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The geographical distribution of ready mix concrete factories using GIS and assessment of some of its adverse effects in the Gaza Strip

Odeh Jameel Faleet

Administrative and Academic Deputy, Al-Quds Open University, Khan Younis, Branch, Gaza Strip, Palestine.

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Gaza strip have (32) concrete production factories distributed in all Gaza strip governorates, and it's a large number when compared with the geographical area. So, the target population of the study is all concrete production factories in Gaza strip. This study is a massive survey conducted during the period of April to August 2015, and designed to identify the environmental impacts of concrete production factories and its workers and its geographical distribution by using geographical information systems (GIS) in all concrete production Factories in Gaza strip governorates. There are 32 factories and the total number of workers in is 290; as a result, it was concluded that particulate matter concentration from the concrete factories varies widely from 83 to 212 µg/m3, with an average particulate matter of 147 µg/m3, which is about more than 4 times higher than the particulate matter existing standard of 35 µg/m3, so these concentrations can lead to adverse environmental impacts. Geographic distribution of concrete production factories in Gaza Strip was shown by using geographical information system and respiratory tract symptoms reported in this study among the factories workers from emitted particulate matter air pollution were cough, sputum build-up and dyspnea; these symptoms were found to be related to exposure of PM air pollution.

Key words: Geographical, concrete factories, geographical information systems (GIS), adverse effects, Gaza Strip.

INTRODUCTION

Environmental impact assessment

Environmental impact assessment (EIA) is an assessment of the possible impact (positive or negative) that a project may have on the natural environment. The environmental impact of building products consists of procurement of raw materials, the manufacturing process and also the use of energy resources during transportation, all of which to some extent are burden to the environment. Environmental burdens of the cement industry consist of limestone quarrying, burning and grinding of clinker. Extraction, excavation, manufacturing and transportation of aggregates and distribution of the final products are elements for EIA of concrete industries (Parrott, 2002;

E-mail: o_faleet@hotmail.com.

Malhotra, 2004; Vares and Häkkinen, 2002).

Concrete production industries

The concrete industries can make substantial contributions to sustainable developments by creating and adopting technologies that can reduce the emissions of greenhouse gases. The cement and concrete industries could contribute to meeting the goals and objectives of the 1997 Kyoto Protocol (Naik et al.2003; Liquid Stone (2004); UNFCCC COP9 Report (2004); American Cement Manufactures (2015); Concrete Thinking for a Sustainable Future, 2004).

Goals and objectives

The goal of this research was to identify the environmental impacts of concrete production factories and its geographical distribution by using geographical information systems (GIS). The objectives of this research are as follows:

1) To measure the concentration of emitted PM.
2) To display a geographical distribution of concrete production factories
3) To evaluate and identify air quality, and respiratory health impacts which is related to concrete production factories.

Research questions

The researcher developed the following research questions for his study, and divided them into four questions:

1) Is the concentration of PM higher than accepted level and can lead to adverse environmental impacts (air quality and respiratory health impacts)?
2) What is the relationship between the geographic distribution of factories and increase in the adverse environmental impacts.
3) Is there any significance between concrete production factories and its surrounded air quality?
4) What is the relationship between the work of concrete production factories and appearance of respiratory symptoms?

Background and literature review

Concrete industry in Palestine

Since September 29th, 2000, as a result of the closure policy on the Palestinian territories, over three million Palestinian have being cut off from the rest of the world, and forced to be confined to their cities, villages, and refugee camps. In addition to the siege, there is also a deliberate and systematic destruction for some of the basic physical, social and productive infrastructure by the Israeli military forces and the Israeli settlers (Center for National Information, 1999; Palestinian Central Bureau of Statistics, 2000; Palestinian Ministry of National Economy, 2013; Palestinian Ministry of public work, 2005).

Environmental impacts of concrete industry

People in developed and developing countries are spending more and more of their time in various indoor and outdoor environments (Farrow, 1997). Pollution is any addition of matter or energy that degrades the environment for humans and other organisms. Suspended particle 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 (Fenger, 1999).

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

PM emission effects

PM also known as particle pollution, 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, soil or dust particles (EPA, 2007).

