

Environmental Impact Assessment of Quarries and Stone Cutting Industries in Palestine: Case Study of Jammain

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Abstract

Although quarries and the stone industries represent a significant industrial sector in Palestine in terms of production and exports and thus enhancing the economic situation, these operations have adverse impact on the environment and human health. The present study revealed that particulate matter (dust) produced as a result of the different activities associated with these industries causes several problems to the environment and people living in the area. Measurements of air quality showed that high concentrations of different particulate matter are in the study area. In this regard, the majority of the people (70% of the respondents) confirmed that air is permanently dusty, and the conditions are not limited to working hours, where higher effects are normally noticed in summer season. Also, the study showed that these industries have negative impact on water resources, and about 68% of the respondents confirmed that groundwater is polluted as a result of these industries and their wastes. Concerning the health situation, the study demonstrated that there is high prevalent rate of diseases caused as a result of these industries and particularly due to air pollution; cough and cold, dyspnea, inflammation of nasal, Asthma and hearing impairment due to noise pollution were the most prevalent diseases. Furthermore, these industries cause stress and discomfort to people and affect their homes as different degrees of crack are developed due to vibrations.

Keywords

Quarries, Stone Cutting Industries, AirPollution, WaterPollution, ImpactAssessment

Received: August 31, 2016 / Accepted: September 11, 2016 / Published online: October 19, 2016

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1. Introduction

Quarrying and stone cutting industry are economically important activities worldwide. In Palestine like other countries, stone and marble industry is a growing and successful industry. The competitiveness of Palestinian marble and stone derives from two sources: first, its origin from the Holy Land "Jerusalem Gold Stone" which creates spiritual and symbolic imagery in the minds of much of the world's population, and the second, the variety of colors and textures of the products [1, 2].

The available data about these industries in Palestine estimates that there are approximately more than 300 quarries and 1000 factories and workshops which yield over 100 million tons of raw stone, and approximately 25 million square meters of stone per annum. Accordingly, this implies that Palestine represents approximately 4% of the world's production of stone and marble [1]. Actually, this industry contributes approximately 4.5% to gross national product (GNP) and 5.5% to gross domestic product (GDP). Total investment in the industry is estimated at around \$700 million, making it a major employer of Palestinian capital (15-20,000 direct jobs), with greater proportion than any of

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the other major Palestinian industries [1, 2].

Although quarrying and stone cutting industries have a great role in improving the economical situation, these activities are normally associated with environmental and health impacts. In this regard, dust or particulate matter (PM) is the main source of air pollution caused by such industries, where degree of pollution by such source of pollution depends on the local microclimate conditions, the concentration of dust particles in the ambient air, the size of the dust particles and their composition [3]. Concerning the environmental impact, quarries and stone cutting industries cause ecological disturbance, destruction of natural flora, pollution of air, land and water, instability of soil and rock masses, landscape degradation [4]. On the other side and regarding their health impact, dust and emissions resulted from these industries can lead to chronic health effects; for instance decreased lung capacity and lung cancer resulting from long-term exposure to toxic air pollutants [5]. Furthermore, a very high degree of respiratory morbidity is associated with these industries. Fine rock and mineral dust of many kinds have been shown to be carcinogenic when inhaled [6]. Control of particulate pollution is a matter of both health and aesthetics. Increasing attention is being paid to the impacts of dust on human health, as finer particles can be inhaled and breathed into the lungs and cause harm. It is generally recognized that dust up to 10 μm can be inhaled beyond the larynx and dust up to 4 μm can be breathed into the lungs [7]. Potential health impacts are almost exclusively linked to the presence of airborne dusts, in particular respirable particles, i.e. those that are less than 10 μm in diameter (also known as PM_{10}), have the potential to affect human health, including effects on the respiratory and cardio-vascular systems [8]. According to Banez, et al [8], inhalation of dusts can cause "pneumoconiosis" which is a term that refers to a group of lung diseases. The objective of the current research was to assess the impact of quarries and stone cutting industries on the environment, mainly air quality and water pollution. Also, the assessment of their impact on people health within the surrounding area, by determining the main diseases, injuries, death caused by such activities. Furthermore, the study tried to shed light on other impacts associated with these activities like vibration, cracks in home, and noise pollution.

