or inorganic in nature (Fierro, 2000).

Their chemical composition varies according to the source of their generation. The coarse fraction is mostly dominated by aluminum, silicon, sulphur, potassium, calcium and iron, which make up 40–50%, while components such as nitrate, sulphate and ammonium ions, elemental and organic carbon make up only 10–20%. The major sources of coarse particles are fugitive dust from roads, industry, agriculture, construction and fly ash from fossil fuel combustion whereas; fine particles are mainly composed of sulphates, carbonaceous materials, nitrates, trace elements and water followed by organic substances representing 26–47% (Azzez and Mohanraj, 2004 and Fierro, 2000).

1.1.3. Respiratory Health Effects

The health impact of particulate matter is known since a long time. London smog episodes (1952, 1962), confirmed the harmful effects of PM on variety of pulmonary disorders, including mortality (Faith and Atkinson, 1972).

Particulate matter is the most important pollutant in terms of adverse effect on human health and has shown the strongest association with premature mortality and morbidity (Fierro, 2000).

Since the late 1950s acute infections involving upper respiratory damages causing major morbidity from respiratory illnesses such as influenza, bronchitis (acute and chronic) pneumonia, all types of asthma, sinusitis and other respiratory disorders have been ascribed to excessive level of particulate matter (Dohan, 1960 and Neill, 1962). Till date, a number of epidemiological studies have also established the morbidity and mortality impact of particulate matter, especially with Respirable Suspended Particulate Matter (RSPM) and fine particulate matter. It has been observed that the harmful impact of particulate matter varies with the aerodynamic size, number and quantity of PM in the atmosphere. Also, elderly and asthmatic people are at higher risk due to air pollution. Primarily, air pollutants impact three target tissues of human body viz, respiratory passage, blood vessels and respiratory membrane (Gross, 1961).

The most prevalent pulmonary disorder is asthma in which the target tissues are the walls of the bronchi and bronchioles. Further, PM has been associated with a variety of other adverse health effects (EPA, 1997).

1.1.4. Crushers and Crushing

A crusher is a machine designed to crush and grind rocks or rubble resulting from construction waste, and converted to materials can be re-used in the building and construction. Stone crushing industry is an important industrial sector in the country. The crushed stone is then used as raw material for various construction activities i.e. construction of roads, bridges, buildings and canal (Sardar, 2007).

1.2. Problem Statement

Worries that air pollution may have significant effects on health have recently been fuelled by publication of new evidence linking low levels of ambient air pollution with small public health effect.

In order to suffer health effect, an individual must be exposed to a pollutant, and the pollutant must be able to reach those parts of the body that are vulnerable to its effect.

The main portal of entry is the respiratory tract which is, however, very effective at dealing with noxious substances before they reach the lower airways and lung tissue. For example, the nose and upper airways are excellent at filtering and removing coarse particulate material before it reaches the lower airways and lung tissue, and only a fraction containing the finest particles (under 10μm) can reach the deep lung (Ayres and Walters, 1983).

In more recent years, concern has focused on the potential health effects of much lower levels of pollutants, particularly inhalable particulate matter (PM_{10}) and daily mortality, with approximately a 1% rise in all causes mortality for every 10μg/m3 increases in PM_{10}, although more recent US studies have suggested a rise in mortality closer to 0.5% per 10μg/m3. The effect seems to be greatest for respiratory and circulatory causes of death, rather than hourly peak levels (Tucker *et al.,* 1998).

Others studies have shown that the association between particulate matter exposure and premature death is stronger for $PM_{2.5}$ than for PM_{10} which typically deposit deeper in the lungs (Pope *et al.,* 1996).

Still others have shown that particulate matter from particular sources, such as diesel engines or residential natural gas home appliance, has even larger health impact (Tucker *et al.,* 1998).

Some particles can cause damage from very short-term exposure, not withstanding accumulation in the lungs. Acidic particles may dissolve and distribute into the body or do contact damage where they land. Allergens do not need to penetrate the lung to cause a reaction as they typically contain protein that causes a histaminic reaction in certain people.

1.3. Significance

Because of the brutal blockade imposed by Israeli occupation of the Gaza governorates, and the large quantities of rubbles from building that destroyed by Israel bombardments during wars 2008 and 2011, the Palestinian owners of crushers plants using homemade crushers, was the only way to rebuild what was destroyed by the occupation in Gaza governorates.

Many disadvantages emerged as result of the use of this way, where the impact of the use of crushers on air quality in the vicinity of the factory, and impacted negatively on the respiratory health of workers in the crushers.

The researcher attempts to measure the concentration of PM10 in crushers plants during operation , and to examine the health effects on the respiratory system that have occurred as a result of direct exposure of workers to particulate matter air pollution for contentious long hours of work. Due to that there is limited available data about the respiratory health effects that caused to crushers workers , and limited available data associated with concentration of PM_{10} in crushers plants.

1.4. Justification

- Protect the workers health, especially respiratory system, in order to complete his life in a good health .
- Reduce the chance of respiratory diseases for workers, through the promotion of the use of preventive equipment.
- Increase awareness of workers and owners of the crushers and the people to the seriousness of the presence of these crushers in populated areas.

1.5. Objectives

1.5.1. General objective

The general objective of this study is to evaluate the level of particulate matter air pollution in crushers plants, and their impacts on respiratory human health .

1.5.2. Specific objectives

1. To measure the concentrations of particulate matter in the work place .
2. To identify the relationship between exposure of particulate matter air pollution and appearance of respiratory symptoms .
3. To investigate the relationship between particulate matter air pollution and vital signs disturbance (blood pressure, pulse rate, respiratory rate and temperature) .
4. To examine the relationship between particulate matter air pollution and complete blood count (WBCs, RBCs, HGB).

1.6. Research questions

The researcher has developed the following research questions for his study, and dived them into four questions .

1. Is the concentration of PM_{10} higher than accepted level and can lead to adverse respiratory health effects ?
2. Is there any significance between exposure of PM_{10} air pollution and appearance of respiratory symptoms?
3. Is there any significance between PM_{10} air pollution and vital signs disturbance (BP, PR, RR and T) ?
4. Is there any significance between PM_{10} air pollution and complete blood count (WBCs, RBCs, HGB) ?

CHAPTER 2

Literature Review

2.1. Introduction.

In this chapter the researcher will explore literatures related to his research topic, to provide background information needed to understand the study, to justify his choice of research question, and to establish importance of the topic.

2.2. Air pollution.

Air pollution can be defined as a condition in which the concentrations of substances in the atmosphere are high enough to cause measurable effect on man, animals, vegetation or materials. Air pollution is a complex mixture of compounds in gaseous [ozone, CO and NOx (nitrogen oxides)] and particle phases (Seinfeld, 1986).*The most considerable sources of anthropogenic air pollutants are processes involving fossil fuel combustion such as energy production, traffic, and industry.*

2.2.1. Particulate matter:

"Particulate matter," also known as particle pollution or PM, is a complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles .

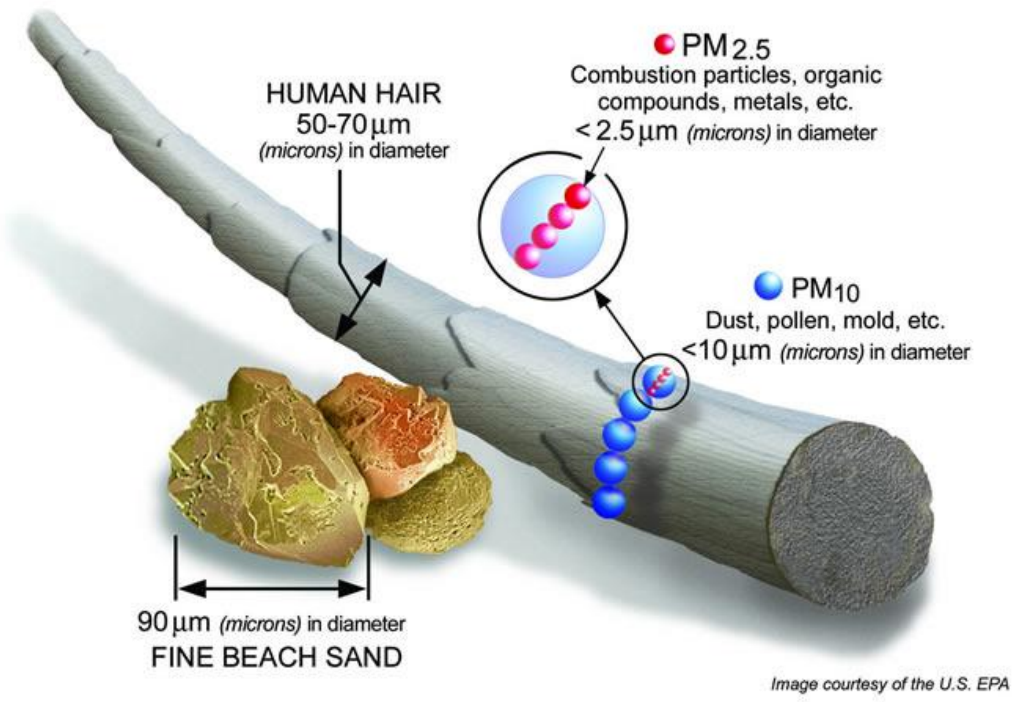
The size of particles is directly linked to their potential for causing health problems. EPA is concerned about particles that are 10 micrometers in diameter or smaller because those are the particles that generally pass through the throat and nose and enter the lungs and possibly the bloodstream. Once inhaled, these particles can affect the heart and lungs and cause serious health effects (EPA, 2007).

EPA (2007) groups particle pollution into two categories:

1) "Inhalable coarse particles," such as those found near roadways and dusty industries, are larger than 2.5 micrometers and smaller than 10 micrometers in diameter, Environmental Protection Agency(EPA), also state that “Research has confirmed the links between exposure to $PM_{2.5}$ and increases in respiratory health problems, hospitalizations and premature death.”.

2) "Fine particles," such as those found in smoke and haze, are 2.5 micrometers in diameter and smaller. These particles can be directly emitted from sources such as forest fires, or they can form when gases emitted from power plants, industries and automobiles react in the air. (EPA, 2007).

The following figure created by EPA, explains sizes of particulate matter compared with human hair :



Figure(2.1): Sizes of particulate matter compared with human hair (EPA, 2007).

2.2.2 Particulate matter sources and Size fractions:

When speaking of "particulate matter" we refer to substances that under normal conditions are in liquid or solid form in the atmosphere and that vary in size and density (Seinfeld, 1986). Particles under 20 micrometers in aerodynamic diameter are of special interest because they settle out slowly from the air (Koutrakis and Sioutas, 1996).

Because the exact size of particles cannot be determined, they are usually considered as spheres and the measure "aerodynamic diameter" is used to describe the size of particles. Strictly speaking, aerodynamic diameter is the diameter of a sphere of unit density (1g cm-3) that has the same gravitational settling velocity as the particle in question. Particulate matter is often classified particularly by the physical size of particles. Physical size refers to the above mentioned aerodynamic diameter of particles that varies from few nanometers to tens of micrometers. Many properties and atmospheric reactions of particles are predicted based on their size, the compounds they are formed of, and the size of their surface area (Seinfeld, 1986).

Ultrafine particles have diameter less than 0.1 micrometer. One sub-fraction of ultrafine particles is called nucleation mode (< 0.01 micrometer). These particles are formed by gas-to particle conversion, and condensation of hot vapors, but sometimes they are also directly emitted as particles from combustion processes. Nucleation mode particles have a short life span and they coagulate fast with each other to form larger particles, Aitken mode particles (0.01–0.1 micrometer) (Seinfeld and Pandis, 2006).

In addition to formation via gas-to particle conversion, condensation and coagulation processes, ultrafine particles are also emitted directly as particles.

Ultrafine particles are derived from local emission sources such as traffic and fuel combustion in stationary sources (Colls J, 2002; Seinfeld and Pandis, 2006). Ultrafine particles contribute little to the particulate mass (Pekkanen and Kulmala, 2004), but they are large in number and have high short-term peak concentrations.

Therefore especially nucleation mode particles can make a considerable contribution to the short-term inhalable particle exposure. Aitken mode particles have lower peak concentrations than nucleation mode, but they are always present in the ambient air (Colls J, 2002; Seinfeld and Pandis, 2006).

Besides having large number, ultrafine particles have also large surface area in relation to their mass. From the epidemiological point of view, large surface area means that there is more active area for particle-cell interactions in the airways, which is one reason why ultrafine particles are considered more toxic than larger particles (Donaldson and Stone, 2003; Sioutas et al., 2005).

Another reason for the harmfulness of these particles can be their ability to penetrate deep into the airways. It has been demonstrated that particles in the size fraction of < 0.1 micrometer would reach best the alveolar region of the lungs (Schulz, 2000).

Fine particles ($PM_{2.5}$, < 2.5 μm) are emitted straight from combustion sources but they are also formed in the air via condensation of precursor gases onto existing particles, and via coagulation of ultrafine particles (Seinfeld and Pandis, 2006).

The growth rate depends on the number of particles, their velocity, and surface area. The term "fine particles" is currently considered a synonym for the mass of particles less than 2.5 micrometer in aerodynamic diameter, $PM_{2.5}$. Slightly stricter size range, 0.1 μm to ~ 2 μm, defines a sub-fraction of fine particles that is also called accumulation mode (Seinfeld and Pandis, 2006).

Fine and accumulation mode particles do not grow into larger, coarse, particles due to growth limiting physical factors and therefore they are "accumulating" and lasting (Seinfeld and Pandis, 2006). Particles in the accumulation mode fraction are special in that they account for most of the ambient fine particle surface area (Hussein et al., 2004b; Seinfeld and Pandis, 2006).

Fine particles consist mainly of sulfate, nitrate, ammonium and secondary organics (Seinfeld and Pandis, 2006). Most of the particles are emitted from combustion processes using fossil fuel such as traffic and power plants. Other fine particle sources are waste incinerators, wood combustion, especially in residential areas where wood may be used as a secondary source of energy, and sea salt spray in the vicinity of sea (Colls J, 2002).

Fine particles have low settling velocity that enables long life span and transportation of these particles over thousands of kilometers from the emission source (Spengler and Wilson, 1996).

Therefore the total ambient particle mass is always affected by elsewhere produced fine particles as well as older particles. The composition of fresh and old particles may be different because of the conversion of particles through chemical processes that take place in the atmosphere (Seinfeld, 1986; Seinfeld and Pandis, 2006). Local combustion particles and long-range transported particles are therefore also defined as primary and secondary particles, respectively, and thought to probably have different health effects (Schwarze et al., 2006).

Generally, particles from 2.5 up to 50 μm are considered as coarse particles and they are mostly primary particles containing only some secondary sulfates and nitrates (Seinfeld and Pandis, 2006).

In epidemiological studies, however, the diameter used for coarse particles is most often defined as 2.5–10 μm (PM10–PM2.5), because these particles are in inhalable size fraction, and may therefore have biologically plausible effects on health. These particles are formed by fragmentation of matter and in other mechanical processes such as wearing off roads (Colls J, 2002). Traction sanding gives also rise for the formation of coarse particles that are thereafter distributed by local winds.

However, these particles are not transported far from their initial source because they are larger in size and heavier than combustion derived particles and therefore deposited faster.

Both, the coarse and the fine fraction of particles contain also material of biological origin like bacteria, pollen, and fungal spores. However, the major part of such intact bio-aerosols occurs in the coarse mode, and in deposited and re-suspended dust, particles of biological origin may be abundant (Monn, 2001).

2.2.3. Particulate Matter (PM10):

PM_{10} is particulate matter with an aerodynamic diameter of 10 μm or less. Particles of this size settle very slowly and stay suspended in the air. Medical data suggests that it is this fraction of particulate matter that becomes deeply imbedded in human lung tissue and causes respiratory problems and exacerbates other cardiovascular diseases. In addition to the negative health effects, particulate matter reduces visibility and speeds the deterioration of buildings.

The primary man-made sources of PM_{10} include fugitive dust from motor vehicles, combustion of solid fuels, agricultural activities, and construction activities. Volcanic emissions, windblown dust, marine aerosols and fly ash from forest fires are some of the more important natural sources of PM_{10}. Particles can also be formed in the atmosphere by the condensation or the transformation of emitted gases such as sulfur dioxide and volatile organic compounds (Matsumoto et al., 1996).