Respiratory health effects

The health impact of PM 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). PM 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). Till date, a number of epidemiological studies have also established the morbidity and mortality impact of PM, especially with respirable suspended particulate matter (RSPM) and fine PM (Dohan and Neill, 1960; 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, 2009).

METHODOLOGY

The researcher here measured the concentration of PM of dust from concrete production factories during work, and evaluates the environmental impacts (air quality and respiratory health impacts) that have occurred as a result to geographical distribution of concrete production factories.

Study design

Massive survey design

A massive survey was designed to identify the impacts of concrete production factories and its geographical distribution by using GIS. Three main purposes of research are to describe, explain, and validate findings. Description emerges following creative exploration, and serves to organize the findings in order to fit them with explanations, and then test or validate those explanations (Borg and Gall, 1989; Krathwohl, 1993).

Target population

Gaza Strip has (32) concrete production factories and it is a large number when compared with the geographical area, distributed in all Gaza Strip governorates. So, the target population of the study is all concrete production factories in Gaza Strip. Each of the concrete production factories has almost 9 workers as they have worked in the concrete production and exposed to dust without protective devices; male, their age is 15 to 50 years, with no past medical history.

Sample size

All concrete production factories in Gaza Strip governorates are included in the current study. There are 32 factories and the total number of workers is 290.

Sitting of study

The study was conducted from April to August 2015 on all concrete production factories, at Gaza Governorates, Palestine.

Data collection

Data was collected in April and June, 2015. By using structured questionnaire, PM was measured through HAL-HPC300 handheld optical particle counter in each factory in the surrounding area. Both verbal and written consent was obtained from each individual included in the study.

Instruments and techniques

All individuals included in the study were subjected to the following procedures

Questionnaire

Large number of researchers maintained that a questionnaire is the best method of collecting data especially if the survey strategy is used (Saunders et al., 2007). Each individual filled out the questionnaire with the researcher, it included the following: Personal data (age, birth date, qualification, marital status, number of children, if any, detailed occupational history of the present occupation; exposure to PM and duration, also the previous occupation (exposure and duration), Life style and smoking habits (type, number per day and duration), respiratory symptoms (cough, sputum buildup, and dyspnea).

Techniques

The researcher measured the concentration of PM pollution during factory work and devices used which are borrowed from the Islamic University and examined the respiratory health effects resulting from their work in these factories.

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

Geographical distribution of concrete factories by geographical information systems (GIS)

In this section, the researcher will display details about the concrete factories according to governorates which were studied:

Northern governorate

Foreword

Figure 1 shows that northern governorate is one of the five governorates of Palestine in the Gaza Strip which is administered by Palestine, 270,245 (7.2% of the Palestinian population) with 40,262 households in 2007 (Palestinian Central Bureau of Statistics, 2007).

General details of the concrete factories in the northern governorate

Northern governorate has 9 concrete factories distributed on all areas of the governorate. More than half of these factories are located nearly from populated areas, each factory space ranging from 7 to 9 acres, also there are factories with 2 to 3 cement stores. In addition, each factory has from 2 to 3 silos.

Gaza Governorate

Foreword

Figure 2 shows that Gaza governorate is the second of the five governorates of Palestine in the Gaza Strip, the Governorate has a population of 505,700 (Palestinian Central Bureau of Statistics, 2007).

General details of the concrete factories in Gaza governorate

Gaza governorate has six concrete factories distributed on all areas of the governorate. Most of these factories are located far from the populated areas, each factory space range from 6 to 9 acres; also, there are factories with 1 to 3 cement stores. In addition, each factory has 2 to 4 silos.