2. Materials and Methods

2.1. The Study Area

In Palestine, there are a large number of quarries and stone cutting industries as mentioned before. To assess their impact on different aspects and sectors, Jamma'in was selected as the study area; it is about 530 m above the sea level and located

in the southern part of Nablus district (about 16km) in the West bank, Palestine, as shown in Fig. (1). It has about 10000 inhabitants. The selected area is one of the most famous areas of quarrying and stone cutting industries. It has more than 60 quarries and 40 stone cutting industries.



Figure 1. Map showing the study area.

2.2. Data Collection and Analysis

Data for assessment process was obtained from primary and secondary sources. Primary data which was collected by questionnaires that have been structured for these objectives. 200 questionnaires were distributed in the field to residents in the target area and some workers in quarries. Also, and in order to have a clear image about the situation, interviews were conducted, this included interviews with people in the area, workers, physician, health centers, and formal interviews with the mayor of Jamma'in and other opinion leaders in the areas were also contacted for relevant information. Moreover, there were field observations to working sites and other areas to determine the effects of the industry operations.

Secondary data was obtained using 5 channels (PM_1 , $\text{PM}_{2.5}$, PM_7 , PM_{10} and TSP) laser-operated portable OPC, (Aerocet 531, MetOne, USA) for measurement of the particulate matters (dust). It is an automatic instrument that estimates PM in a range of 1, 2, 5, 7 and 10 μm in aerodynamic diameters in mass mode, and $\text{PM}_{\leq 0.5}$ and $\text{PM}_{\leq 10}$ in count

mode. Additionally, a real time measurements of the concentration of hydrogen cyanide (HCN) mg/m^3 , ammonia (NH_3) ppm, sulfur dioxide (SO_2) ppm, ozone (O_3) ppm, hydrogen sulfide (H_2S) ppm, carbon monoxide (CO) %, total volatile organic compounds (TVOCs) ppm, carbon dioxide (CO_2) ppm, nitric oxide (nitrogen monoxide) (NO) ppm, nitrogen dioxide (NO_2) ppm, temperature $^\circ\text{C}$, relative humidity (%RH), dew point $^\circ\text{C}$ and humidity ratio lb/lb were performed with a multi-gas electrochemical gas sensors (TG-501 and TG-502 Direct Sense Tox multi-gas monitor sensors, GraywolfTM Sensing Solutions, USA). The probes were attached in parallel to each other and in series with a trend logging pre-programmed pocket personal computer (PC). The pocket PC was programmed for logging the average data for each 10 minutes interval over all the measuring period. All probes calibration was performed at the supplier company before use.

Three sampling locations were selected; these locations were about 500-700m far from quarries or stone cutting industries. The instruments were placed 2-3m above the ground level, and sampling was conducted for one hour in each location. Also, a location far from working site was selected as a control.

Data analysis was performed using Chi-square tests for significantly difference ($p < 0.05$) in Statistical Package for Social Sciences (IBM, SPSS, version 15). Microsoft Excel 2007 (Microsoft Office, 2007) was used for calculation and presentation of figures.

3. Results and Discussion

3.1. Air Quality

Quarries and stone cutting industries activities are normally associated with different types of pollution. Air pollution is regarded as the most notable one, where particulate matter (dust) with diameter 1-75 μm are generated and found in the surrounding areas of such activities. Particles with aerodynamic diameters of less than 50 μm (termed Total Suspended Particulate matter, or TSP) can become suspended in the atmosphere, and those with aerodynamic diameters of less than 10 μm termed PM_{10} (inhalable particles) can be transported over long distances [9], and enter the human respiratory system [10]. Table 1 demonstrates the concentration of particulate matter during the sampling campaigns.

Table 1. Concentration of Particulate Matter in sampling locations.