2.2.4. Air pollution in Palestine:

Air pollution is considered one of the main pollution problems around the world. Most countries consider this problem a threat to national health and enforce strict regulations, among other solutions, trying to reduce it as much as possible.

The main sources of air pollution in Palestine are the various means of transportation, the smoke rising from the chimneys of factories, the heavy dust from crushers, the burning of solid wastes, and the effects of water treatment projects. The Israeli industries in the West Bank, Gaza Strip, and inside the part of Palestine occupied in 1948 are the biggest cause of atmospheric pollution in Palestine. Many Israeli sawmills pollute the air across the West Bank with large quantities of greenhouse gases. A 2009 study prepared by George Karzam of the Ma'an Development Centre predicts that the greenhouse gases emitted from the territories occupied in 1948 will increase by 40 percent by the year 2020.

In the West Bank, there is a little data collected on air pollution, including some notes concerning the sources of such pollution. Between 40 and 50 percent of air pollution comes from urban areas. It comes from coal factories in Jenin, crushers, the random burning of solid waste, the emission of smog from the factories inside Israeli settlements in the West Bank, and the smog from Israeli factories, which is moved by the wind toward the West Bank.

According to a report from the Applied Research Institute of Jerusalem from 2009, statistics indicate that there are 20 industrial settlements distributed around the West Bank (five industrial settlements in Salfit, four in Qalqilya, three each in Hebron and Jerusalem, and one settlement each in Nablus, Jenin, Jericho, and Bethlehem). This is in addition to the establishment of at least seven industrial zones in the Palestinian Territories on the border of the area of Palestine occupied in 1948, which were created by the Israeli government (Applied Research Institute of Jerusalem, 2009).

Another prominent cause of pollution is Israeli crushers in the West Bank, which release massive amounts of dust into the air, damaging a wide range of agricultural land when the dust falls on agricultural crops and trees. Six Israeli crushers were established in the West Bank to provide stone for use in the construction sector, and these crushers cover 80 percent of Israeli needs.

In the Gaza Strip, the issue of air pollution is attributed to the density of motor vehicles. Also, air pollution is caused by the gases and smog emitted from Israeli factories, especially from crushers, and coal-operated power stations, and transferred to Gaza Strip by the wind. These factories are located in Isdude (Ashdod) and Al-Majdal (Ashqelon) inside the part of Palestine occupied in 1948.

2.3. Air pollution health impacts worldwide

Clean air is considered to be a basic requirement of human health and well being. However, air pollution continues to pose a significant threat to human health worldwide. Air pollution continues to be a growing concern globally, with increases in both population and energy consumption contributing to higher pollution levels (WHO, 2005).

The World Health Organization (WHO) assessment of the burden of disease due to Air Pollution (2005) states modestly that more than two million premature deaths occur each year as a result of the effects of urban outdoor air pollution and indoor air pollution. Deaths as a result of indoor air pollution are predominantly caused by the burning of solid fuels. Additionally, more than half of this disease burden is borne by the populations of developing countries (WHO, 2005).

In 2007, the WHO released data on estimated deaths worldwide attributable to selected environmental risk factors including deaths per country per year as a result of outdoor air pollution.

Of all the major pollutants emitted to air, PM10 pollution is consistently and independently related to the most serious effects on human health worldwide in both developed and developing countries.

The range of health effects is broad, but are predominantly linked to the respiratory and cardiovascular systems. All population is affected, but susceptibility to the population may vary with health or age (WHO,2005).

The risk for various health outcomes has been shown to increase with exposure and there is little evidence to suggest a threshold below which no adverse health effects would be anticipated. Further, the epidemiological evidence shows adverse effects of PM10 following both short-term and long-term exposures (Cohen et al. 2005).

The WHO Global Burden on Disease Comparative Risk Assessment: The Burden of Disease Attributable to Urban Ambient Air Pollution, (2005) was estimated in terms of mortalities and disability-adjusted life years (DALYs), that is, years of 'healthy' life lost in states of less than full health, broadly termed disability (Cohen et al. 2005).

The analyses on which this report is based, estimate that ambient air pollution, in terms of particulate air pollution (PM10), causes approximately 3% of mortality from cardiopulmonary disease (heart and lungs), 5% from cancer of the trachea, bronchus, and lung, and 1% from acute respiratory infections in children five years and under, worldwide. As a result, this amounts to about 0.8 million (1.2%) premature deaths and 6.4 million (0.5%) years of life lost (Cohen et al. 2005).

As previously stated, this burden occurs predominantly in developing countries; 65% in Asia alone (Cohen et al. 2005). Furthermore, these estimates consider only the impact of air pollution on mortality (years of life lost) and not on DALYs due to the limitations in the global epidemiologic database. If air pollution multiplies for both incidence and mortality to the same extent (i.e., the same relative risk), then the DALYs for cardiopulmonary disease increase by 20% worldwide alone (Cohen et al. 2005).

2.4. PM_{10} exposure and health outcomes.

The main health effects of PM_{10} exposure are to the respiratory system. This section will briefly outline the clinical effects of PM_{10} exposure on respiratory system. However, the focus of this segment is on the health outcomes of PM_{10} exposure. Primarily, these include mortality and morbidity.

2.4.1. Possible mechanisms of ambient air pollutants on respiratory health.

To better understand and avoid the harmful effects of air pollutants, the mechanisms of the health effects have been under vigorous investigation.

Particulate matter deposited in the airways can cause epithelial barrier disruption via oxidative and toxic compounds imported on their surface (Costa and Dreher, 1997; Gilmour et al., 1996; Vinzents et al., 2005).

Structural changes in the mucosal membranes and disruption of the epithelial barrier caused by irritation can lead to pulmonary dysfunctions and increase the permeability of airway epithelia (Timonen et al., 2004).

Increased permeability facilitates further the penetration of macromolecules and particulate matter into the epithelium tissue and circulation (Bhalla, 1999; Chuang et al., 2007).

Inflammation, a mechanism that lies behind several pulmonary and extra-pulmonary diseases, can be induced by the oxidative stress following particulate exposure (Brook et al., 2004; Delfino et al., 2005; and Rahman, 1998).

In pulmonary inflammation, cytokines such as interleukins 1 and 2 are released that further activate the defense mechanisms in the airways. Local inflammation may also lead to systemic inflammation where inflammation markers such as fibrinogen and C-reactive protein are released into the blood circulation. (Gabay and Kushner, 1999).

Systemic inflammation in the airways leads to deterioration of lung function (Thyagarajan et al., 2006), and it possibly increases the risk of chronic pulmonary disease, cardiovascular disease and several neurological and skeletal defects (Agusti, 2005).

The cardiovascular effects of particles may also occur through local inflammation in the blood vessels. Inflammation can induce the formation of plaques that may rupture as a result of sudden increase in blood pressure, for example. This can cause thrombus in the heart or brain vessels, which are observed as myocardial infarction or ischemic stroke, respectively. Inflammation may also increase the levels of interleukin 6 that promotes blood clotting, which also increases the risk of cardiac arrest and stroke (Samet et al., 2007).

The effect of fine particles on cardiovascular system has also been suggested to occur via mechanisms including the autonomic nervous system. In the respiratory system several sensory receptors become activated by chemical components on inhaled particles، through oxidative stress, or through inflammation. This induces reflex changes in the cardiovascular system (Widdicombe and Lee, 2001).

The autonomic nervous system controls heart rate variability (HRV) that thus can be affected by short-term exposure to air pollutants (Chuang et al., 2007; Gold et al., 2000; Lipsett et al., 2006; Timonen et al., 2006; Yeatts et al., 2007). Changes in HRV further increase the risk of myocardial ischemia and the risk of arrhythmias especially among susceptible persons (Berger et al و .2006 ؛Rich et al., 2005).

In addition, the autonomic nervous system, the current state of the myocardium, and myocardial vulnerability are contributing to the cardiac morbidity and mortality as presented by Zareba et al. (2001).

The effect mechanisms of ultrafine particles are partly the same as those of fine particles. However, it has been shown that ultrafine particles cause more oxidative stress than larger particles (Li et al., 2003). Reason for the greater oxidative capacity maybe the small size or large number of particles, because ultrafine particles composed also of nontoxic substances have been found to be harmful (Donaldson and Stone, 2003; Monteiller et al., 2007; Nel et al., 2006).

Carbon black particles and aggregates of ultrafine particles can also impair the phagocytosis of human macrophage cell line to a greater extent than fine particles, which is why inflammation possibly occurs more readily after exposure to ultrafine particles compared to fine particles (Donaldson et al., 2001; Lundborg et al., 2006; Renwick et al., 2001). However, opposite results have also been found, showing higher inflammation marker occurrence after exposure to fine or coarse particles than ultrafine particles (Becker et al., 2005).

Another effect mechanism of ultrafine particles is suggested to be the translocation of particles into the circulation and further into secondary target organs (Nemmar et al., 2002; Nemmar et al., 2004; Oberdorster et al., 2005).

However, it has been reported that only 5% of the deposited particles in the lungs is systemically translocated (Kreyling et al., 2006). Thus it can be that the effects of the smallest particles are due to their larger surface area that determines the potential number of reactive groups on particle surfaces, rather than the small size alone.

Among the reactive groups on ultrafine particle surfaces are metals. Evidence of the toxicity of particle coating metals has been found in cell and animal studies, where iron, silicon, zinc, copper, manganese, nickel, and vanadium have been associated with increases in various inflammation markers (Becker et al., 2005; de Kok et al., 2006; Molinelli et al., 2006; Rice et al., 2001).

Health effects of coarse particles may also occur via the inflammatory cascade (Schins et al., 2004). Especially, the endotoxin contaminants of particles have been linked to the harmfulness of coarse particles (Becker et al., 2003; Huang et al., 2002; Schins et al., 2004). Besides endotoxins, the insoluble components of coarse particles can modulate the functionality of alveolar macrophages (Soukup and Becker, 2001).

Coarse particles have also been found to activate monocytic cells, which may enhance responses to allergens or bacteria in individuals with allergy (Alexis et al., 2006). However, relatively little knowledge is available on the exact mechanisms of health effects of coarse particles.

2.4.2. Clinical effects on respiratory system.

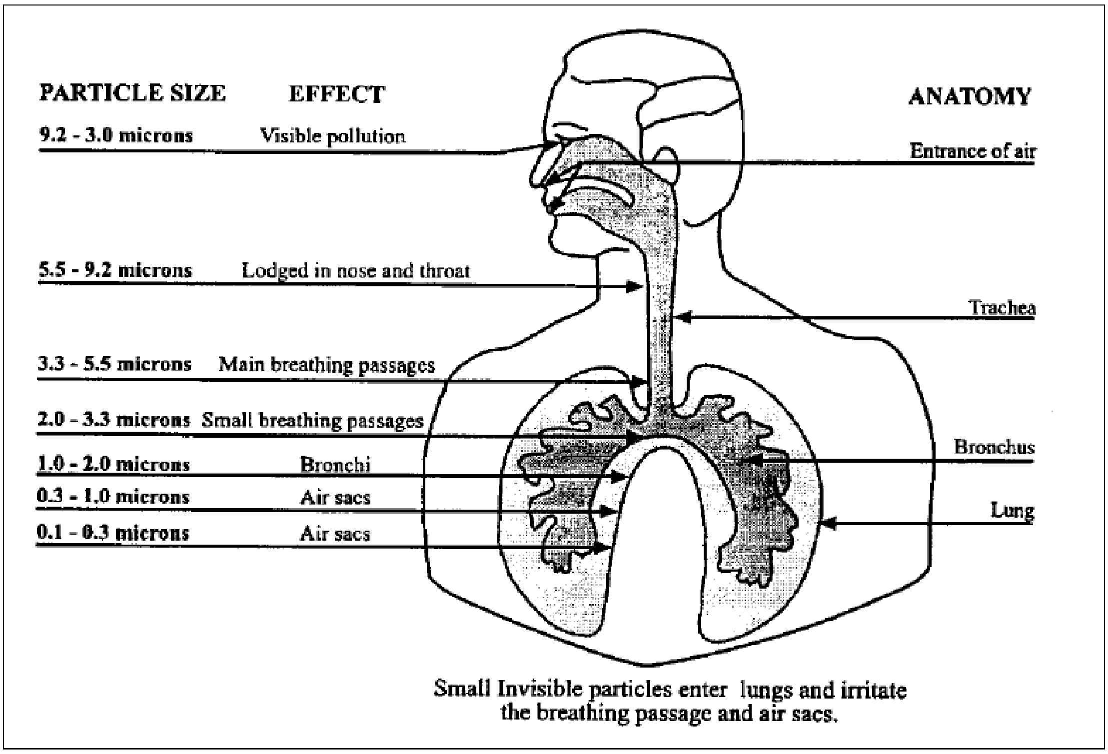
Deposition of particles in the nose and lungs is mainly dependant on the size of the particles (Koenig, 2000). The degree that PM_{10} affects an individual varies considerably.

Typically the sub-populations of society that are at greatest risk are young children, whose respiratory systems are still developing. The elderly, whose respiratory systems are most likely to function poorly, and persons who have pre-existing diseases such as asthma, emphysema, and heart disease (Stern et al. 1984).

PM10 particles are not efficiently removed by the respiratory system, heightening the potential of becoming lodged within the lung (Godish, 1991). These fine particles are too small to be seen or avoided, even by staying indoors during times of high pollution. Even finer particles less than 2.5 microns in diameter ($PM_{2.5}$), are especially of concern because of their ability to be deposited at or near airway bifurcations, and because nerve endings are concentrated at these sites, resulting in reflex coughing and asthma (Dockery and Pope, 1994).

Figure (2.2) illustrates the level within the lung that various size particles can penetrate and their corresponding effect. Furthermore, with increasing concentrations of PM_{10} pollution there will generally be graded responses from the respiratory system. Low concentrations can cause nasal irritation which may cause nasal stuffiness and nasal congestion, and perhaps lead to other non specific complaints such as headache, while higher prolonged concentrations can result in reflex sneezing, nasal secretion and tearing of the eye; and with very high concentrations there may be the initiation of respiratory inhibition and a slowing of breathing and periods of apnoea (Ayres et al. 2006).

Furthermore, exposure to PM_{10} pollution may result in nasal and throat inflammation and rhinitis, while a slowing of the rate of mucociliary clearance may be predisposed to injury, infectious and allergic diseases (Ayres et al. 2006).



(Figure 2.2) Schematic diagram of penetration of particles into the respiratory system (Chilton, 1999).

On the other hand, evidence shows that there are two interlinked mechanisms by which concentrations of particulate pollutants in inspired air could have acute cardiovascular consequences. First, inhalation and interstitialisation of fine particles might provoke an inflammatory response in the lungs, with the consequent release into the circulation of pro-thrombotic and inflammatory cytokines. A systemic acute-phase response of this nature would put individuals with coronary atheroma at increased risk of plaque rupture and thrombosis. Second, cardiac autonomic control is likely to be affected by exposure to PM10 pollution, leading to an increased risk of arrhythmia in susceptible patients (Seaton, 1995).

2.4.3. PM10 exposure and mortality

Since the early 1990s numerous studies reviewed by Pope and Dockery (2006) have illustrated that PM_{10} exposure has causal connections with mortality. Indeed, this is dependent on both exposure concentrations and length of exposure. Studies usually measure short term exposure to PM_{10} and mortality or long term exposure and mortality. Short term studies rely on evaluated changes in daily mortality counts associated with daily changes in PM10 while long term studies, though similar, can span years to decades.

Since the early 1990s there have been well over 100 published research articles that report results of short-term exposure to PM_{10} and mortality. The majority of these studies are single-city daily time series mortality studies (Haidong et al. 2006; Shrestha et al. 2005; Burnett et al. 1998; Hoek et al. 1997; Simpson et al. 1997; Schwartz, 1993; Pope et al., 1992).

Multi-city daily time series studies have also been conducted and one of the largest and most ambitious is the National Morbidity, Mortality, and Air Pollution Study (NMMAPS). This study grew out of efforts to replicate several early single-city time series studies and was designed to address concerns about city selection bias, publication bias, and influence of co-pollutants (Pope and Dockery, 2006).