Middle governorate

Foreword

Figure 2 shows that middle governorate is the third of the five

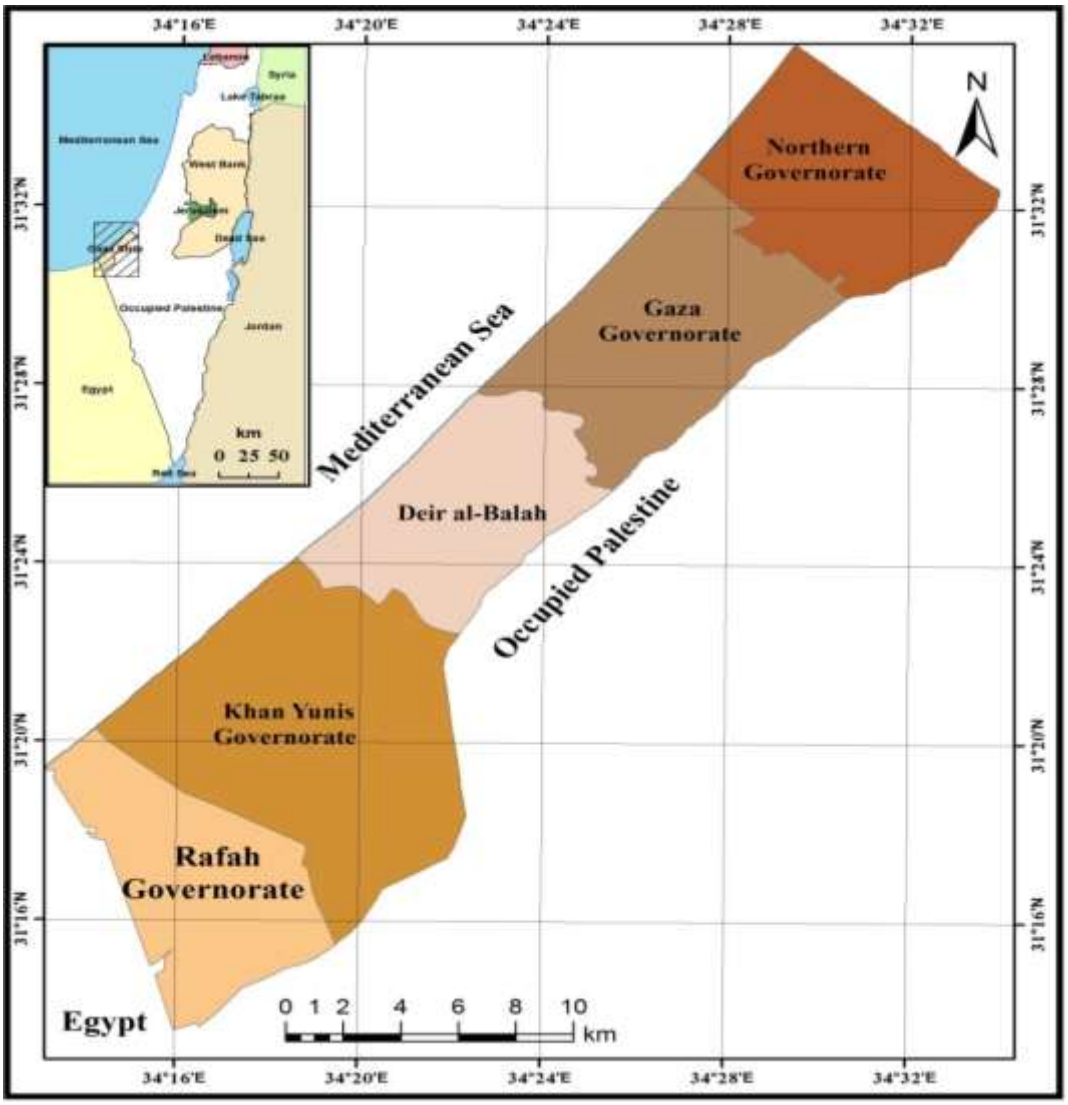

Figure 1. Gaza Strip governorates displayed through Geographical information systems.
Source: Researcher.

governorates of Palestine in the Gaza Strip. The governorate had a population of 205,414 in 2007 (Palestinian Central Bureau of Statistics, 2014).

General details of the concrete factories in middle governorate

Middle governorate has eight concrete factories distributed in all its areas. Most of these factories are located nearly from populated areas, each factory space range from 6 to 7 acres; also, there are factories with 1 to 2 cement stores. In addition, each factory has from 1 to 2 silos.

Khan Younis Governorate

Foreword

Figure 2 shows that Khanyounis governorate is the fourth of the five governorates of Palestine in the Gaza Strip, the governorate had a population of 280,000 in 2007. Its land area is 69.61% urban, 12.8% rural and 17.57% comprising the Khan Younis refugee camp (Palestinian Central Bureau of Statistics, 2007).