Location	Day	PM_1 (mg/m^3)	$\text{PM}_{2.5}$ (mg/m^3)	PM_7 (mg/m^3)	PM_{10} (mg/m^3)	TSP (mg/m^3)
Location 1: Albatin	1	0.0045	0.0105	0.2160	0.2335	0.2475
	2	0.0049	0.0454	0.4031	0.6389	0.8759
	3	0.0035	0.0615	0.1795	0.2340	0.2920
	4	0.0013	0.0203	0.1480	0.1973	0.2597
Location 2: Almeqtala	1	0.0015	0.0045	0.0530	0.0580	0.0615
	2	0.0015	0.0105	0.0400	0.0675	0.0980
	3	0.0113	0.1960	1.9087	3.1853	4.3930
	4	0.0023	0.0350	0.6047	1.0080	1.5910
Location 3: AlmarjAlsharqi	1	0.0017	0.0077	0.3520	0.4577	0.5567
	2	0.0073	0.0938	0.7228	0.9310	1.3003
	3	0.0128	0.1453	0.6388	1.0615	1.9793
	4	0.0059	0.0701	0.7921	1.3256	1.8453

As it can be seen in Table 1, the concentrations of the particulate matter in all sampling sites were high as they were selected close to working sites. However, these concentrations are normally decreased with distance as they dispersed, but still they have an impact on human and environment in general. Concerning the gas emissions, the concentrations were very low (data not shown here), and below standard pollution threshold.

About 70% of the respondents (Figure 2) indicated that the air in the targeted area is permanently dusty as a result of quarrying and stone cutting industries. It is worth to mention that not only working in the sites is the only source of dust, but also the movement of trucks from and to these sites produces big amounts of dust and other pollutions resulted

from fuel combustion. Furthermore, about 70% of the respondents (Figure 3) confirmed that the effect of the dust is not limited to working hours.

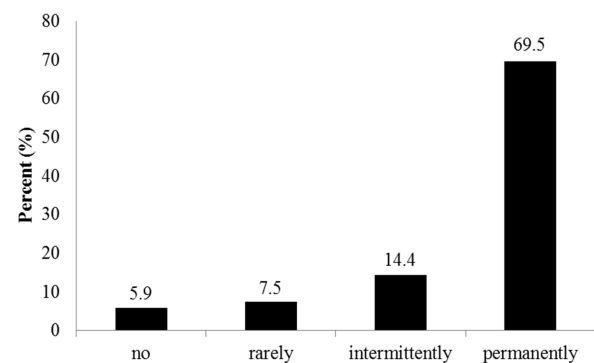


Figure 2. Percentage of respondents about the presence of dust in the air.

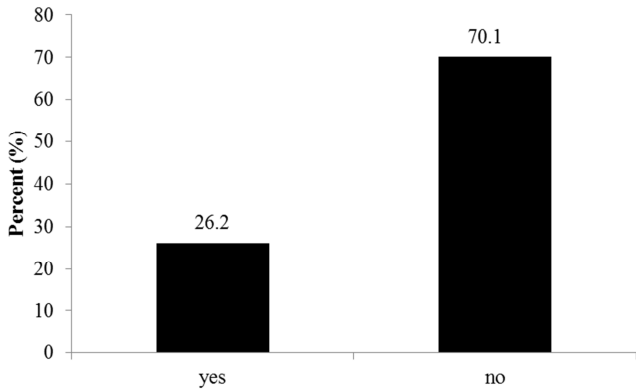


Figure 3. Percentage of respondents if dust is limited to working hours.

The study showed (Figure 4) that the people living within the targeted area suffering from quarries and stone cutting industries almost all the year (45.5% of the respondents) as working in these sites take place throughout the year. However, when comparing the most affected season, summer was the highest one (29.5% of the respondents), which is reasonable as dispersion of dust is highly affect by dominant weather conditions. Indeed, the produced particulate matter remains suspended in the atmosphere, and even some of them are deposited (dry deposition), they are mostly re-suspended due to wind, trucks movement and human activities in general. In winter which is the lowest affected season (1.1% of the respondent), the precipitation helps in sinking these pollutants (wet deposition) and most of the produced dust is wetted and mixed with soil, where another part is transported with runoff, and this reduced its negative impact as demonstrated in Figure 4. These results are in agreement with the results obtained by El-Nashar [11]; such that summer season was the strongest season concerning dust deposition.