The study focused on the 20 largest metropolitan areas in the USA, home to 50 million inhabitants, during 1987-1989 (Brunekreef and Holgate, 2002). Strong evidence linked a short-term association between fine particulate matter pollution, namely PM_{10}, and mortality from all causes and in particular, from cardiovascular and respiratory illnesses (Peng et al. 2005). All-cause mortality increased by 0.5% (95% CI 0.1-0.9) for each 10μg/m3 increase of PM_{10}.

A parallel research effort was the Air Pollution and Health: A European Approach (APHEA) Project. This study examined the short term PM_{10} mortality effects in multiple European cities and found that daily mortality was significantly associated with PM_{10} concentrations (Katsouyanni et al. 1997; Zmirou et al. 1998).

A continuation and extension of the APHEA Project, often referred to as the APHEA-2 Project, included further analysis of daily mortality and pollution for less than 29 European cities. APHEA-2 also found that PM_{10} air pollution was significantly linked with daily mortality counts together with cardiovascular and respiratory mortality (Analitis, 2006).

The risk of cardiovascular mortality in the APHEA-2 study was slightly higher than that for respiratory mortality (Analitis, 2006). The combined effect estimate showed that all-cause daily mortality increased by 0.6% (95% CI 0.4-0.8) for each 10μg/m3 increase in PM_{10}, a value close to the NMMAPS study (Brunekreef and Holgate, 2002). Furthermore, there are several other well acknowledged multi-city studies that show strong connections between mortality and particulate matter pollution exposure (Simpson et al. 2005; Le Tertre et al. 2002; Omori et al. 2003; Schwartz, 2000, 2003; Ostro et al. 2006).

It is important to note that these studies of mortality and short term daily changes in particulate matter are observing small effects. For example, assume that a short-term elevation of $PM_{2.5}$ of 10μg/m3 results in a 1% increase in mortality. Based on the year 2000 the average mortality rate for the US was (8.54 deaths/1000 per year), a 50μg/m3 short-term increase of $PM_{2.5}$ would result in an average of only 1.2 deaths per day in a population of 1 million (compared with the expected rate of 23.5/ day). Therefore, on any given day, the number of people dying because of particulate matter exposure in a population is small (Pope and Dockery, 2006).

In comparison to short term studies of PM_{10} exposure and mortality, long term exposure and mortality studies are less common. This is because such studies require collecting information on large numbers of people and following them prospectively for long periods of time (years to decades) therefore, they are costly and time consuming. However, two well acknowledged long-term projects include the Harvard Six Cities and the Amercian Cancer Society (ACS) prospective cohort studies which both provide compelling evidence of mortality effects from long-term exposure to fine particulate air pollution.

The Havard Six Cities Study reported on a 14 to 16 year prospective follow up of more than 8000 adults living in six U.S. cities, representing a wide range of pollution exposure (Dockery et al. 1993).

In both long-term studies, cardiopulmonary (heart and lungs) mortality was significantly and most strongly associated with PM2.5 and sulphate concentrations (Dockery et al. 1993; Pope et al. 1995). Nevertheless, these two studies were controversial, and there validity came under intense scrutiny and therefore both studies led to further analysis.

Extended analysis included longer follow up time on participants, and overall results still showed strong links between mortality and fine particulate pollution exposure (Pope and Dockery, 2006). One notable difference however was in the reanalysis of the Harvard Six Cities Study where reductions in $PM_{2.5}$ concentrations were associated with reduced mortality in cities with the largest declines in $PM_{2.5}$. Laden et al. (2006) note that such a finding suggests that mortality effects of long-term air pollution may be at least partially reversible over periods of a decade.

Several other long-term studies have found associations between PM_{10} exposure and mortality however they are predominantly carried out as independent research (Abbey et al. 1999; Enstrom, 2005; Hoek et al. 2002; Filleul et al. 2005).

2.4.4. PM10 exposure and morbidity.

Many other adverse health endpoints as well as mortality have been associated with PM_{10}, such as pulmonary function decrements, respiratory symptoms, increases in medication use in subjects with asthma, emergency department visits, and hospital admissions. These indicators of morbidity are reviewed at this point.

Many studies have shown that acute exposure to PM_{10} is associated with decrements in pulmonary function. Studies have observed that long-term PM10 exposures are associated with deficits in lung function and increased symptoms of obstructive airway disease, such as chronic cough, bronchitis, and chest illness (Schwartz, 1989; Chestnut et al. 1991; Tashkin et al. 1994; Raizenne et al. 1996; Ackermann et al. 1997).

Exacerbation of upper and lower respiratory symptoms have been linked to PM_{10} exposure in several studies. Upper respiratory symptoms primarily consist of phlegm-build up‘ coughing, and throat discomfort while lower respiratory symptoms include breathing problems and wheezing. Studies which have found positive relationships between individual symptoms or a combination of symptoms with exposure to PM_{10} include (Abbey et al. 1995; Pope et al. 1995; Romieu et al. 1996; Timonen and Pekkanen, 1997; Roemer et al. 1999; Zemp et al. 1999; Zee et al. 2000).

Exposure to high PM_{10} concentrations has been shown in many studies to increase medication use in subjects with asthma. A well recognized study supporting this hypothesis was conducted by Pope, (1991) on residents of the Salt Lake City area in the Utah Valley where PM10 is emitted primarily by a steel mill. Results showed that increases in medication use were associated with PM_{10} in a panel of subjects with asthma. In the study, the probability of increased medication use was 6.2 times higher when 24 hour PM_{10} levels were at the highest compared to the medication use during a 24 hour period at the lowest PM_{10} level.

Further, other well known studies have been carried out in Germany and Austria and have also found significant relationships between medication use in subjects with asthma and daily PM10 levels (Peters *et al.* 1997).

There have been numerous short-term and long-term studies which link hospital admissions and PM_{10} exposure. Well recognized short term studies such as the APHEA-2 project (discussed in section 2.4.3) also conducted a hospital admissions study which covered a population of 38 million people living in eight European cities, which were studied for 3-9 years in the early to mid 1990s (Atkinson *et al.* 2001).

Results showed that hospital admissions for asthma and chronic obstructive pulmonary disease (COPD) among people older than 65 years were increased by 1.0% (95% CI 0.4-1.5) per 10μg/m3 increase in PM_{10}, and admissions for cardiovascular disease (CVD) were increased by approximately 0.5% (95% CI 0.2-0.8) per 10μg/m3 increase in PM_{10} (Brunekreef and Holgate, 2002).

The NMMAPS project introduced in section 2.3.2 also incorporated a hospital admissions study where ten cities with a combined population of 1 843 000 individuals older than 65 years were monitored. Effects of PM_{10} on COPD admissions were 1.5% (95% CI 1.0-1.9) and on CVD admissions 1.1% (95% CI 0.9-1.3) per 10μg/m3 increment of PM10 (Brunekreef and Holgate, 2002).

Many other large scale and multicity short term studies have focused on PM_{10} exposure and hospital admissions (Schwart, 1999; Zanobetti *et al*. 2000; Le Tertre *et al.* 2002; Dominici *et al*. 2006; and COMEAP 2006).

Long term studies associating PM_{10} exposure with hospital admissions have predominantly been conducted as cross-sectional studies whereby it is assumed that current PM_{10} exposure is sufficiently representative of long-term previous exposure to make a plausible link with current health status (Brunekreef and Holgate, 2002). Further, one of the most recognized long term studies of the relationship between hospital admissions and PM_{10} was conducted by chance according to Koenig, (2000). A steel mill in Utah was closed for a period of one winter due to strike among workers. Bronchitis and asthma hospital admissions were tallied for the winter of the strike and for the preceding and subsequent winters (Pope, 1991). Both PM_{10} concentrations and hospital admissions were significantly lower during the winter of the strike and therefore this study gave very compelling results.

2.4.5. Health endpoints associated with PM10 exposure.

When examining the overall health endpoints of both short-term and long-term studies, PM_{10} has an effect on respiratory system mortality and morbidity. It is important to categorize the specific health endpoints of PM_{10} exposure to show the wide ranging spectrum. The general health endpoints include:

1) Mortality: All non-accidental mortality causes.
2) Hospital Admissions: Cardiovascular and respiratory hospital admissions.
3) Emergency Room Visits: Visit to an emergency department.

4) Asthma Symptom Days: Exacerbation of asthma symptoms in individuals with diagnosed asthma.
5) Restricted Activity Days: Days spent in bed, missed from work, and days when activities are partially restricted due to illness.
6) Acute Respiratory Symptoms: Respiratory-related symptoms such as chest discomfort, coughing and wheezing.

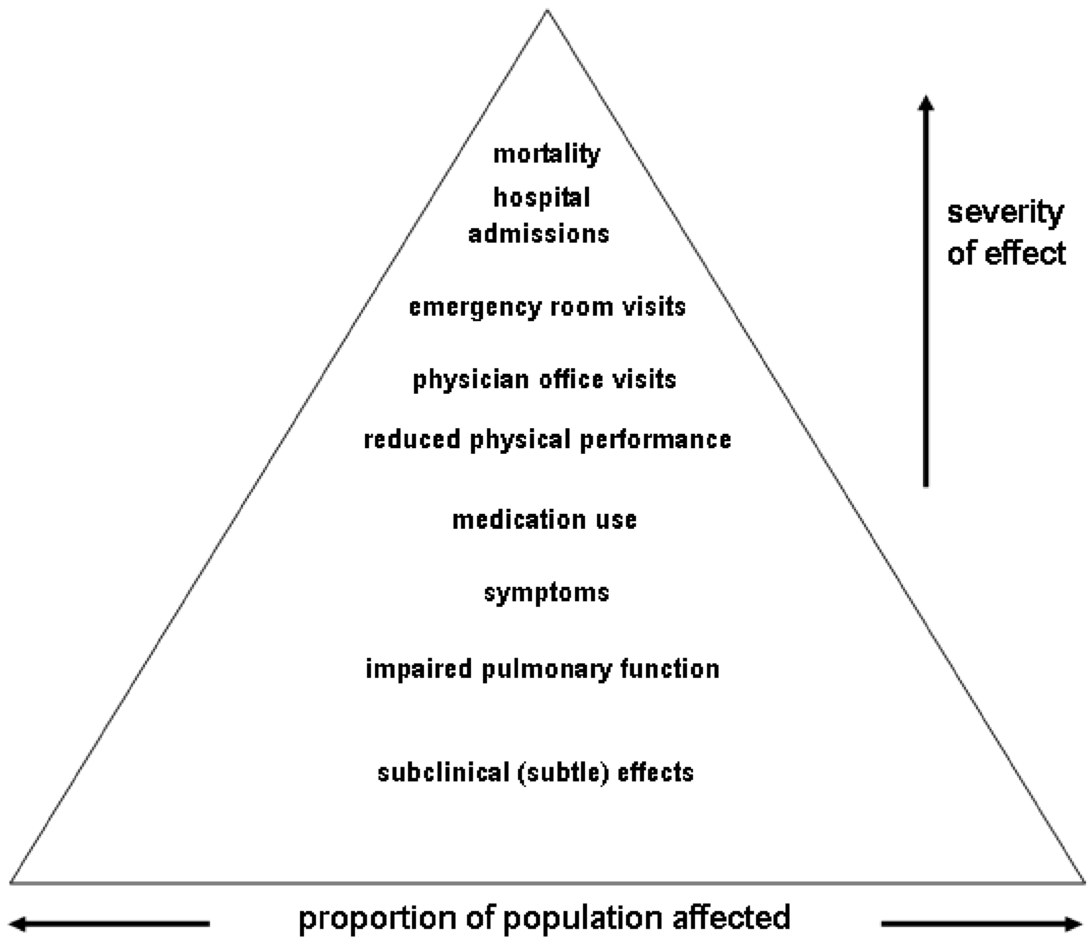


Figure (2.3): Pyramid of the different health endpoints due to PM10 air pollution (Modified after Health Canada, 2006).

(Figure 2.3): illustrates the health endpoints in the form of a pyramid, with the mildest but more common effects at the bottom of the pyramid, and the least common but more severe at the top of the pyramid. The pyramid demonstrates that as severity decreases the number of people affected increases.

2.5. History of particulate air pollution regulations.

The public health narrative concerning particulate air pollution or particulate matter (PM) is best told as a combination of politics, epidemiology, and research through following the history of the regulation of PM. The first environmental law concerning PM in the modern industrialized world was the British Clean Air Act of 1956. This act was passed following findings of a 1954 report by the United Kingdom Ministry of Health that investigated a London incident in December 1952 where PM concentrations were in excess of 1000 µg/ml and concluded that the incident was strongly associated with increased mortality from respiratory and cardiovascular conditions among the elderly (Greenbaum *et al.*, 2003).

2.5.1. Primary standards institutions :

EPA instituted primary standards for total suspended particulate (TSP) of 260 µg/m3, a 24 hour standard not to be exceeded more than once per year with an annual mean of 75 µg/m3.

Following contentious public debate and the first substantial legal challenges to EPA rulemaking (Greenbaum, 2003), the EPA replaced TSP as the principle indicator of PM with a size differentiated standard of PM10 (particulate matter with a 50% "cut-point" of 10 µm aerodynamic diameter), The 24 h standard was 150 µg/m3 with one exceedance per year and an annual average standard of 50 µg/m3. The 10 µm diameter was selected for attention since it is a size capable of entering the thoracic region of the respiratory system, (National Center for Environmental Assessment, 2003).

2.5.2. New set of standards :

After evaluation of research involving $PM_{2.5}$, the EPA proposed and eventually adopted a new set of standards for PM2.5. After a public review process that was very contentious involving questions concerning the strength of the epidemiologic studies, the lack of a plausible biologic mechanism, and potential exposure measurement error, the EPA adopted a new standard of $PM_{2.5}$; a 24 h average of 65 μg/m3 and annual average of 15 μg/m3, with seven exceedances allowed per year (Greenbaum, 2003).

In 1996 the EPA relied heavily upon two major studies justifying the new standards, the Harvard Six Cities Study which showed the greatest hazard ratio with early all cause mortality of 1.75 (1.32-2.32 95% confidence interval ,CI) among currently smoking men (Dockery et al., 1993) and the American Cancer Society (ACS) study (Pope *et al.,* 1995) which showed a ratio of 1.17(1.09-1.26 95% CI) ratios with only cardiopulmonary and lung cancer but not all cause mortality. The relative risks were slight, albeit significant. These findings were quite important since previous studies demonstrated the mean effects on mortality associated with air pollution were essentially the same for PM and gases and were "invariant with respect to particle diameter" indicating that there was not a difference between particle diameters and proposed PM2.5 regulations lacked support (Lipfert and Wyzga, 1995). The EPA's reliance upon the ACS and Six Cities studies brought intense attention upon the two studies.

In response to the demand for the data from the two studies to be made public given concerns about the reliance of the EPA on those studies, and public and political questions concerning the data. Later the American Cancer Society (ACS) eventually joined the project resulting in independent analysis of both studies (Higgins et al., 2003).

2.5.3. Air quality standards for particles in Palestine:

In Palestine there are only a few studies about air quality and its effects, the particles emissions are not characterized and analyzed yet. The major anthropogenic particle sources in the West Bank are traffic, solid waste combustion, the industry, stone crushers and stone cutting. A high number of old cars, stone crushers located near to residential areas and randomly burned trash leads to high particulate concentration. There are no continuous measurements of particulate matter concentrations in Palestine at the moment to survey the currents situation. A lack of air quality standards and of emission regulations leads to an uncontrolled situation.

The report of WHO Air Quality guidelines for particulate Matter, ozone, nitrogen dioxide and sulphur dioxide – Global update defined standards for air pollutants as a guidance for the regulations of different countries. The WHO Guidelines have been chosen in a way, that they reflect the concentration, where an increased mortality due to the PM exposure is expected. There is little evidence that a threshold for particulate matter exists, below which no adverse health effects are anticipated. The standard should be set in a way to minimize the concentrations in the context of local constraints, capabilities and public health priorities. The WHO studies set a guideline for $PM_{2.5}$ and converted this limit to a PM_{10} concentration by anticipating a ratio A $PM_{2.5}$/PM10. For local standards this ratio can be adopted to local conditions (WHO, 2005). As there are no Standards and Limits set in Palestine, the WHO guidelines will be used to analyze the PM10 concentrations.

Table (2.1): Air quality standards for particles in Palestine (WHO, 2005).