General details of the concrete factories in Khan Younis governorate

Khan Younis governorate has 6 concrete factories distributed in all its areas. More than half of these factories are located nearly from populated areas, each factory space range from 5 to 8 acres, also, there are factories with 1 to 2 cement stores.

Rafah Governorate

Foreword

Figure 2 shows that Rafah governorate is the fifth of the five governorates of Palestine in the Gaza Strip, the governorate

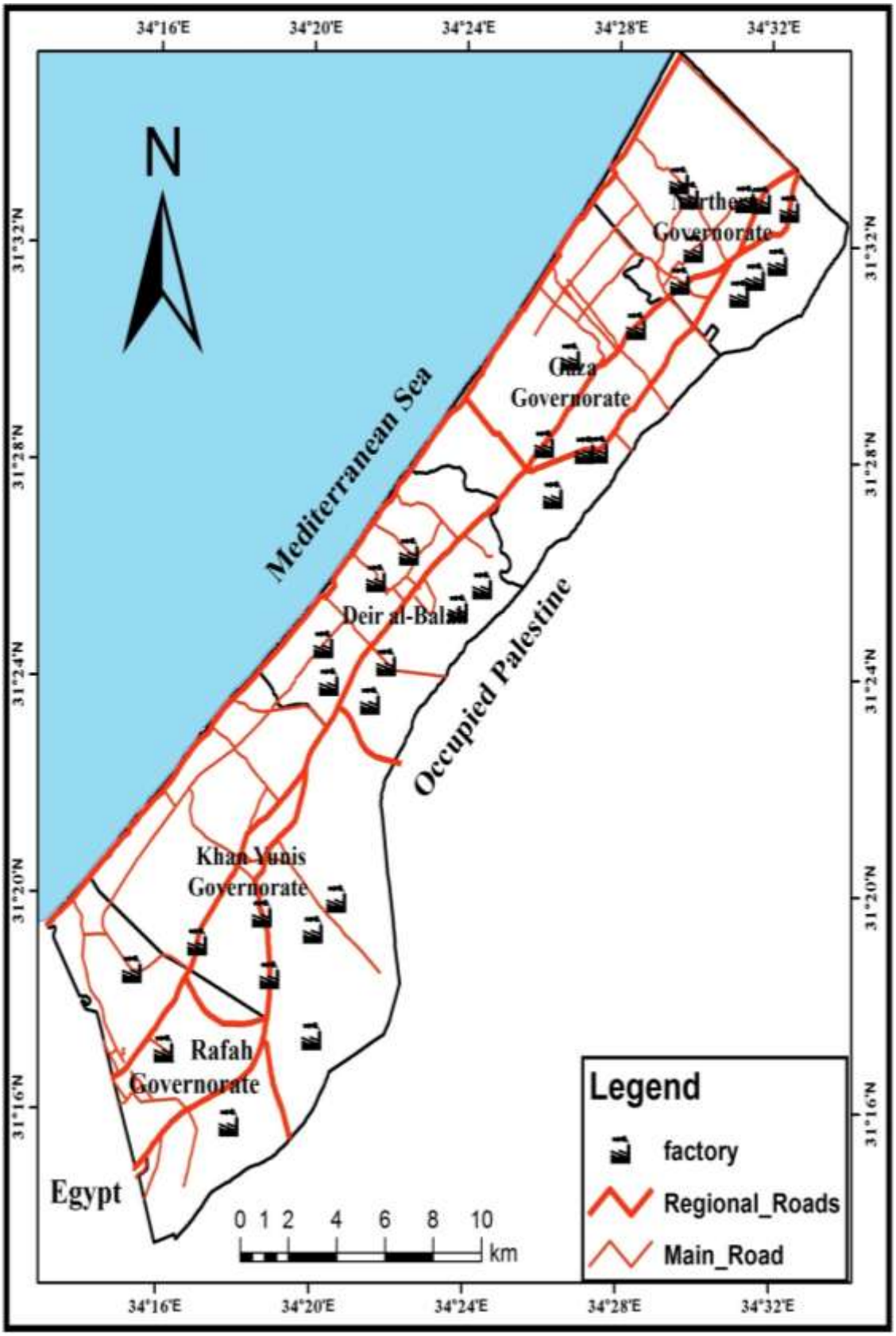

Figure 2. Geographical distribution of concrete factories in Gaza Strip governorates through geographical information systems. Source: Researcher.