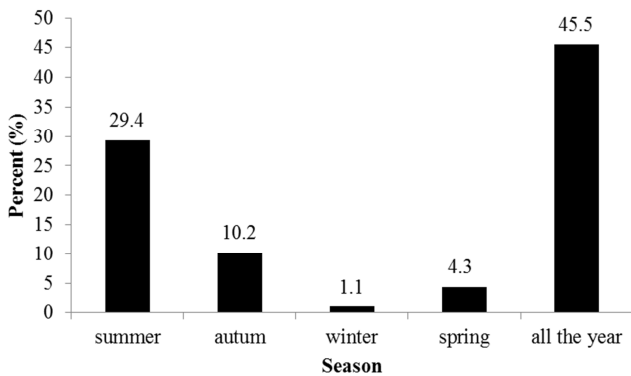


Figure 4. Percentage of respondents about the season that is mostly affected by dust.

3.2. Water Quality and Pollution

Quarries and stone cutting industries operations impact the environment in several ways, and water pollution is a major concern in such operations. For instance quarry dust can change the chemistry of water resources by dissolving in them, it can also settle in water bodies and cause pollution.

Furthermore, these operations disrupt the existing movement of surface water and groundwater; they interrupt natural water recharge and can lead to reduced quantity and quality of drinking water for residents and wildlife near or downstream from a quarry site.

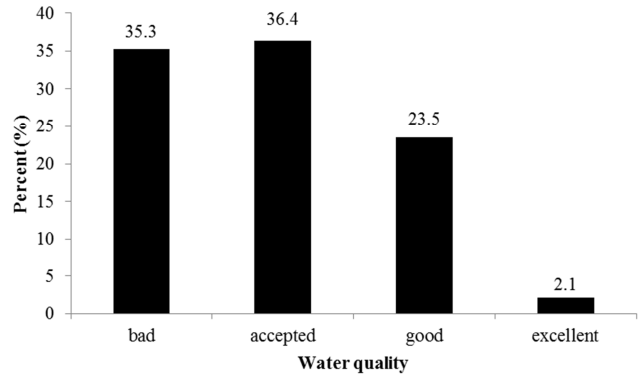


Figure 5. Percentage of respondents about water quality.

According to respondents who answered the question related to water quality, Figure 5 indicates that 36.4% of respondents showed that water quality is accepted as a result of quarrying and stone cutting industries, while 35.3% of respondents indicated that water quality is bad. Also it shows that 23.5% of respondent pointed that a good water quality appear, where 2.1% of respondents showed that water quality is excellent. Accordingly, one can conclude that quarrying and stone cutting affect water quality [12].

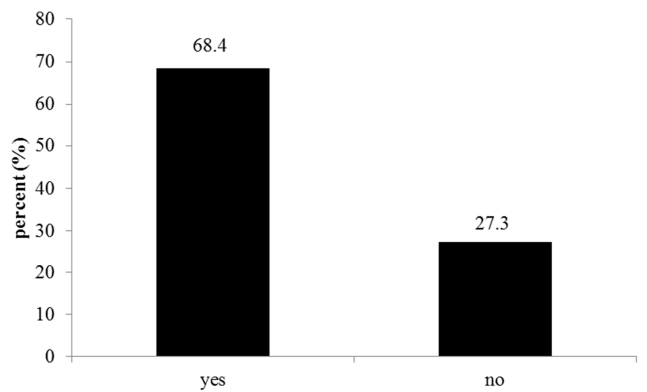


Figure 6. Percentage of respondents about the impact on groundwater.