	PM2.5 [µg/m3]		PM10 [µg/m3]		TSP [µg/m3]	
	24h mean	annual mean	24h mean	annual mean	24h mean	annual mean
WHO Guidelines	25	10	50	20		
Israel			150	60	200	75

2.6. Background Research.

Many studies have shown that acute exposure to PM_{10} is associated with decrements in pulmonary function. Studies have observed that long-term PM_{10} exposures are associated with deficits in lung function and increased symptoms of obstructive airway disease, such as chronic cough, bronchitis, and chest illness (Schwartz, 1989; Chestnut *et al.*, 1991; Raizenne et al., 1996; and Ackermann et al. 1997).

Exacerbation of upper and lower respiratory symptoms have been linked to PM_{10} exposure in several studies. Upper respiratory symptoms primarily consist of phlegm-build up‹ coughing, and throat discomfort while lower respiratory symptoms include breathing problems and wheezing. Studies which have found positive relationships between individual symptoms or a combination of symptoms with exposure to PM10 include (Abbey et al. 1995; Pope et al. 1995; Romieu et al. 1996; Timonen and Pekkanen, 1997; Roemer et al. 1999; Zemp et al. 1999; Zee et al. 2000).

Pop *et al.,* (1997) established that a 10 µg/m3 increase in PM_{10} in most studies are typically associated with one to ten percent increase in symptoms such as cough, sputum build up, and combined lower respiratory symptoms such as wheezing and breathing problems.

Burnett R., (1997) studied the association between daily PM_{10} (particles with a median aerodynamic diameter of < or = 10 microns) and iron particle concentrations and respiratory health in a population of adults selected for current or recent bronchodilator use. Acute changes in respiratory health were measured as changes in peak expiratory flow (PEF), and daily prevalence of respiratory symptoms and medication use as recorded in a diary. The study period was October 11 through December 22, 1993. The study population included 32 adults living near a large steel industry in Wijk aan Zee, the Netherlands. During the study period, 24-h average PM_{10} concentrations in Wijk aan Zee ranged from 36 to 137 micrograms/m3 while the 24-h average concentrations of iron, silicon, sodium, and manganese ranged from approximately zero to 6.95, 1.84, 12.02, and 0.37

micrograms/m3 respectively. The steel industry was found to contribute significantly to the PM_{10} concentrations, and especially to the iron and manganese concentrations in the air. The association of changes in respiratory health with changes in PM_{10}, iron, sodium, and silicon was evaluated using a time series approach. A statistically significant decrease in PEF was found to be associated with increasing PM_{10} concentrations. Stronger associations were found for smokers than for nonsmokers, and for subjects reporting many chronic respiratory symptoms than for subjects reporting few such symptoms.

Pope A. (1990) assessed in his study the association between respiratory hospital admissions and PM_{10} pollution in Utah, Salt Lake, and Cache valleys during April 1985 through March 1989. Utah and Salt Lake valleys had high levels of PM_{10} pollution that violated both the annual and 24-h standards issued by EPA. Much lower PM_{10} levels occurred in the Cache Valley. Utah Valley experienced the intermittent operation of its primary source of PM_{10} pollution: an integrated steel mill. Bronchitis and asthma admissions for preschool-age children were approximately twice as frequent in Utah Valley when the steel mill was operating versus when it was not. Similar differences were not observed in Salt Lake or Cache valleys. Even though Cache Valley had higher smoking rates and lower temperatures in winter than did Utah Valley, per capita bronchitis and asthma admissions for all ages were approximately twice as high in Utah Valley. During the period when the steel mill was closed, differences in per capita admissions between Utah and Cache valleys narrowed considerably. Regression analysis also demonstrated a statistical association between respiratory hospital admissions and PM_{10} pollution. The results suggest that PM_{10} pollution plays a role in the incidence and severity of respiratory disease.

Wichmann H. (2001) assessed the association between blood pressure, meteorology, and air pollution in a random population sample. Blood pressure measurements of 2607 men and women aged 25 to 64 years who participated in the Augsburg Monitoring of Trends and Determinants in Cardiovascular Disease survey were analyzed in association with 24-hour mean concentrations of air pollutants. During the air pollution episode in Europe in January 1985, an association between blood pressure and air pollution was observed, which disappeared after adjustment for meteorology. Continuous concentrations of total suspended particulates and sulfur dioxide were associated with an increase in systolic blood pressure of 1.79 mm Hg (95% confidence interval [CI] = 0.63, 2.95) per 90 micrograms/m3 total suspended particulates and 0.74 mm Hg (95% CI = 0.08, 1.40) per 80 micrograms/m3 sulfur dioxide. In subgroups with high plasma viscosity levels and increased heart rates, systolic blood pressure increased by 6.93 mm Hg (95% CI = 4.31, 9.75) and 7.76 mm Hg (95% CI = 5.70, 9.82) in association with total suspended particulates. The observed increase in systolic blood pressure associated with ambient air pollution could be related to a change in cardiovascular autonomic control.

Nitta *et al.* (1993) found that cough, expectoration, rhinitis, chronic bronchitis and dyspnea were significantly more common in exposed than non-exposed individual to PM_{10} air pollution.

Cheng *et al.* (2003) found a significant association between PM_{10} air pollution exposure and respiratory symptoms among general population sample of 9651 people living in eight different study sites within Switzerland.

Thishan G. (2008) monitored the analysis of ambient air quality data at Colombo Fort monitoring unit clearly revealed that PM_{10} is the dominant air pollutant in the Colombo atmosphere. Further investigation showed that PM_{10} has strong associations with three types of respiratory illnesses, especially among children. Among these associations, the disease category which includes bronchitis, emphysema and other chronic obstructive pulmonary diseases showed a prominent association with a correlation coefficient of 0.717 at 99% confidence. In addition, an application of health impact assessment software developed by WHO revealed that nearly 20% of Asthma patients recorded at LRH (the Lady Ridgeway Hospital for Children) in 2005 could be attributed to exposure to PM_{10}in Colombo. It was observed that nearly 60% of the respiratory cases occurred at reasonably lower concentrations (below 80 μ gm^{-3}) thus, future management plans aiming toward positive health impacts should focus on shifting the entire PM_{10} pollution distribution towards lower ends.

Van *et al.* (1997) found an association between chronic coughing and dyspnea and exposure to PM10 in cohort study of 3914 people in California.

Brown M., (2009) associated higher risks of coughing and throat irritation and sputum build up with exposure to PM10 in population of 6000 Reefton, New Zealand.

2.7. Summary of Literature Review.

The worldwide effects that air pollution has on humans, illustrating that it is becoming an ever growing concern in certain regions around the world that are continuing to develop. Following this, PM_{10} air pollution and its specific clinical effects on the human body were examined and discussed. Health endpoints associated with both short and long term exposure to PM_{10} were analyzed thoroughly with findings from numerous studies presented. Further, the health impacts of PM_{10} in Palestine and history of particulate air pollution regulations were discussed. Finally, more than seven similar previous studies of short and long term exposure to PM_{10} and its findings was mentioned.

Chapter 3
Materials and Methods

3.1. Introduction

The researcher here measured the concentration of PM10 of dust from crushers during work, and examined the health effects on the respiratory system that have occurred as a result to direct exposure of workers to dust for long hours.

This chapter describes the research methodology, research design, target population, sampling design and size, sitting of the study details, instruments and techniques, inclusion and exclusion criteria, data collection, data analysis, and ethical considerations.

3.2.Study design :

Case-control study design. A case-control study is designed to help determine if an exposure is associated with an outcome (i.e., disease or condition of interest). In theory, the case-control study can be described simply.

First, identify the cases (a group known to have the outcome) and the controls (a group known to be free of the outcome). Then, look back in time to learn which subjects in each group had the exposures, comparing the frequency of the exposure in the case group to the control group (Porta, 2008).

By definition, a case-control study is always retrospective because it starts with an outcome then traces back to investigate exposures. When the subjects are enrolled in their respective groups, the outcome of each subject is already known by the investigator. This, and not the fact that the investigator usually makes use of previously collected data, is what makes case-control studies ‘retrospective’ (Porta, 2008).

Case-control studies have specific advantages compared to other study designs. They can obtain findings quickly, can often be undertaken with minimal funding, efficient for rare diseases, can study multiple exposures and generally requires few study subjects (Rothman, 2011).

Due to the multiplicity of advantages , and to meet of study requirements and suitability, the researcher select this type of study design.

3.2.1. Case group (Exposed) :

All workers in the six crushers at Middle Governorate who accomplished criteria, the number of workers is 40, as they worked in gravel crushers and continuously exposed to dust without using any protective devices, the exposed workers were male, their age ranged from 15-65 years, and does not have any past medical history.

3.2.2. Control group (Unexposed) :

The control group contain 47 individuals who live in the same area of case group, their ages ranged from 15-65 years, do not have any past medical history, but not work in the gravel crushers.

3.3. Target population :

The target population of the study is (87) individual . The case (exposed) group is 40, because there are (6) gravel crushers in the Middle governorate, each one of the gravel crushers nearly (7) workers, as they were worked in gravel crushers and continuously exposed to dust without using any protective devices during that, the exposed workers were male, their age ranged from 15-65 years, and does not have any past medical history. In addition to control (unexposed) group that contain 47 individual who lives in the same areas of cases, their ages ranged from 15-65 years, does not have any past medical history, but not work in the gravel crushers.

3.4. Sample size :

All crushers workers in the Middle governorate included in the current study. There are (6) crushers and the total number of workers in is (40). At the same time, The control group was used as a comparison consist of (47) participants, who are not working in gravel crushers, and they matched with age, and had not any past medical history.

3.5. Sitting of the study :

This study was conducted during the period from April till August 2013 in gravel crushers, at Middle Governorate, Gaza Governorates, Palestine. Six crushers distributed on all areas of the Middle governorate. The researcher conducted his study on all crushers and workers in the Middle governorate.

3.5.1. General Details of The Six Crushers

In this section, the researcher will display details about the six crushers which has studied :

1. **<u>Crusher NO.1</u>**

❖ **Basic Details:**

The crusher is located in the western region of Deir El Balah camp in Middle Governorate .

The raw material is rubble of destroyed houses of the war or old houses to be rebuilt. The crusher are in operation for one shift per day, for 7 hours, from 7AM to 2PM, the number of workers in the crusher range between 7 worker, the distance of crusher plant is 23m*45m, an area of the crusher plant is 1035 square meters, comprehensive brickyard. In this way the brickyard and crusher plant located in an area 1035 square meters.

❖ **Process Description:**

The raw material (rubble of destroyed houses of the war or old houses to rebuilt) are come from all over Dier El Balah refugee camp, and moved by dragging carts to the crusher plant.

These raw materials are placed in the crusher by buckets that filled by crusher workers from raw material piles. After raw material crushing, the produced small gravel will be used for the manufacture of bricks in the same place.

- ❖ **Protective Techniques and Suppression Systems:**

This crusher does not use any type of protection techniques for workers or population who are in the neighbored , and does not use any techniques or system to reduce the existing dust and particulate matters.

2. **Crusher NO.2**

- ❖ **Basic Details:**

The crusher is located in the Northern Region of Al Nusairat refugee camp in Middle Governorate .

The raw material is rubble of destroyed houses of the war or old houses to be rebuilt. The crusher are in operation for one shift per day, for 7 hours, from 7AM to 2PM, the number of workers in the crusher range between 6 workers, the distance of crusher plant is 29m*34m, an area of the crusher plant is 986 square meters, comprehensive brickyard. In this way the brickyard and crusher plant located in an area 986 square meters.

- ❖ **Process Description:**

The raw material (rubble of destroyed houses of the war or old houses to rebuilt) are come from all over the Al Nusairat refugee camp and Al Zawaida Village , and moved by dragging carts to the crusher plant.

These raw materials are placed in the crusher by buckets that filled by crusher workers from raw material piles. After raw material crushing, the produced small gravel will be used for the manufacture of bricks in the same place.

- **Protective Techniques and Suppression Systems:**

This crusher does not use any type of protection techniques for workers or population who are in the neighbored , and does not use any techniques or system to reduce the existing dust and particulate matters except spraying water on raw materials during crushing operation, in spite of the use of this technique, the dust and particulate matter comes out significantly.

3. <u>Crusher NO.3</u>

- **Basic Details:**

The crusher is located in the Western Region of Al Maghazi refugee camp in Middle Governorate .

The raw material is rubble of destroyed houses of the war or old houses to be rebuilt. The crusher are in operation for one shift per day, for 7 hours, from 7AM to 2:30 PM, the number of workers in the crusher is 7 workers, the distance of crusher plant is 25m*18m, an area of the crusher plant is 450 square meters.

- **Process Description:**

The raw material (rubble of destroyed houses of the war or old houses to rebuilt) are come from all over the Al Maghazi refugee camp, and moved by dragging carts to the crusher plant.

These raw materials are placed in the crusher by buckets that filled by crusher workers from raw material piles. After raw material crushing, the produced small gravel will be sold to brickyards, to be used for the manufacture of bricks.

- **Protective Techniques and Suppression Systems:**

This crusher does not use any type of protection techniques for workers or population who are in the neighbored , and does not use any techniques or system to reduce the existing dust and particulate matters, for that the dust and particulate matter comes out significantly.

4. Crusher NO.4

- **Basic Details:**

The crusher is located in the western region of Al Braij camp in Middle Governorate .

The raw material is rubble of destroyed houses of the war or old houses to be rebuilt. The crusher are in operation for one shift per day, for 7 hours, from 7AM to 2PM, the number of workers in the crusher range between 7 workers, the distance of crusher plant is 19m*25m, an area of the crusher plant is 475 square meters.

- **Process Description:**

The raw material (Rubble of destroyed houses of the war or old houses to rebuilt) are come from all over Al Braij refugee camp and Al Moghraga Village, and moved by dragging carts to the crusher plant.

These raw materials are placed in the crusher by buckets that filled by crusher workers from raw material piles. After raw material crushing, the produced small gravel will be sold to brickyards, to be used for the manufacture of bricks.

- **Protective Techniques and Suppression Systems:**

This crusher does not use any type of protection techniques for workers or population who are in the neighbored , and does not use any techniques or system to reduce the existing dust and particulate matters, for that the dust and particulate matter comes out significantly.

5. Crusher NO.5

❖ **Basic Details:**

The crusher is located in the Eastern Region of Deir El Balah camp in Middle Governorate .

The raw material is rubble of destroyed houses of the war or old houses to be rebuilt. The crusher are in operation for one shift per day, for 7 hours, from 7AM to 2PM, the number of workers in the crusher is 5 workers, the distance of crusher plant is 25m*36m, an area of the crusher plant is 900 square meters.

❖ **Process Description:**

The raw material (Rubble of destroyed houses of the war or old houses to rebuilt) are come from all over Dier El Balah refugee camp and liberated areas adjacent to the camp, and moved by dragging carts to the crusher plant.

These raw materials are placed in the crusher by buckets that filled by crusher workers from raw material piles. After raw material crushing, the produced small gravel will be sold to brickyards, to be used for the manufacture of bricks.

❖ **Protective Techniques and Suppression Systems:**

This crusher does not use any type of protection techniques for workers or population who are in the neighbored , and does not use any techniques or system to reduce the existing dust and particulate matters, for that the dust and particulate matter comes out significantly.

6. Crusher NO.6

❖ **Basic Details:**

The crusher is located in the Eastern Region of Al Zawaida Village in Middle Governorate .

The raw material is rubble of destroyed houses of the war or old houses to be rebuilt. The crusher are in operation for one shift per day, for 7 hours, from

7AM to 2PM, the number of workers in the crusher range between 7-8 workers, the distance of crusher plant is 37m*31m, an area of the crusher plant is 1147 square meters. In this way the brickyard and crusher plant located in an area 1147 square meters.