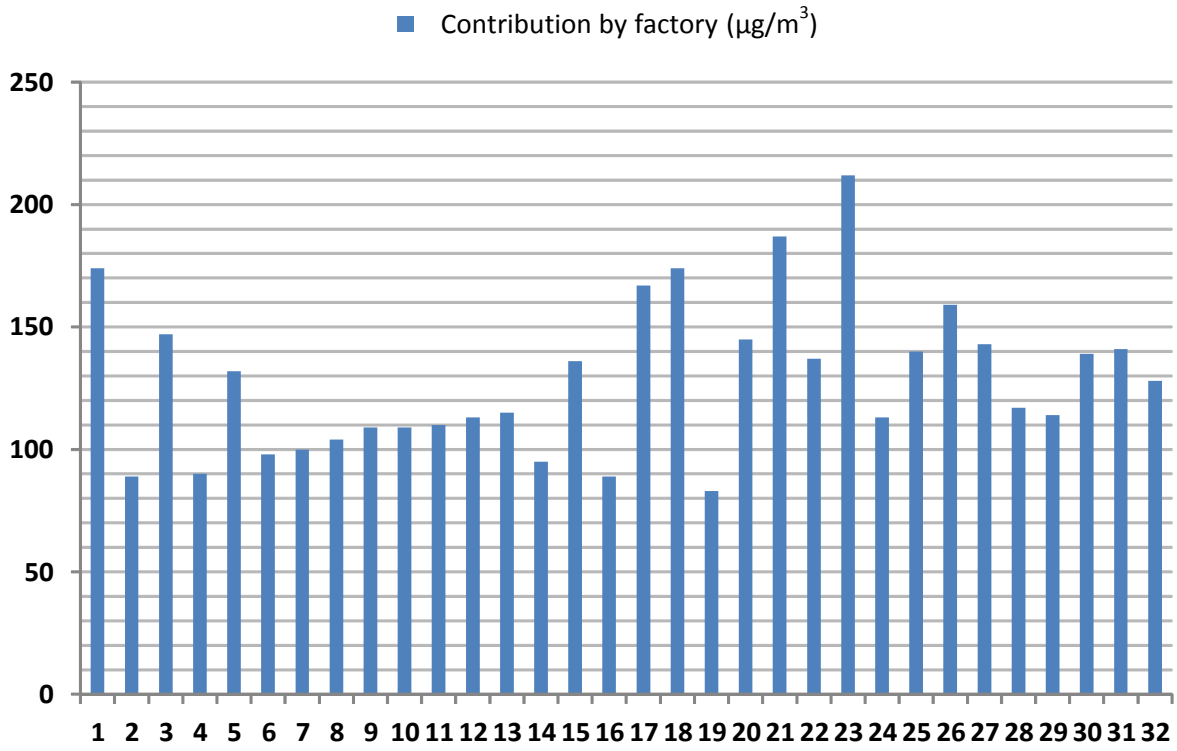

Figure 3. Concentrations of PM emitted from concrete factories and the average of these concentrations.

had a population of 171,363.

General details of the concrete factories in Rafah governorate

Rafah governorate has 3 concrete factories distributed in all its areas. Most of these factories are located nearly from populated areas, each factory space range from 7 to 8 acres. Also, there are factories with 2 to 4 cement stores. In addition, each factory has 1 to 3 silos.

Process description

Raw material consists of prefabricated cement concrete, water, gravel (sand-gravel-broken) stones, chemicals and mineral materials. Cement mixture with which occur to form cement paste always thicken and harden from time to time and are linked to granulated gravel (sand, gravel, broken stone) and stick.

Protective techniques and suppression systems

All the factories do not use any type of the protection techniques for workers or population who are in the neighboring area, and does not use any techniques or system to reduce the existing dust and PMs.