It is clear from Figure 6 that operations in the quarries and stone cutting industries highly affect groundwater resources, as about 68.4% of the respondents agreed upon such impact. In fact, the removal of top soil and surface rock strata can increase the vulnerability of groundwater to contamination [13]. This is because of the karst characteristics of hard limestone and high infiltration rate of disturbed sands [12, 13, 14, 15]. In this regard, and according to Al-Jabari and Sawalha [16], the problems related to water consumption and random wastewater dumping from this industry has been classified as one of the major environmental problems in the

West Bank. Improper management of the stone cutting industry wastes is the main reason for the increasing of the Total Suspended Solids (TSS) levels in Hebron groundwater.

3.3. Impact on Health Situation

Dust is one of the most visible, invasive, and potentially irritating impacts associated with quarrying, and its visibility often raises concerns that are not directly proportional to its impact on human health and the environment [17]. Dust may occur as fugitive dust from excavation, from haul roads, and from blasting, or can be from point sources, such as drilling, crushing and screening [18]. Site conditions that affect the impact of dust generated during extraction of aggregate and dimension stone include rock properties, moisture, ambient air quality, air currents and prevailing winds, the size of the operation, proximity to population centers, and other nearby sources of dust. Dust concentrations, deposition rates, and potential impacts tend to decrease rapidly away from the source [17]. Health effects associated with quarrying and stone cutting industries activities are noteworthy. The research revealed that there is high prevalent rate of diseases (figure 7) as a result of these operations. The impact of high-pitched and other noises is known to include damage to the auditory system, cracks in buildings, stress and discomfort [19].

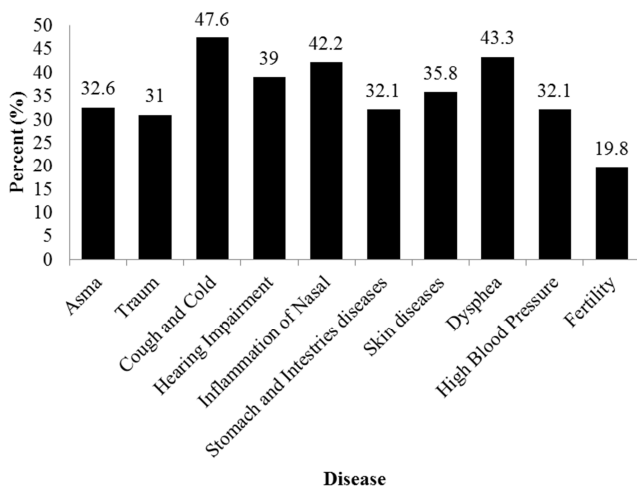


Figure 7. Percentage of respondents about diseases.

Figure 7 indicates that cough and cold, dyspnea, inflammation of nasal and hearing impairment are the most prevalent diseases (47.6%, 43.3%, 42.2, 39 respectively). Also, 35% of respondents showed that skin diseases are caused by these operations. This figure also shows that 32.6% of respondents pointed out that Asthma are caused by these activities, while 32.1% indicated that they cause high blood pressure. Consequently, one can conclude that quarrying and stone cutting industries cause various diseases

to workers or people who live close to operations.

Beside the health problems and diseases mentioned before, several incidents occur in these operations (Figure 8). Fractures are most prevalent incidents (13.9% of the respondents) as workers have to deal with heavy rocks and equipments. Some of these accidents cause permanent disabilities (10.2%), whereas 3.7% of the respondents indicated that these incidents are fatal. In most cases, these incidents are caused by the absence of monitoring and controlling regulations.

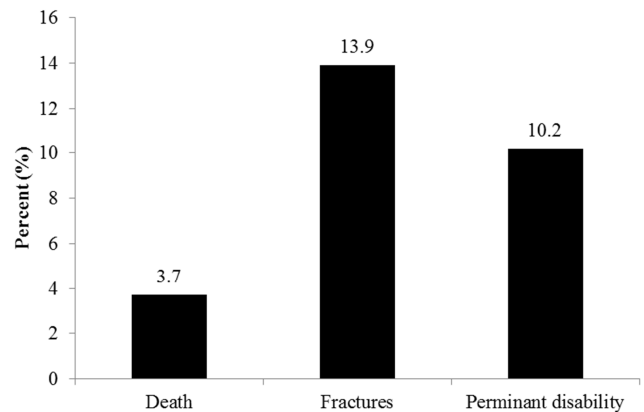


Figure 8. Percentage of respondents about accidents in quarries and stone cutting industries.