- **Process Description:**

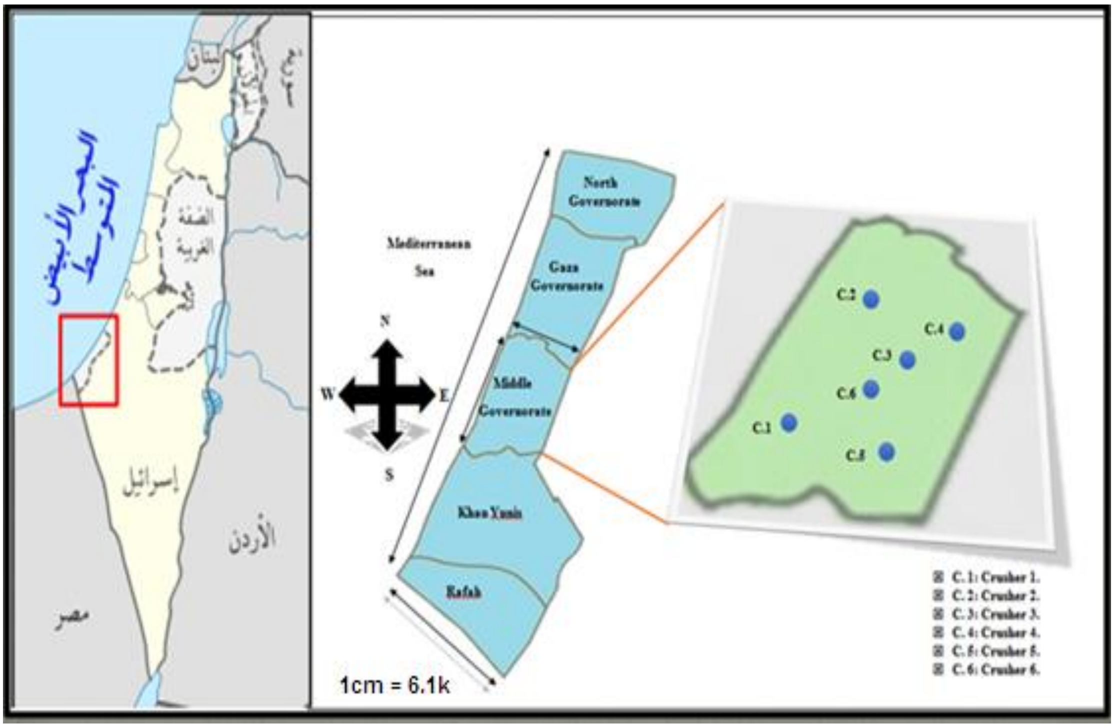
The raw material (Rubble of destroyed houses of the war or old houses to rebuilt) come from all over Al Zawaida Village, and moved by dragging carts to the crusher plant.

These raw materials are placed in the crusher by buckets that filled by crusher workers from raw material piles. After raw material crushing, the produced small gravel will be used for the manufacture of bricks in the same place.

- **Protective Techniques and Suppression Systems:**

This crusher does not use any type of protection techniques for workers or population who are in the neighbored , and does not use any techniques or system to reduce the existing dust and particulate matters, for that the dust and particulate matter comes out significantly.

(Figure 3.1) : Pictures of some crushers in Middle Governorate.



(Figure 3.2) : The geographical distribution of crushers in Middle Governorate.

3.6.Data collection:

Data was collected in April and May, 2013. By using structured questionnaire in a face-to-face interview, blood sample, vital signs from each individual and measuring PM10 in each gravel crusher plant.

Detailed information about the study was given to the individuals, Both verbal and written consent was obtained from each individual included in the study.

3.7.Instruments :

Every person included in the study was submitted to the following procedures:

3.7.1. Questionnaire :

Saunders, Lewis and Thornhill (2007), maintain that a questionnaire is the best method of collecting data especially if the survey strategy is used.

Each worker fill out the questionnaire with the researcher, ,

It included the following:

- **A.** Section 1: Personal data (age, birth date, qualification, marital status, number of children, if any).
- **B.** Section 2: Detailed occupational history of the present occupation(exposure to dust and duration), also the previous occupation (exposure and duration).
- **C.** Section 3: Life style and Smoking habits (type, number per day and duration…ect.).
- **D.** Section 4: Respiratory symptoms (cough, haemoptysis, sputum color and odor, dyspnea, wheeze …ect.).
- **E.** Section 5: Past history of hypertension, pulmonary tuberculosis, heart diseases, diabetes .
- **F.** Section 6: Vital signs values that have been measured for each individual, which includes (blood pressure, pulse rate, temperature, and respiration rate).
- **G.** Section 7: Complete blood count values highlighted by the researcher, which include (Red blood cells, white blood cells, hemoglobin).

3.7.2. Vital signs

For over 100 years, medical staff have performed this surveillance using the same vital signs: blood pressure, heart rate, respiratory rate, and temperature (Ahrens, 2008). Vital signs might provide surveillance for changes in their condition, recognizing early clinical deterioration and protection from harm or errors (Rogers *et al*, 2008).

Blood pressure (BP) refers to the pressure exerted by blood against the arterial wall. It is influenced by cardiac output, peripheral vascular resistance, blood volume and viscosity and vessel wall elasticity (Fetzer, 2006).

Pulse is defined as the palpable rhythmic expansion of an artery produced by the increased volume of blood pushed into the vessel by the contraction and relaxation of the heart (Piper, 2008).

Respiratory rate is an important baseline observation and its accurate measurement is a fundamental part of assessment (Jevon, 2010).

Temperature of the human body's represents the balance between heat produced and heat lost, body temperature may be affected by factors such as underlying pathophysiology (e.g. sepsis), or skin exposure (Frommelt *et al*, 2008).

For these reasons, the researcher measured the vital signs (blood pressure, pulse rate, respiratory rate, and temperature) of all individuals who participated in the study.

3.7.3. Complete Blood Count (CBC):

A complete blood count (CBC) is a blood test used to evaluate your overall health and detect a wide range of disorders, including anemia, infection and leukemia.

A complete blood count test measures several components and features of your blood, including:

- Red blood cells, which carry oxygen.
- White blood cells, which fight infection.
- Hemoglobin, the oxygen-carrying protein in red blood cells.
- Hematocrit, the proportion of red blood cells to the fluid. component, or plasma, in your blood.
- Platelets, which help with blood clotting.

Abnormal increases or decreases in cell counts as revealed in a complete blood count may indicate that you have an underlying medical condition that calls for further evaluation (Mayo Foundation for Medical Education and Research, 2011).

Blood sample was withdrawn from each individual participant in the study by the researcher, complete blood count was conducted, the researcher focused on research-related values, which include (red blood cells, white blood cells and hemoglobin).

3.8. Techniques .

Including that the researcher measured the concentration of PM_{10} during crushers work, and examined the respiratory health effects resulted from their work in the crushers.

Therefore, the researcher used the following techniques and equipments:

3.8.1. Laboratory techniques .

3.8.1.1. Complete blood count principles

After withdrawing blood sample, Complete blood count performed by an automated analyzer that counts the numbers and types of different cells within the blood. It aspirates a very small amount of the sample through the narrow tubing. Within this tubing, there are sensors that count the number of cells going through it, and can identify the type of cell; this is called flow-cytometry. For detection light detectors are used as well as the measurement of electrical impedance. One way the instrument can tell what type of blood cell is present is by size. Other instruments measure different characteristics of the cells to categorize them.

3.8.2. Field techniques .

The researcher measured the concentration of PM_{10} during crusher work time, and the researcher used the device for measuring PM_{10} borrowed from the Islamic University.

PM10 concentrations monitoring was conducted using two sets of particulate matter samplers, one placed at the upwind location and the other on the downwind direction during the operation of the crusher.

The downwind particulate matter sampler was located at appropriate locations covering emission from all the sources of particulate matter generation. So two results (upwind and downwind) was documented for each crusher.

The upwind side particulate matter is so located that it gives the background concentration, which is due to the particulate matter from other sources i.e. mounds of crushed stones, mixing cement with gravel machines and brick manufacturing machines.

The downwind side particulate matter sampler measures PM_{10} emission from the crusher plant under the study as well as the other sources .

The difference between downwind and upwind concentration gives the concentration actually contributed by virtue of operation of the stone crushing plant.

(Downwind reading) -(Upwind reading) = (Contribution by the unit).

3.8.3. Laboratory Equipment .

A hematology analyzer:

A hematology analyzer is an instrument used to perform a complete blood count (CBC or FBC). It carries out quantitative and qualitative analyses of red and white blood cells and of platelets (erythrocytes, leukocytes and thrombocytes).

These devices are primarily used to diagnose anemia, leukemia, thromboses and other problems linked to a change in blood constants. They are found in medical laboratories and in hospital hematology services. Certain models are for veterinary use.

The advantages of hematology analyzer are rapid analyses and improved accuracy. The disadvantage are expensive, high maintenance need and require calibration.

3.8.4. Field Equipment .

PM_{10} measuring device:

The Model HAL-HPC300 handheld optical particle counter used to measure the concentration of PM_{10} in the air, its utilizes the laser technology for single particle detection. The scattering of light from the particles in the sampling air steam is converted into electrical pulses, which is then measured and calculated as a particle size. The HAL-HPC300 consists of a handheld set with a main base unit that allows users to conduct the sampling around with a handheld set while easily expanding to multiple functionalities with a base unit. These extended functions include data downloading, data real-time printing, software upgrading, and battery charging, etc.

3.9. Inclusions and Exclusion criteria .

3.9.1 Inclusions criteria:

According to Rees (1997), inclusion criteria are “the characteristics we want those in our sample to possess”.

Included people are People who work in crushers at middle governorate , and the ages of 15-65, and have no medical history .

3.9.2 Exclusion criteria:

Rees (1997), defines exclusion criteria as “characteristics، which a participant may possess, that could adversely affect the accuracy of the results”.

Excluded people are People who do not work in the middle governorate , and who are under the age of 15 years or more than 65, and have past history.

Note

The control group was selected according the inclusion criteria, except they did not work in gravel crushers .

3.10. Ethical Considerations.

Permission Approval took from each worker before starting the study, and they signed a consent form that they agree to participate in the study.

3.11. Informed Consent.

Informed consent is “a legal requirement before one can participate in a study” (Ethical principles and guidelines for the protection of human subjects of research report, 2004). After a full explanation of the nature of the study, participants were asked to give either verbal consent for those who could not read or written consent of their willingness to participate in the study.

3.12. Avoiding Harm

Avoiding harm is another basic human right to be considered when conducting research on human beings. According Ethical principles and guidelines for the protection of human subjects of research report (2004), risks that may be encountered in research include physical, psychological, emotional, social and financial ones. In this study, psychological harm through periods of long waiting and maintaining confidentiality. The researcher minimized the time of interviewing the participants. Maintaining privacy, confidentiality and anonymity during the interview also prevented psychological harm.

3.13. Statistical Tools and Data Analysis.

Data analysis is “the systematic organization and synthesis of the research data and the testing of research hypotheses, using those data” (Polit & Hungler, 1995).

Data checked, coded, entered and analyzed using SPSS 20 (The Statistical Package for Social Sciences 20) software, with the 0.05 significance level.

The researcher used both qualitative and quantitative data analysis methods.

The Data analysis was made utilizing SPSS 20, . The researcher would utilize the following statistical tools:

1) Frequency .

2) Descriptive analysis (means and standard deviation "S.D").

3) Tabular and Graphical display.

4) Independent Samples T-test.

5) Analysis of Variance " ANOVA".

Chapter 4

Results

This chapter presents the results and interpretations from the data gathered by the researcher, statistical treatment, , data analysis.

4.1. Introduction

The general objective of this study is to evaluate the level of PM10 air pollution in crushers plants, and their impacts on respiratory system health, vital signs and complete blood count for crusher workers.

The target population of the study is (87) individual . The case (exposed) group is 40, and control (unexposed) group contains 47. The included people who work in crushers at Middle Governorate , and the ages of 15-65, and have no medical history, while excluded who do not work in the Middle Governorate , and who are under the age of 15 years or more than 65, and have past medical history.

This case-control study was conducted during the period from April - August 2013 in gravel crushers, at Middle Governorate, Southern governorates, Palestine.

This study conducted on all crushers and workers in the Middle Governorate which has six crushers distributed on all areas .

4.2. PM_{10} Air Pollution Monitoring Data for The Six Crushers.

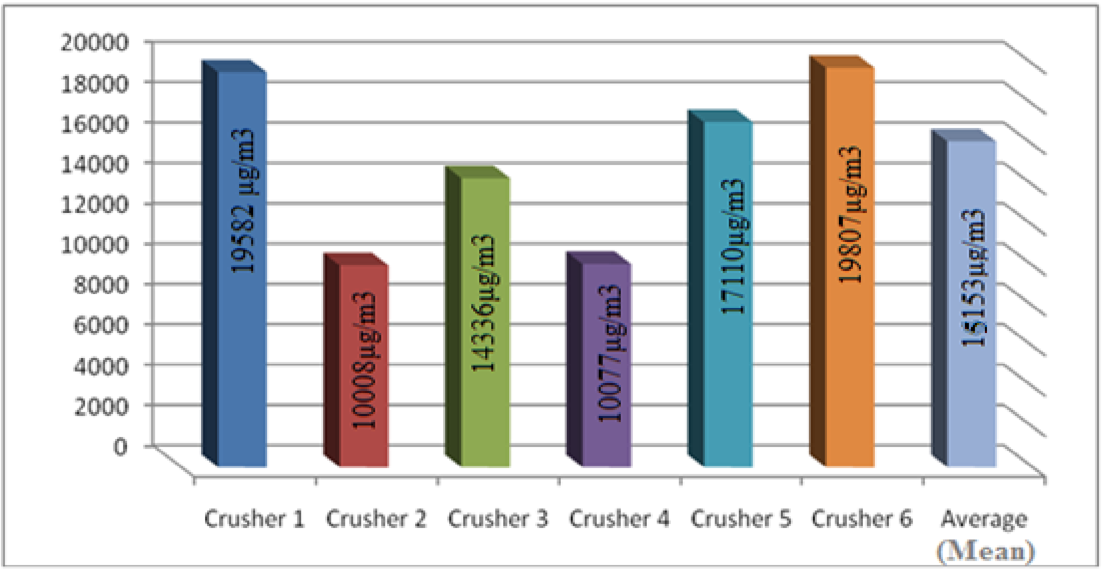


Figure (4.1): Concentrations of PM10 that emitted from six crushers and the average of these concentrations.

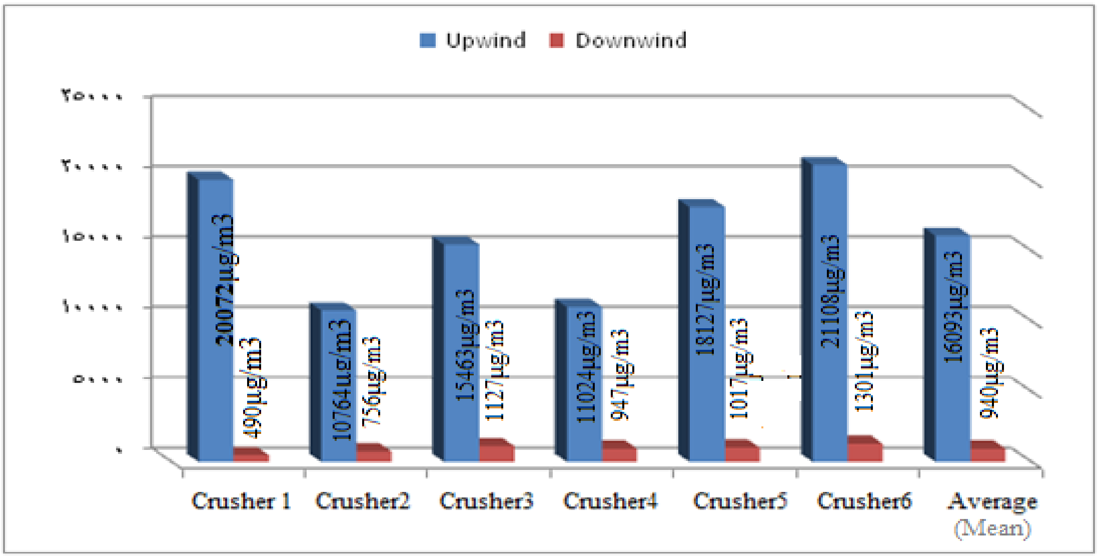


Figure (4.2): Upwind and downwind concentrations of PM_{10} that emitted from six crushers and the average of these concentrations.

As shown in Fig (4.1) and (4.2) reveals that the emission of PM_{10} by the crushers varies widely from 10008 to 19807 µg/m3, with an average particulate matter contribution of 15153 µg/m3, which is about more than 100 times higher than the particulate matter (PM_{10}) existing daily average standard of 150 µg/m3 (EPA, 2012).

4.3. Results of Vital Signs (Systolic and diastolic blood pressure, Pulse rate, Respiratory rate and Temperature) between (40) case group and (47) control group.