RESULTS AND DISCUSSION

This section presents the results and interpretations of the data gathered by the researcher, statistical treatment and data analysis. The goal of this paper is to identify the environmental impacts of concrete production factories and the geographical distribution by using GIS.

The target population of the study is all concrete production factories in Gaza Strip. Each of these factories has about 9 workers, as they have worked in a concrete factory and continuously exposed to dust without using any protective devices, and the exposed workers were male, their age ranged from 15-50 years, and does not have any past medical history.

Air quality impacts

PM air pollution

Is the concentration of PM higher than accepted level and can lead to adverse environmental impacts (air quality, and respiratory health impacts)?

The above data in chart Figure 3 reveals that the emission of PM by the concrete production factories varies widely from 83 to 212 µg/m^3, with an average PM of 147 µg/m^3, which is about more than 4 times higher than the PM existing standard of 35 µg/m^3 (EPA, 2012).

Respiratory health impacts

Is there any significant between the work of concrete

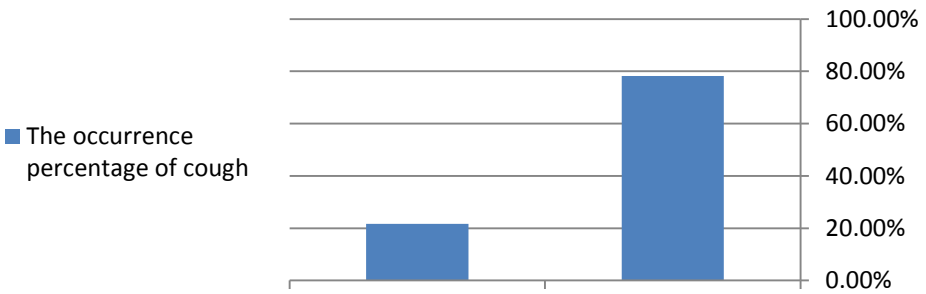

Figure 4. The occurrence percentage of cough.

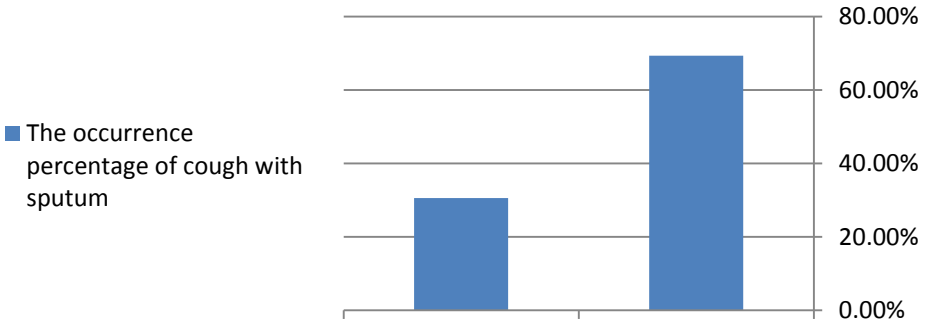

Figure 5. The occurrence percentage of cough with sputum.

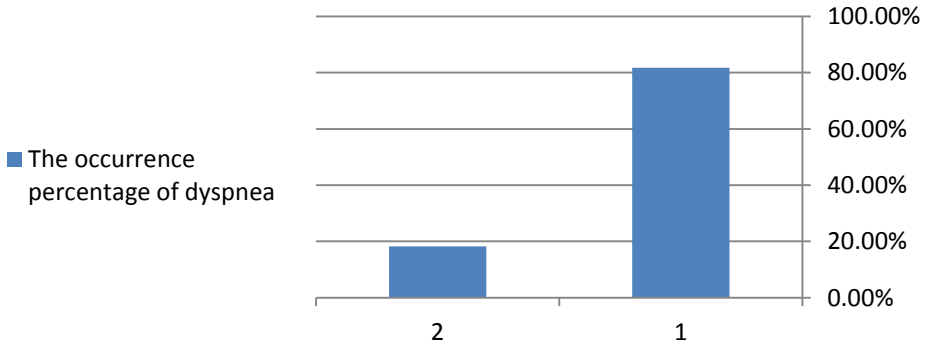

Figure 6. The occurrence percentage of dyspnea.

production factories and appearance of respiratory symptoms?