3.4. Vibration, Cracks and Noise Pollution

Vibrations and noise pollution are associated with many types of equipment used in quarries and stone cutting industries operations, but blasting is considered the major source. Vibration has affected the stability of infrastructures, buildings, and homes of people living near to these working sites [19].

Figure 9 and figure 10 present the respondent's answers regarding vibrations, noise and cracks as a result of operation in quarries and stone cutting industries. As shown in figure 9, (35.3%) of respondents showed that vibrations always occur as a result of working and equipment, while 28.3% of respondents indicated that vibration rarely occur as a result of working and equipment. This implies that quarrying and stone cutting industries cause vibrations. Also, about 75% of the respondents indicated that they are suffering from noise pollution as a result of these operations. In this regard, noise pollution may include noise from vehicle engines, loading and unloading of rock into steel dumpers, chutes, power generation, and other sources. According to figure 10 and field observations, some buildings were observed to have developed different degrees of cracks. These cracks were basically due to strong vibrations coming from rock blasting and other activities within these sites [19].

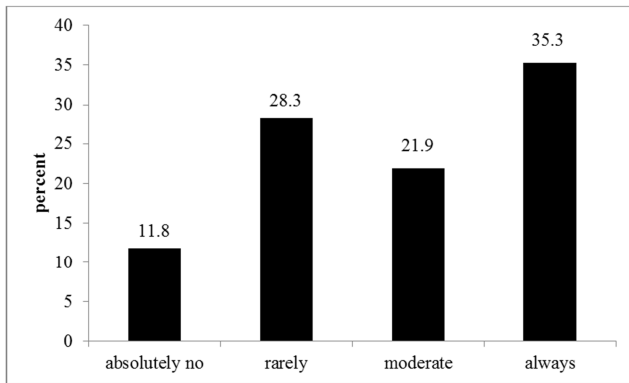


Figure 9. Percentage of respondents about vibrations due to working and equipments.

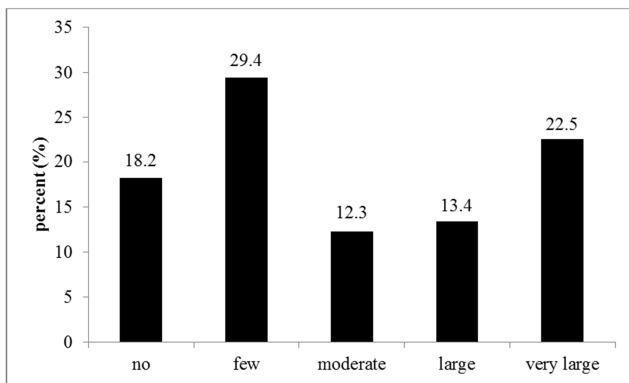


Figure 10. Percentage of respondents about the degree of cracks.

4. Conclusion

It was clear throughout the study that quarries and stone industries have adverse impact on the environment and human health. The most impact is attributed to the generated particulate matter (dust) as a result of the different activities associated with these industries. High concentrations of different particulate matter were found in the study area, and this was reflected and confirmed by residents in the surrounding as most of the respondents (70%) confirmed that air is permanently dusty, and the conditions are not limited to working hours, where higher effects are normally noticed in summer season. Also, the study showed that these industries have negative impact on water resources, and about 68% of the respondents confirmed that groundwater is polluted as a result of these industries and their wastes. Concerning the health situation, the study demonstrated that there is high prevalent rate of diseases caused as a result of these industries and particularly due to air pollution; cough and cold, dyspnea, inflammation of nasal, Asthma and hearing impairment due to noise pollution were the most prevalent diseases. Therefore, and according to the aforementioned findings, an environmental management and mitigation solutions should be considered for sustainable utilization of these resources without harming the environment and humans.

Acknowledgement

The author would like to thank Eng. Othman Abdulrahman for his effort in data collection; also he would like to thank Mr. Nasouh Sous for statistical analysis of the data.

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