Table (4.1) shows the results of independent samples T-test for vital signs (systolic blood pressure, diastolic blood pressure, pulse rate, respiratory rate, and temperature) between (40) cases and (47) controls .

Vital Signs	Groups	N	Mean	SD	T-Test value	P-value
Systolic Blood Pressure	case group	40	131.93	6.48	9.708	0.000
	control group	47	117.65	7.13		
Diastolic Blood Pressure	case group	40	80.38	5.25	6.176	0.000
	control group	47	73.51	5.10		
Pulse Rate	case group	40	84.70	6.65	8.834	0.000
	control group	47	75.21	2.93		
Respiratory Rate	case group	40	23.90	2.01	7.674	0.000
	control group	47	20.74	1.82		
Temperature	case group	40	37.02	0.36	8.091	0.000
	control group	47	36.42	0.33		

4.3.1. Blood Pressure (BP).

4.3.1.1. Systolic Blood Pressure (SBP)

As shown in table (4.1) the mean of Systolic Blood Pressure for case and control group is (131.93, with SD of 6.48) and (117.65, with SD of 7.13), respectively. The value of the T-test equals 9.708, with p-value equals 0.000. This implies that there is an evidence to conclude that mean of Systolic Blood Pressure is significantly different between the two groups. Since the sign of the T-test is positive, then mean of *SBP* for case group is significantly greater than control group.

4.3.1.2. Diastolic Blood Pressure (DBP)

The mean of Diastolic Blood Pressure for case and control group is (80.38, with SD of 5.25) and (73.51, with SD of 5.10), respectively. The value of the T-test equals 6.176, with p-value equals 0.000. This reveal that there is an evidence to conclude that mean of DBP is significantly different between the two groups. Since the sign of the T-test is positive, then mean of DBP for case group is significantly greater than control group.

4.3.2. Pulse Rate (PR)

The mean of Pulse Rate for case and control group is (84.70, with SD of 6.65) and (75.21, with SD of 2.93), respectively . The value of the T-test equals 8.834, with p-value equals 0.000. This implies that there is sufficient evidence to conclude that mean of PR is significantly different between the two groups. Since the sign of the T-test is positive, then mean of PR for case group is significantly greater than control group.

4.3.3. Respiratory Rate (RR)

The mean of Respiratory Rate for case and control group is (23.90, with SD of 2.01) and (20.74, with SD of 1.82), respectively. The value of the T-test equals 7.674, with p-value equals 0.000. This mean that there is an evidence to conclude that mean of RR is significantly different between the two groups. Since the sign of the T-test is positive, then mean of RR for case group is significantly greater than control group.

4.3.4. Temperature (T)

The mean of Temperature for case and control group is (37.02, with SD of 0.36) and (36.42, with SD of 0.33), respectively. The value of the T-test equals 8.091, with p-value equals 0.000. This reveal that there is an evidence to conclude that mean of Temperature is significantly different between the two groups. Since the sign of the T-test is positive, then mean of Temperature for case group is significantly greater than control group.

4.4. Results of Complete blood counts results between (40) case group and (47) control group.

Table (4.2) shows the result of independent samples T-test for Complete blood counts results between (40) case group and (47) control group.

Complete blood counts results	Groups	N	Mean	SD	T-Test value	P-value
RBCS	case group	40	5.04	0.51	-1.260	0.211
	control group	47	5.17	0.44		
WBCS	case group	40	8.67	1.24	6.975	0.000
	control group	47	7.22	0.64		
HGB	case group	40	14.75	0.92	-1.170	0.245
	control group	47	14.97	0.81		

4.4.1. Red Blood Cells (RBCs)

The mean of RBCs for case and control group is (5.04, with SD of 0.51) and (5.17, with SD of 0.44), respectively. The value of the T-test equals -1.260, with p-value equals 0.211. This means that there is sufficient evidence to conclude that mean of RBCs is insignificantly different between the two groups. In other words, there is insignificant difference in the mean RBCs between case and control group.

4.4.2. White Blood Cells (WBCs)

The mean of WBCs for case and control group is (8.67, with SD of 1.24) and (7.22, with SD of 0.64), respectively. The value of the T-test equals 6.975, with p-value equals 0.000. This reveal that there is an evidence to conclude that mean of WBCs is significantly different between the two groups. Since the sign of the T-test is positive, then mean of WBCs for case group is significantly greater than control group.

4.4.3. Hemoglobin (HGB)

The mean of HGB for case and control group is (14.75, with SD of 0.92) and (14.97, with SD of 0.81), respectively. The value of the T-test equals -1.170, with p-value equals 0.245. This implies that there is sufficient evidence to conclude that mean of HGB is insignificantly different between the two groups. In other words, there is insignificant difference in the mean HGB between case group and control group.

4.5. The relationship between PM10 air pollution and vital signs disturbance :

Table (4.3): ANOVA test of Vital Signs and their p-values.

Group	Vital Signs	Test Value	Significance
Case	Systolic Blood Pressure	6.689	0.000
	Diastolic Blood Pressure	5.447	0.001
	Pulse Rate	17.161	0.000
	Respiratory Rate	5.712	0.001
	Temperature	3.709	0.009
Control	Systolic Blood Pressure	1.094	0.378
	Diastolic Blood Pressure	0.262	0.931
	Pulse Rate	1.014	0.384
	Respiratory Rate	0.431	0.726
	Temperature	0.427	0.827

4.5.1. For case group:

Table (4.3) shows that the p-value (Significance) is smaller than the level of significance $\alpha = 0.05$ for all Vital Signs " SBP, DBP, PR, RR and T ". It can be conclude as there is significant relationship between PM10 air pollution and vital signs.

4.5.2. For control group:

Table (4.3) shows that the p-value is greater than the level of significance $\alpha = 0.05$ for " SBP, DBP, PR, RR and T ". It can be conclude as there is insignificant relationship between PM10 air pollution and vital signs.

4.6. The relationship between exposure of PM10 air pollution and appearance of respiratory system symptoms:

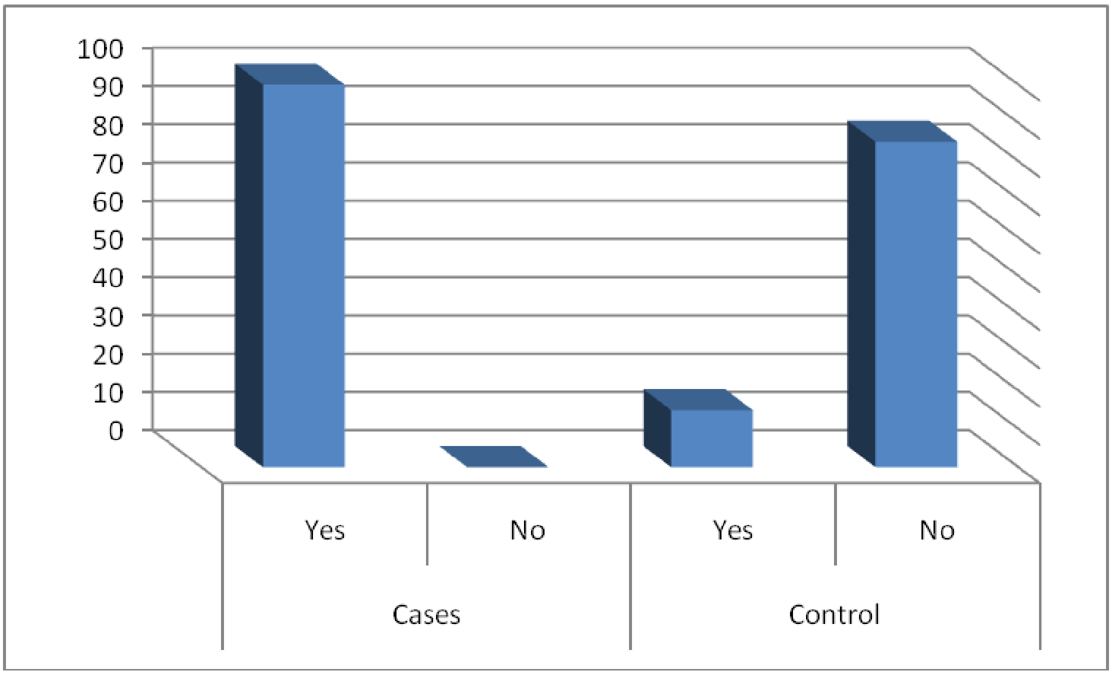


Figure (4.3) : The percentage of cough among cases and control .

The results in Figure (4.3) shows that all members of the case group suffer from cough, but 85.1% of the control group do not suffer from cough and the rest of the same group (14.9 %) suffer from cough.

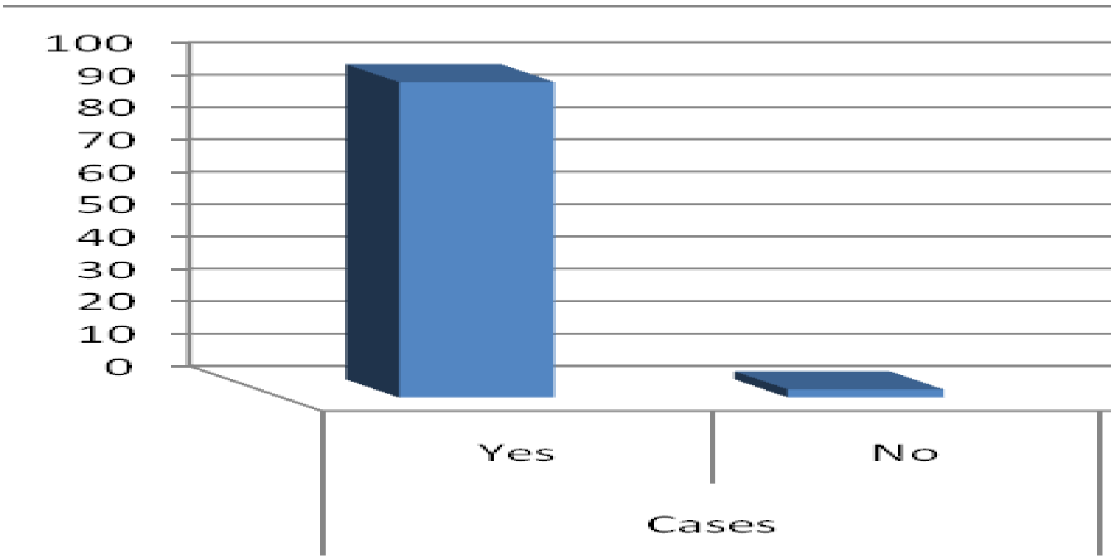


Figure (4.4): Percentage of cough aggravation for cases during PM10 air pollution exposure at work.

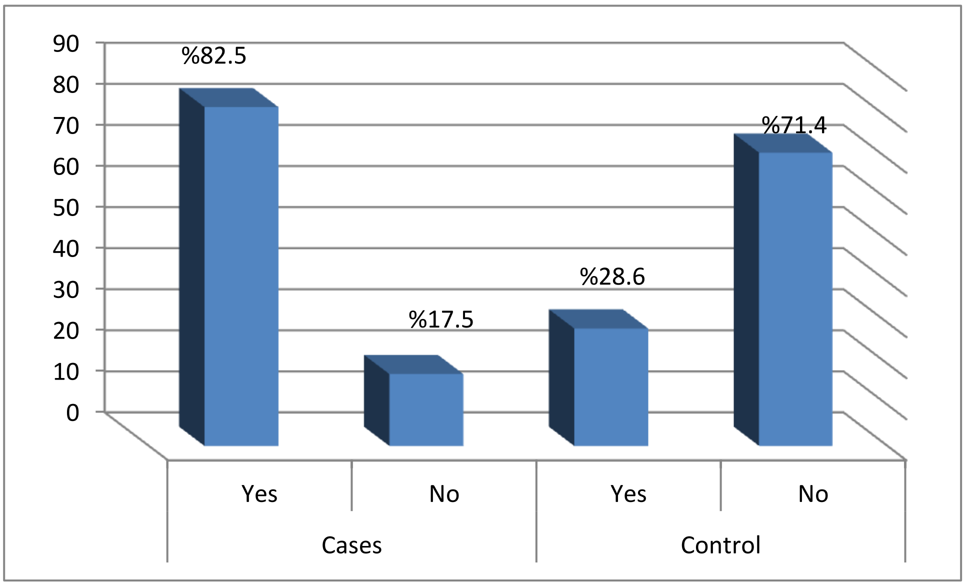


Figure (4.5) : The presence percentage of sputum buildup among groups.

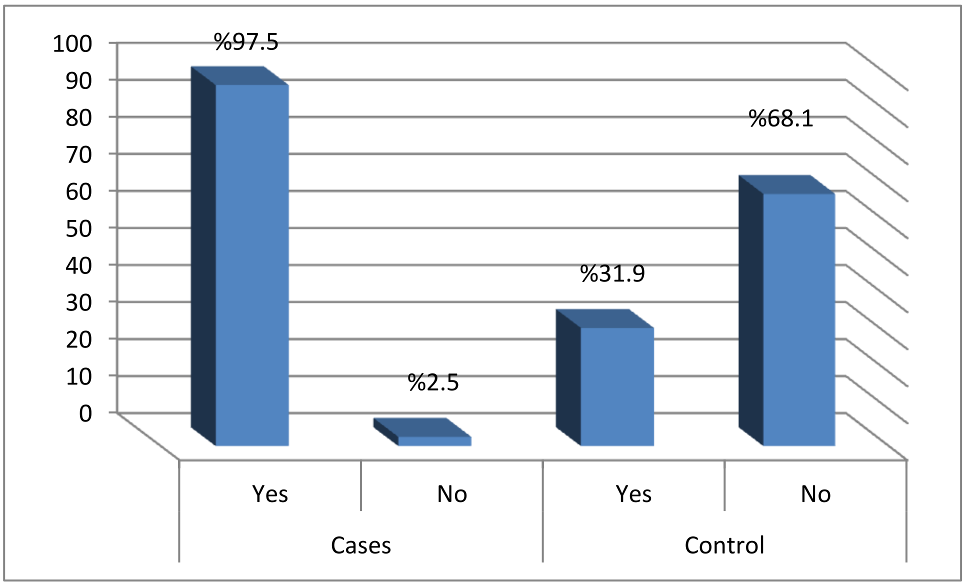


Figure (4.6) : The presence percentage of dyspnea among groups.

Figure (4.4) shows the percentage of cough aggravation for exposed cases during PM10 air pollution exposure at work place. Where it shows that 97.5% of the case group suffer from aggravated coughing during exposure to PM10 concentration at work. Furthermore, 82.5% of cases have sputum buildup, and 97.5% of cases have dyspnea as shown in figures (4.5)and(4.6).

It can be conclude as there is significant relationship between PM10 air pollution and appearance of respiratory system symptoms.

4.7. The relationship between PM10 air pollution and complete blood count :

Table (4.4): ANOVA test of complete blood counts and their p-values.

Group	Complete blood counts	T-Test Value	Significance
Case	RBCs	0.958	0.457
	WBCs	5.954	0.000
	HGB	0.624	0.682
Control	RBCs	1.038	0.408
	WBCs	0.985	0.439
	HGB	1.555	0.194

4.7.1. For case group:

Table (4.4) shows that the p-value is greater than the level of significance α = 0.05 for "RBCs" . It can be conclude as there is insignificant relationship between PM10 air pollution and "RBCs".

Table (4.4) shows that the p-value is greater than the level of significance α = 0.05 for "HGB" . It can be conclude as there is insignificant relationship between PM10 air pollution and " HGB".

Table (4.4) shows that the p-value is smaller than the level of significance α = 0.05 for " WBCs ". It can be conclude as there is significant relationship between PM10 air pollution and " WBCs".

4.7.2. For control group:

Table (4.4) shows that the p-value is greater than the level of significance α = 0.05 for all complete blood counts. It can be conclude as there is insignificant relationships between PM10 air pollution and complete blood counts.