DISCUSSION

The goal of this paper is to identify the environmental impacts of concrete production on factories and the geographical distribution by using GIS.

The target population of the study is all concrete production factories in Gaza strip. Each of these factories has about 9 workers, as they have worked in a concrete factory and continuously exposed to dust without using any protective devices, and the exposed workers were male, their age ranged from 15-50 years, and does not have any past medical history.

PM monitoring in the concrete production Factories

PM emission monitoring was carried out in 32 concrete factories with objective to generate information on the existing level of the PM emissions from uncontrolled operations, which could form a baseline data for future

comparison after incorporation of the controlled protective measures.

Data in Figure 3 reveals that the emission of PM by the concrete production factories varies widely from 83 to 212 μg/m^3, with an average PM from 147 μg/m^3, which is about more than 4 times higher than the PM existing standard of 35 μg/m^3 (EPA, 2012).

This is primarily due to inoperative suppression system and inadequate control. The high PM concentrations in cement plants (Parrott, 2002, EPA, 2009; Krathwohl, 1993) is primarily due to working process, height of the cement silos from the surface greater than others, and non-use of water to reduce dust emissions which lead to more emitted PM.

These high concentrations call for stricter measures to be enforced on factories and control guidelines and systems should be applied.

The relationship between the work in concrete production factories and appearance of respiratory symptoms

Significant and positive relationship is observed between PM air pollution exposure and appearance of respiratory system symptom (cough, sputum build-up and dyspnea). Figure 4 shows that 78.2% of the workers suffer from cough.

Figure 5 shows that the occurrence percentage of sputum buildup among workers is 69.3%. Figure 6 shows the occurrence percentage of dyspnea among workers is 81.7% of the workers suffering from dyspnea, but 18.3% of the workers not suffer from dyspnea. The distribution of respiratory system symptoms was statistically descriptive among workers for cough, sputum buildup and dyspnea.

The results of the acute respiratory symptom scores are in agreement with data reported by Mwaiselage et al. (2013) that found a high prevalence of shortness of breath, stuffy nose and sneezing among exposed cement factory workers (Mwaiselage et al., 2014; 2004). The statistical strength of these relationships are in line with review carried out by Mariammal in 2012 (Mariamma et al., 2012). It was observed that occupational respiratory diseases are usually caused by extended exposure to irritating or toxic substances that may cause acute or chronic respiratory ailments.

Indeed, Short and Petsonk (1996) findings with similar descriptive strength for the relationships found that high concentration and/or prolonged inhalation of cement dust in cement industry workers can provoke clinical symptoms and inflammatory response that may result in functional and structural abnormalities (Zeleke et al., 2013; Atkinson et al., 1999; Short and Petsonk, 1996).

In summary, these results are consistent with the results of studies that have mentioned positive and significant relationship between exposure of concrete factories PM air pollution and appearance of respiratory system symptom (cough, sputum build-up and dyspnea).

Conclusions

From the results, it can be concluded that:

1) PM concentration emitted from the concrete factories varies widely from 83 to 212 μg/m^3, with an average PM of 147 μg/m^3, which is more than 4 times higher than the PM existing standard of 35 μg/m^3, so these concentrations can lead to adverse environmental impacts.
2) Geographic distribution of concrete production factories in Gaza Strip displayed by using geographical information system.
3) Respiratory symptoms reported among workers were cough, dyspnea and sputum build-up, these symptoms were found to be related to exposure of PM air pollution.

RECOMMENDATIONS

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

1) Workers should be oriented of PM hazardous effects on health and enforced them to use the protective clothing and equipment.
2) Apply environmental control techniques of PM emissions in all factories.
3) Give advice on current and future levels of PM, trends, sources and characteristics of air pollutants.
4) Use of continuous emissions monitoring and environmental and geographical management systems.
5) Finally, this research could be repeated in the future with larger population size and longer time of exposure, and more broadly geographical distribution, which would allow a more in-depth analysis.

Conflict of Interests

The authors have not declared any conflict of interests.

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