4.8. Age of cases and control group:

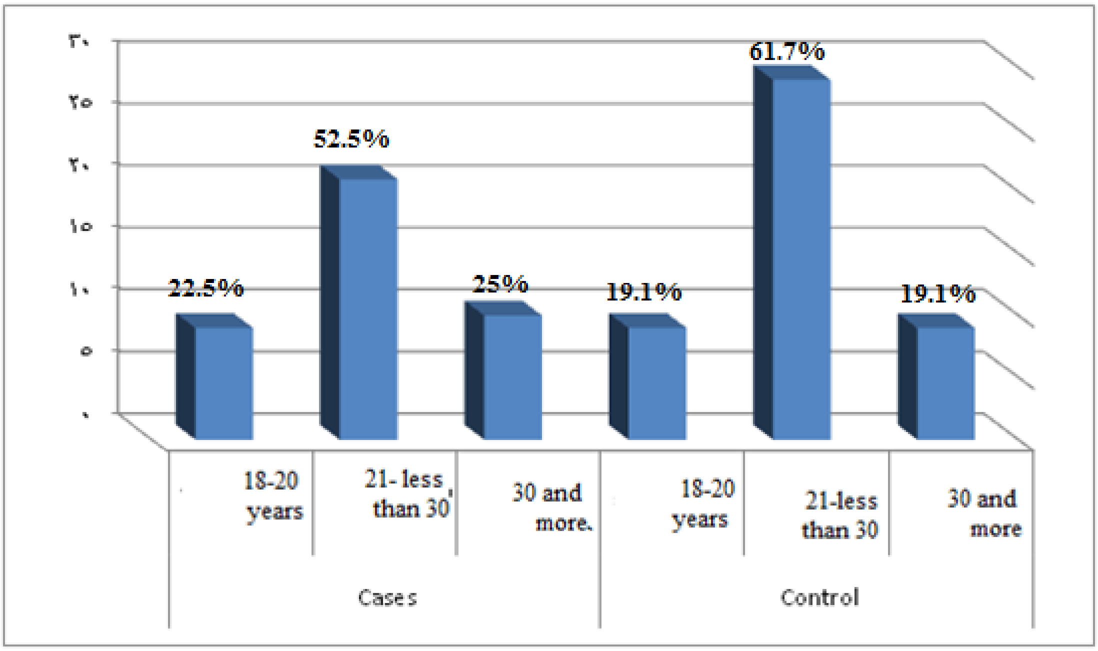


Figure (4.7) : Age of cases and control groups.

The results in Figure (4.7) show the percentage of ages for both cases and control groups. Furthermore, it shows the elevated level of ages rapprochement between the two groups, which increase the accuracy of the study .

Chapter 5

Discussion

5.1. Introduction

This case-control study was conducted during the period from April till August 2013 in gravel crushers, at Middle Governorate, Southern governorates, Palestine.

The general objective of this study is to evaluate the level of PM_{10} air pollution in crushers plants, and their impacts on respiratory system health on workers. As well as, the specific objectives of this study is to measure the concentrations of PM_{10} in the work place, to identify the relationship between PM_{10} air pollution and vital signs disturbance, to identify the relationship between exposure of PM10 air pollution and appearance of respiratory system symptoms, and to identify the relationship between PM_{10} air pollution and complete blood count .

5.2. PM10 air pollution monitoring in the six crushers:

PM10 emission monitoring was carried out in six crusher plants with an objectives to generate information on the existing level of the PM_{10} emissions from uncontrolled crushing operations, which could form a baseline data for future comparison after incorporation of the controlled protective measures.

Data in table (4.1), reveals that the emission of PM_{10} by the crushers varies widely from 10008 to 19807 μg/m3, with an average PM_{10} contribution of 15153 μg/m3, which is about more than 100 times higher than the (PM_{10}) existing standard of 150 μg/m3 (EPA, 2012). This is primarily due to inoperative suppression system and inadequate control.

Figure (4.1) shows the concentrations of PM_{10} that emitted from six crushers and the average of these concentrations. The high PM_{10} concentrations in crusher plants (1 and 6) is primarily contributed by the large size of these crushers, and due to mounds of rubble and crushed stone in the vicinity of crushers, and height of the two crushers from the surface of the earth greater than others, which generate more dust and emission. These high concentrations call for stricter measures to be enforced on stone crushers. Control and suppression systems should be applied for all crushers, if dry type control and suppression systems, which adopted widely in crushers in developed countries are not accepted due to the high price and not available, while wet suppression systems have low price, available and can be used such as water spray.

5.3. The relationship between exposure of PM_{10} air pollution and appearance of respiratory system symptoms:

Positive significant relationship is observed between PM_{10} air pollution exposure and appearance of respiratory system symptom (cough, sputum build-up and dyspnea).

The results shown that all members of the case group suffer from cough, but 85.1% of the control group do not suffer from cough and the rest of the same group (14.9 %) suffer from cough.

The results shown the percentage of cough aggravation for exposed cases during PM10 air pollution exposure at work. Where it shows that 97.5% of the case group suffer from aggravated coughing during exposure to PM_{10} air pollution at work. Furthermore, 82.5% of case group have sputum buildup, and 97.5% of case group have dyspnea, respectively.

The distribution of respiratory system symptoms were statistically significant among case group (exposed) compared to the control group (non exposed) for cough, sputum buildup and dyspnea .

These results of higher prevalence of respiratory symptoms among the cases (exposed) than control (non exposed) are in agreement with data reported by (Oleru, 1984; Yang *et al.,* 1996, Noor *et al.,* 2002; Al- Neaimi *et al.,* 2001). found a higher prevalence of the cases with cough, sputum build up and dyspnea than control. This difference was significantly related to PM_{10} air pollution exposure.

Also, Nitta *et al.* (1993) find that cough, expectoration, rhinitis, chronic bronchitis and dyspnea were significantly more common in exposed than non-exposed to PM10 air pollution.

The statistical strength of these relationships are in line with review paper carried out by Pop *et al.* (1995) where several studies worldwide were reviewed, and observed increases in selected health symptoms similar to those monitored in this study, occurred as result of PM_{10} air pollution exposure .

Pop *et al.* (1997) established that a 10 μg/m3 increase in PM_{10} in most studies are typically associated with 1-10% increase in symptoms such as cough, sputum build up, and combined lower respiratory symptoms such as wheezing and breathing problems.

Indeed, findings with similar statistical strength to the relationships found in this study were made by Zemap (2004) on association between PM_{10} air pollution exposure and respiratory symptoms among general population sample of 9651 people living in eight different study sites within Switzerland.

Such close comparison with other few studies are limited because of different definitions of health symptoms and conditions, and differences in exposure assessment.

Moreover, results of this study are also in line with those in studies conducted in different geographic regions of the United States and Europe on sample of the general population.

Van *et al.* (1997) found an association between chronic coughing and dyspnea and exposure to PM_{10} in cohort study of 3914 people in California. Brown M., (2009) find associated higher risks of coughing and throat irritation and sputum build up with exposure to PM_{10} in population of 6000 Reefton, New Zealand.

Further, in a study conducted in 20 areas located in six French cities, association were found between PM_{10} air pollution exposure and the prevalence of lower and upper respiratory symptoms across all ages of the general population (Zemap, 2004).

In summary, our results and findings are consistent with the results of studies that have mentioned and other, which showed positive and significant relationship between exposure of PM_{10} air pollution and appearance of respiratory system symptom (cough, sputum build-up and dyspnea).

5.4. The relationship between PM_{10} air pollution and vital signs disturbance:

5.4.1. Blood pressure:

Positive significant relationship is observed between PM_{10} air pollution exposure and vital signs disturbance (BP, PR, RR, T).

The significant relationship between PM10 air pollution and increasing blood pressure consistent with Zannobetti et al (2001) study results which showed increase in systolic as well as diastolic blood pressure with elevated concentrations of ambient particle pollution.

An increase of sympathetic tone in association with particulate air pollution and/or the modulation of basal systemic vascular tone due to increased concentrations of endothelin associated with particulate air pollution were suggested as potential mechanisms for this increase in blood pressure (Iblad-Mulli *et al*., 2003).

In consistent, Hooven (2011) observed significant associations for PM_{10} air pollution exposure and elevated systolic and diastolic blood pressure.

Indeed, number of previous studies reported increases in systolic and diastolic blood pressure following exposure to PM_{10} air pollution (Chuang, 2011 and Kim, 2010).

Furthermore, Auchincloss A. et al. (2008) which conducted among 5112 adults exposed long term for particulate air pollution, and reported stronger associations for PM_{10} air pollution with systolic and diastolic blood pressure elevation.

In the present study, it was found that systolic and diastolic blood pressure were increased significantly with exposure to PM_{10}.

However, Gong et al. (2004) study conducted by a group from the university of Southern California, a decrease in systolic and diastolic blood pressure after exposure to concentrated air particles was reported, these findings cannot be explained by the underlying mechanisms that were suggested in previous studies. But may be due to the different size of particulate matter and different target groups, where they examined the impact of $PM_{2.5}$ for patients with asthma.

In summary, our findings are consistent with the results of studies that have been mentioned, which show positive and significant relationship between PM10 air pollution exposure and increasing blood pressure.

5.4.2. Pulse rate

Positive significant relationship is observed between PM_{10} air pollution and increasing pulse rate.

These findings are in line with results of a study which conducted by Peters et al. (1999) that indicated an increase in pulse rate in association with PM_{10} air pollution exposure was observed during an air pollution episode in Germany.

Consistent previous studies have reported significant association between PM_{10} air pollution exposure and increasing pulse rate (Gold *et al.*, 2000).

In consistent, Magari *et al.,* (2001) observed association between PM_{10} air pollution and increasing pulse rate for construction workers in Delhi, India.

Furthermore, a previous study that used 24 hr electrocardiogram monitoring was also conducted along the Wastch Front in Utah estimated that 100 μg/m3 increase in PM_{10} was associated with increasing pulse rate.

The physiologic importance of these observed changes in pulse rate is not fully understood yet, there is growing recognition to be more clearly and understood .

In the present study, it observed significant relationship between PM_{10} air pollution and increase pulse rate. The fact that small but statistically significant association were observed, suggest that PM_{10} air pollution may be one of multiple factors that influence pulse rate.

5.4.3. Respiratory rate and temperature

This study show positive and significant relationship between PM_{10} air pollution exposure and (increasing respiratory rate and temperature).

Particulate matter deposited in the airways can cause epithelial barrier disruption via oxidative and toxic compounds imported on their surface (Costa and Dreher, 1997; Gilmour et al., 1996; Vinzents et al., 2005).

Increased permeability facilitates further the penetration of macromolecules and particulate matter into the epithelium tissue and circulation (Chuang *et al.*, 2007).

Inflammation, a mechanism that lies behind several pulmonary and extra-pulmonary diseases, can be induced by the oxidative stress following particulate exposure (Brook *et al.*, 2004; Delfino *et al.*, 2005).

Systemic inflammation in the lungs and airways lead to deterioration of lung function and appearance of respiratory inflammation symptoms and it possibly increases the risk of chronic pulmonary disease, cardiovascular disease and several neurological and skeletal defects (Agusti, 2005) .

In the present study, it observed significant relationship between PM_{10} air pollution and (increasing respiratory rate and temperature), both are symptoms of respiratory system inflammation.

These findings are in line with Herman (2006) and Sholf (2012) study which observed significant relationship between respiratory inflammation symptoms (increasing respiratory rate and increasing temperature) and exposure of PM_{10} air pollution.

In consistent, Baston (2009) study observed significant association between PM_{10} air pollution exposure and tachypnea (increasing respiratory rate) for workers of cutting rocks.

Furthermore, Lose *et al.* (2005) demonstrated respiratory inflammation symptoms (increasing respiratory rate and increasing temperature) for PM_{10} air pollution exposed individuals, suggesting that the exposure of PM_{10} air pollution considered to be one of the main reasons for appearance of respiratory inflammation symptoms.

In contrast, Jones (2002) observed insignificant association between PM_{10} exposure and (respiratory rate and temperature), may be due to different methodology used by the author, and different target groups.

In the present study, it observed statistical significant association between PM_{10} air pollution exposure and (increasing respiratory rate and temperature). These results are consistent with the results of related previous studies .

5.5. The relationship between PM10 air pollution and complete blood count :

Positive relationship is observed between PM_{10} air pollution and increasing white blood cells (WBCs) (leukocytosis) in this study. The statistical strength of relationship between PM_{10} air pollution exposure and increasing WBCs is in line with the study conducted by Tan *et al.* (1997) have demonstrated leukocytosis in young military recruits exposed to an acute episode of particles air pollution during forest fires of south east Asia in the summer of 1997, suggesting that an episode of acute exposure to PM_{10} air pollution causes bone marrow stimulation in humans.

Furthermore, Van and Tem (2004) which showed that an acute exposure of PM_{10} air pollution causes leukocytosis in humans and proinflammatory cytokines in the blood collect in the south east Asia.

This is supported by other independent longitudinal studies linking elevation of the peripheral blood count to increase mortality during exposure of PM_{10} air pollution.

In consistent, Wells *et al.* (2009) have shown that an increase in leukocyte count is predictor of total mortality, independent of smoking in large population-based studies.

Examination Survey in the United States, conducted among adults aged 20-89 years, which showed significant association between WBC count and estimated local PM_{10} levels during 1 year (Chen *et al.*, 2008).

Also, our findings are consistent with animal experiments showing an increase release of WBCs and their precursors from the bone marrow in response to the deposition of particles in the lungs.

These findings suggest that inflammatory mediators released from lung are capable of irritating not only a local inflammatory response, but also a systematic response when PM_{10} are deposited in the lungs, resulting in leuocytosis.

In the present study, it observed significant relationship between PM_{10} air pollution and increasing WBCs, these results are consistent with physiologic and related studies results.

Insignificant relationship are observed between PM_{10} air pollution and hemoglobin and red blood cells.

A cross-over study among 29 participants with or without biking exercise and exposed to particulate air pollutants did not find any significant association of particulate air pollutants with hemoglobin, RBC and platelet count and markers of inflammation in healthy adolescents and childs (Abasgholi A., 2010).

The associations of particulate air pollutants with hematologic parameters are consistent with the chronic effects of air pollutants on hematological factors (Bahaoddini *et al.*, 2004).

In the present study, it shows insignificant relationship due to the short duration of exposure to PM_{10} for target groups (1-3) years compared with appearance of significant impact on hemoglobin and red blood cells, which need long term period to appear clearly.

In summary, our findings are consistent with the results of studies that have mentioned and other, which showed positive and significant relationship between exposure of PM_{10} air pollution and increasing white blood cells (leukocytosis).

Chapter 6

Conclusions and Recommendations

6.1. Conclusion

This study was conducted during the period from April till August 2013 in gravel crushers, at Middle Governorate, Southern governorates, Palestine.

It was conducted to evaluate the level of particulate matter air pollution in crushers plants, and their impacts on respiratory system health for crusher workers in the six crushers distributed on all areas of the Middle Governorate.

The target population of the study is (87) individual . The case group (exposed) is 40, because there are (6) gravel crushers in the Middle governorate, each one of the gravel crushers nearly have (7) workers, as they worked in gravel crushers and continuously exposed to dust without using any protective devices during that, the exposed workers were male, their age ranged from 15-65 years, and does not have any past medical history. In addition, a control (unexposed) group that contain 47 individuals who live in the same areas of cases was studied, their ages ranged from 15-65 years, does not have any past medical history, but not working in the gravel crushers.

Both groups were subjected to questionnaire on respiratory system symptoms, complete blood counts, and vital signs.

From the results, it can be concluded as:

1. The particulate matter that emitted from the crushers varies widely from 10008 to 19807 µg/m3, with an average particulate matter contribution of 15153 µg/m3, which is about more than 100 times higher than the particulate matter (PM_{10}) existing standard.

2. Respiratory tract symptoms reported in this study among the exposed workers to PM_{10} air pollution were cough, sputum build-up and dyspnea.

These symptoms were found to be related to exposure of PM_{10} air pollution.

3. Cough reported significantly in this study among exposed worker to PM_{10} air pollution, statistical analysis shows that all members of the case group suffer from cough, but 85.1% of the control group do not suffer from cough and the rest of the same group (14.9 %) suffer from cough.

4. Sputum build-up and dyspnea reported significantly in this study among exposed worker to PM_{10} air pollution, statistical analysis shows that 82.5% of cases have sputum buildup, and 97.5% of cases have dyspnea.

5. Increasing in white blood cells count reported in this study among the exposed workers. This increasing was found to be related to exposure of PM10 air pollution, as a result of the inflammatory process.

6. Data analysis shows insignificant relationship between (Red blood cells and Hemoglobin) and PM_{10} air pollution exposure, due to the short duration of exposure to PM_{10} for target groups (1-3) years compared with appearance of significant impact on hemoglobin and red blood cells, which need long term period to appear clearly.

7. Vital signs disturbances (Increasing systolic and diastolic blood pressure, increasing pulse rate, increasing respiratory rate and temperature) reported in this study among the exposed workers. These disturbances were found to be related to exposure of PM_{10} air pollution.

6.2. Recommendations

According to the results obtained from the present study, the following recommendations should be followed to reduce the concentrations on PM_{10} emission to accepted levels, and reduce the respiratory hazards related to PM10 air pollution exposure:

1. Pre-placement medical examination for the exposed workers should include a base line clinical examination of the respiratory and cardiovascular system with vital signs monitoring, pulmonary functions

testing and complete blood count monitoring, chest X-ray to exclude workers with chest troubles.

2. Periodic medical examination to be monthly performed particularly for early detection and treatment of susceptible cases, who develop simple respiratory symptoms which persist or vital signs and complete blood count disturbances or show reduction of pulmonary function indices. Exclusion of such cases from jobs requiring exposure to PM_{10} air pollution must be done, since they are vulnerable to develop chronic or complicated symptoms with continuous exposure.

3. Workers should be informed about the different hazardous effects of particles air pollution on health and enforced them to the proper use of protective clothing and equipment.

4. Health education of workers about the synergistic effect of smoking with exposure to PM_{10} air pollution on the respiratory and cardiovascular systems .

5. Workers must learn the first aid procedures in cases of massive accidental breathing or accidental vital signs disturbance.

6. Environmental and engineering control of PM_{10} emissions in the different crushing operations should be applied.

7. Protective techniques, procedures, measures and equipment for workers should be used.

8. Finally, the research that was undertaken in this thesis could also be repeated in the future, however the size of the study population and the time that participants are monitored should both be increased if possible, thus allowing a larger dataset to work with, which would allow a more in-depth analysis and establishing other parameters in the blood including IgE and Cytokinas

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Appendices

1. Appendix A :

Questionnaire

1. البيانات الشخصية (Personal data)

أ-	العمر (Age)	....
ب-	تاريخ الميلاد (Birth date)	....

ت-	**المؤهل العلمي** Qualification	( ) ابتدائي primary	( ) إعدادي preparative	( ) ثانوي Secondary	( ) جامعي University	( ) غير ذلك Other
ث-	**الحالة الاجتماعية** Marital Status	( ) أعزب single	( ) متزوج married	( ) مطلق Divorced	( ) أرمل Widowed	

ج-	**عدد الأبناء (إن وجد)** Number of children, if any.	....

2. التاريخ العملي / الوظيفي . occupational history of the present and previous occupation

- **المهنة الحالية**. Present occupation

أ-	**المدة الزمنية التي قضيتها في المهنة الحالية بالأشهر** The length of time spent in the current occupation in months?	....

No لا( )	yes نعم ( )	**هل تتعرض بشكل مباشر للغبار في مهنتك الحالية** Are you directly exposed to the dust in your current occupation?	ب-
....		Duration of daily **مدة العمل اليومية** work	

- **المهنة السابقة (إن وجد) أذكرها .... previous occupation , if find, mention it**

( ) أكثر من 3 سنوات More than three years	( ) سنة الى3سنوات One to three years	( ) أقل من سنة Less than one year	**المدة الزمنية التي قضيتها في المهنة السابقة** The length of time spent in the previous Occupation	أ-
No لا ( )	yes نعم ( )		**هل كنت تتعرض بشكل مباشر للغبار في مهنتك السابقة** Are you directly exposed to the dust in your previous occupation?	ب-

3. معلومات نمط الحياة . (Life style data)

أ-	**هل أنت مدخن smoking**		( ) نعم yes	( ) لا No
ب-	**إن كان الجواب بـ (نعم) ... . if yes**			
ت-	**نوع التدخين type of smoking**		( ) سجائر **cigarette**	( ) نارجيلة **bubbly**
ث-	**إن كان التدخين سجائر فكم سيجارة يوميا** .... If cigarette smoking, how many of cigarette a day ?			
ج-	**إن كان التدخين نرجيلة فكم مرة يوميا** .... If bubbly smoking , How many times a day?			
د-	**مدة التدخين duration of smoking**	( ) سنة فأكثر One year and more	( ) 5 سنوات فأكثر five year and more	( ) 10سنوات فأكثر ten year and more

4. أعراض الجهاز التنفسي . (Respiratory system symptoms)

1. الكحة (Cough)

أ-	**وجود الكحة Is there a cough?**	( ) نعم yes		( ) لا No
ب-	**مدة استمرارية الكحة Duration of the cough**	( ) أقل من سنة	( ) سنة فأكثر	( ) سنتين فأكثر More than two

years	More than one year		Less than one year				
No لا ( )	yes نعم ( )		هل تعتقد بأن الكحة لها علاقة بعملك **Do you think that cough related to your occupation ?**				ت-
No لا ( )	yes نعم ( )		هل تتفاقم الكحة أثناء تعرضك للغبار في العمل **Do aggravated coughing during exposure to dust at work ?**				ث-
No لا ( )	yes نعم ( )		هل يصاحب الكحة خروج للبلغم **Is accompanied by cough out sputum?**				ج-
( ) غير ذلك Other	( ) أسود black	( ) أخضر green	( ) أصفر yellow	( ) أبيض white	**Sputum color لون البلغم**		ح-
( ) لا توجد رائحة No odor	( ) رائحة سيئة Bad odor		**رائحة البلغم** **Sputum odor**				خ-
No لا ( )	yes نعم ( )		**هل حدث معك كحة مصحوبة بالدم والمخاط؟** **Did you cough accompanied by blood and mucus?**				د-
إذا كان الجواب بـ(نعم) :							ذ-

	If, yes ..			
ر-	**فكم عدد مرات الحدوث** **How many times ?**	( ) مرة واحدة once	( ) مرتين Twice	( ) مرتين فأكثر more than twice
ز-	**هل الدم الخارج؟** **؟Blood abroad**	( ) مخلوط بالشوائب a mixture of impurities	( ) متخثر coagulated	( ) مخلوط بالمخاط a mixture of mucus

2. صعوبة التنفس (Difficulty breathing)

أ-	**هل يحث معك ضيق نفس ؟** **Is there Difficulty breathing (dyspnea) ?**	yes نعم ( )		No لا ( )	
ب-	**تكون صعوبة التنفس مصحوبة** **Difficulty breathing accompanied with ?**	( ) مخرجات أنفية Nasal output	( ) ألم في الصدر Chest pain	( ) صوت صفير Wheezy	( ) لا شي مم اذكر Nothing by other
ت-	**طريقة حدوث صعوبة النفس بشكل :** **Way of breathing difficulty?**	( ) مستمر contentious		( ) هجمة (مفاجئ) Attack (sudden)	

5. **هل تعاني من أي من الأمراض المزمنة التالية . Past medical history**

أ-	**ارتفاع ضغط الدم Hypertension**	( ) نعم yes	( ) لا No
ب-	**مرض السكري Diabetes Mellitus**	( ) نعم yes	( ) لا No
ت-	**التهابات الصدر Chest infection**	( ) نعم yes	( ) لا No
ث-	**أمراض في القلب Heart disorders**	( ) نعم yes	( ) لا No
ج-	**السل الرئوي Tuberculosis**	( ) نعم yes	( ) لا No

6. **العلامات الحيوية Vital Signs**

أ-	**الضغط Blood Pressure**	**...................... ملم زئبقي . Mm/Hg**
ب_	**معدل النبض Pulse Rate**	**.................... نبضة / دقيقة Beat/Min**
ت_	**معدل التنفس Respiratory Rate**	**...................... نفس/ دقيقة . Respiration/Min**
ث-	**درجة الحرارة Temperature**	.... درجة سيلزيوس **Celsius degree.**

7. نتيجة فحص الدم الكامل . (Complete Blood Counts Results)

RESULT	TEST	
	RBCS	أ-
	WBCS	ب-
	HGB	ت-

2. Appendix B :

Frequencies

2.1. Personal data.

Table (1): Age

Age		**Frequency**	**Percent**
Cases	18-20 years	9	22.5
	21-less than 30 years	21	52.5
	30 years and more	10	25.0
	Total	**40**	**100.0**
Control	18-20 years	9	19.1
	21-less than 30 years	29	61.7
	30 years and more	9	19.1
	Total	**47**	**100.0**

Table (2): Qualification

Qualification		**Frequency**	**Percent**
Cases	primary	2	5.0
	preparative	14	35.0
	Secondary	23	57.5
	University	1	2.5
	Total	**40**	**100.0**
Control	preparative	3	6.4
	Secondary	23	48.9

	University	21	44.7
	Total	**47**	**100.0**

Table (3): Marital Status

Marital Status		**Frequency**	**Percent**
Cases	single	21	52.5
	married	18	45.0
	Divorced	1	2.5
	Total	**40**	**100.0**
Control	single	29	61.7
	married	17	36.2
	Divorced	1	2.1
	Total	**47**	**100.0**

Table (4): Number of children

Number of children		**Frequency**	**Percent**
Cases	1	2	12.5
	2	4	25.0
	3	3	18.8
	4	3	18.8
	5	1	6.3
	6	1	6.3
	7	1	6.3
	8	1	6.3
	Total	**16**	**100.0**
Control	1	3	18.8
	2	3	18.8
	3	3	18.8

	4	3	18.8
	5	4	25.0
	Total	**16**	**100.0**

2.2. Occupational history of the present and previous occupation :

Table (5): The length of time spent in the current occupation in months?

The length of time spent in the current occupation in months?		**Frequency**	**Percent**
Cases	18month and less	16	40.0
	19 month -36 month	17	42.5
	More than36 month	7	17.5
	Total	**40**	**100.0**
Control	18month and less	15	31.9
	19 month -36 month	19	40.4
	More than36 month	13	27.7
	Total	**47**	**100.0**

Table (6): Are you directly exposed to the dust in your current occupation?

Are you directly exposed to the dust in your current occupation?		**Frequency**	**Percent**
Cases	Yes	40	100.0
	Total	40	100.0
Control	No	47	100.0

	Total	47	100.0

Table (7): Duration of daily work

Duration of daily work		Frequency	Percent
Cases	7	38	95.0
	8	1	2.5
	9	1	2.5
	Total	40	100.0
Control	6	13	27.7
	7	23	48.9
	8	8	17.0
	9	2	4.3
	10	1	2.1
	Total	47	100.0

Table (8): The length of time spent in the previous Occupation.

The length of time spent in the previous Occupation		Frequency	Percent
Cases	Less than one year	4	21.1
	One to three years	8	42.1
	More than three years	7	36.8
	Total	19	100.0
Control	One to three years	2	66.7
	More than three	1	33.3

	years		
	Total	3	100.0

Table (9): Are you directly exposed to the dust in your previous occupation?

Are you directly exposed to the dust in your previous occupation?		**Frequency**	**Percent**
Cases	Yes	12	63.2
	No	7	36.8
	Total	19	100.0
Control	Yes	1	25.0
	No	3	75.0
	Total	4	100.0

2.3. Life style data :

Table (10): smoking

smoking		**Frequency**	**Percent**
Cases	Yes	38	95.0
	No	2	5.0
	Total	40	100.0
Control	Yes	38	80.9
	No	9	19.1
	Total	47	100.0

Table (11):type of smoking

type of smoking		**Frequency**	**Percent**
Cases	cigarette	38	100.0
	Total	38	100.0

Control	cigarette	34	89.5
	bubbly	4	10.5
	Total	38	100.0

Table (12):how many of cigarette a day ?

how many of cigarette a day ?		**Frequency**	**Percent**
Cases	10	7	18.4
	15	7	18.4
	20	15	39.5
	25	3	7.9
	30	6	15.8
	Total	38	100.0
Control	10	14	41.2
	15	6	17.6
	20	14	41.2
	Total	34	100.0

Table (13): If bubbly smoking , How many times a day?

If bubbly smoking , How many times a day?		**Frequency**	**Percent**
Cases		-	-
Control	1	2	50.0
	2	2	50.0
	Total	4	100.0

Table (14):duration of smoking

duration of smoking		Frequency	Percent
Cases	One year and more	14	36.8
	five year and more	17	44.7
	ten year and more	7	18.4
	Total	38	100.0
Control	One year and more	17	44.7
	five year and more	16	42.1
	ten year and more	5	13.2
	Total	38	100.0

2.4. Respiratory System Symptoms

Table (15):Is there a cough?

Is there a cough?		Frequency	Percent
Cases	Yes	40	100.0
	Total	40	100.0
Control	Yes	7	14.9
	No	40	85.1
	Total	47	100.0

Table (16):Duration of the cough.

Duration of the cough		**Frequency**	**Percent**
Cases	Less than one year	13	32.5
	More than one year	17	42.5
	More than two years	10	25.0
	Total	40	100.0
Control	Less than one year	-	-
	More than one year	4	57.1
	More than two years	3	42.9
	Total	7	100.0

Table (17):Do you think that cough related to your occupation ?

Do you think that cough related to your occupation ?		**Frequency**	**Percent**
Cases	Yes	39	97.5
	No	1	2.5
	Total	40	100.0
Control	Yes	-	-

	No	7	100.0
	Total	7	100.0

Table (18): Do aggravated coughing during exposure to dust at work ?

Do aggravated coughing during exposure to dust at work ?		**Frequency**	**Percent**
Cases	Yes	39	97.5
	No	1	2.5
	Total	40	100.0
Control	Yes	3	42.9
	No	4	57.1
	Total	7	100.0

Table (19): Is accompanied by cough out sputum?

Is accompanied by cough out sputum?		**Frequency**	**Percent**
Cases	Yes	33	82.5
	No	7	17.5
	Total	40	100.0
Control	Yes	2	28.6
	No	5	71.4
	Total	7	100.0

Table (20): Sputum color

Sputum color		Frequency	Percent
Cases	white	13	39.4
	yellow	16	48.5
	green	3	9.1
	black	1	3.0
	Total	33	100.0
Control	white	2	100.0
	Total	2	100.0

Table (21): Sputum odor

Sputum odor		Frequency	Percent
Cases	Bad odor	3	9.1
	No odor	30	90.9
	Total	33	100.0
Control	No odor	2	100.0
	Total	2	100.0

Table (22): Did you cough accompanied by blood and mucus?

Did you cough accompanied by blood and mucus?	Frequenc y	Percent

Cases	Yes	20	50.0
	No	20	50.0
	Total	40	100.0
Control	Yes	1	2.1
	No	46	97.9
	Total	47	100.0

Table (23): How many times ?

How many times ?		**Frequency**	**Percent**
Cases	once	12	60.0
	Twice	4	20.0
	more than twice	4	20.0
	Total	20	100.0
Control	once	1	100.0
	Total	1	100.0

Table (24): Blood abroad?

Blood abroad?		**Frequency**	**Percent**
Cases	a mixture of impurities	6	30.0
	a mixture of mucus	14	70.0
	Total	20	100.0
Control	a mixture of mucus	1	100.0
	Total	1	100.0

2.5. Difficulty breathing :

Table (25): Is there Difficulty breathing (dyspnea) ?

Is there Difficulty breathing (dyspnea) ?		**Frequency**	**Percent**
Cases	Yes	39	97.5
	No	1	2.5
	Total	40	100.0
Control	Yes	15	31.9
	No	32	68.1
	Total	47	100.0

Table (26): Difficulty breathing accompanied with ?

Difficulty breathing accompanied with ?		**Frequency**	**Percent**
Cases	Nasal output	4	10.3
	Chest pain	18	46.2
	Wheezy	9	23.1
	Nothing by other	8	20.5

	Total	39	100.0
Control	Nasal output	2	13.3
	Chest pain	7	46.7
	Wheezy	2	13.3
	Nothing by other	4	26.7
	Total	15	100.0

Table (27): Way of breathing difficulty?

Way of breathing difficulty?		**Frequency**	**Percent**
Cases	contentious	3	7.7
	Attack (sudden)	36	92.3
	Total	39	100.0
Control	Attack (sudden)	15	100.0
	Total	15	100.0

3. Appendix C

Normal Ranges

Test	Normal values
Blood pressure	110/70 - 120/80 mm/hg
Heart rate	70-80 b/min
Respiratory rate	12-20 r/min
RBCS	$4.5\text{-}5.5*10^{6}$/uL
WBCS	$5\text{-}10*10^{3}$/uL
HGB	14-15.5 g/dL