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Assessment and Mitigation of Respiratory Health Risks Associated with Dust Exposure in Construction Sites – A Case Based Study

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ABSTRACT

Nowadays, the issue of construction activities dust has become a major concern for all workers due to its risks in terms of lung diseases, cancer, asthma and silicosis. Annually, many workers lose their lives and working time, due to the improper management of hazardous dust emissions. Specifically, this study aims to evaluate the dust emissions from road construction site activities in Gala express road, Muscat. The study used two data collection methods including a questionnaire to explore workers' knowledge on the status of dust emissions, as well a field experiment in which dust was monitored by a special device to explore the highest construction activity, that generates dusts. The study found that dust in transportation of construction materials by heavy trucks (track out) has recorded the maximum value of dust emissions, followed by surface preparation (earthworks), and the function of mortar mixers, respectively. It obvious that increased wind speed have increase the rate of dust emissions within these activities. On the other hand, the questionnaire reveals the poor awareness of dust hazards amongst workforces and the inadequate management of controlling dust hazards in terms of the variation of designing much more measures to reduce dusts. According to findings, 82% Responses indicate the need to improve dust control procedures, which still weak compared to other risks in the site.

Keywords: Road Construction, Dust Emission, Dust Control measures, Wind Direction.

1. INTRODUCTION

According to Health and Safety Executive [1] Every year over 1000 worker are believed to lose their lives due to lung diseases, which caused by dust emissions. Construction works could pose a serious risk by creating large amounts of dust particles, which present a significant risk for workers in terms of lung diseases, and other health effects such as asthma, lung cancer and silicosis. Numerous activities such as demolition, construction, blasting, the use of power tools such as breakers, saws and grinders as well as the movement of heavy trucks, creates large amount of dusts, which can lead to a serious hazard, especially when working in poor ventilated areas. Significantly, this reflects the need to raise the awareness and concern of dust risk management within different construction cultures to minimize the hazardous dusts.

Thousands of workers lose their lives as a result of respiratory and lung diseases, which caused by dust. Nij et al, [2] agreed that construction activities could cause a range of serious risks to create high levels of dust particles that can influence the health of workers in terms of asthma, silicosis and lung cancer. Rizq [3] stated in his research that prevention, suppression and containment are the 3 principles that need to be established as guidelines. When undertaking a demolition, the contractors need to remove all harmful pollutants emitted from construction. Dr. Jitrapun [4], has studied that measures for minimizing of dust impacts from a construction site in Bangkok have studied the activities that are causing dust emission, for evaluating construction dust emission and finding suitable control measures to minimize impact of dust from construction. According to Gamhan [5], air quality matters a lot and due to this purpose strict measures are taken and the air pollution does not only harm the environment but also the wellbeing of an individual. In London,

certain objectives are already set out for the people the follow to reduce the dust emission. Zhang [6], stated that the development of economy in china rapidly that lead to continue acceleration of urbanization and increases the construction projects in few time has caused environmental pollution issues. According to Hassan [7], the impact of particulate matter is depending on some factors like, construction site's size, weather conditions, the wind speed and direction, activities duration, and existence of plants and people. Planning.gov [8], confirmed that, weak guidelines used for construction sites, does not only affect the environment with dust emission but can cause death of innocent lives. Practices like watering down the affected area can reduce emission. According to Thomas [9], few courts have suggested that the contractors must be fined if they are not taking fundamental precautions and confirmed that water sprays are an effective method to reduce the dust emissions to an extent. Hong [10] studied that, establishing real-time monitoring devices that will help the contractors to identify effects of the environmental issues and economic issues that are produced during the construction phase. Narayana [11] agreed that dust could be controlled by setting up a wall of mesh to reduce or prevent the diffusion of dust while using construction equipment and machines such as concrete mixer, cutting of wood tasks. Another positive stage is to offer electrical equipment, which have sprinkle system to minimize dust instead of manual operations.

2. METHODOLOGY

2.1 Study area

The study was conducted in Muscat, specifically Gala Express Road, the study area was selected to be a road construction site, with a range of activities, including transportation of construction materials, functions construction equipment and earthworks. As normal dry weather, dust

emissions becomes a serious environmental concern in different regions in Muscat. In this study, dust measurement was taken February, when the road was under construction.

Fig.1 Location of road construction site

2.2 Study Population

During the period of data collection, the study involved a selected group of foreign workers from Galfar company, they working under a temporary contract for six months to construct the road. A sample of 25 workers (including site manager, construction workers and truck drivers) were selected to complete a questionnaire based on their work practices.

2.3 Data Collection

Questionnaires were distributed to explore the workers' knowledge on the status of dust emissions, in this, questions were delivered as a hard copy, as some foreign workers, did not have enough experience on emailed online questionnaire, however, they answered all questions within 2 days of submission. The questionnaire consisted of 15 questions, with different format. All questions were designed using a simple rating scale and multiple-choice questions, to completed it in an easy way. In general, the survey was divided into three main sections, including awareness of construction dust risk, applicable of control measures, and the involvement of workface into dust

issues. The general information section covered demographic data including age, gender, and nationality. In relation to questionnaire validity, a simple pilot interview was conducted, in that workers gave their feedback about the issue of dust emissions, as this information could help in interpreting the gained results and forming the questions.

2.4 Experiment method

The experiment was carried out in a road construction site located in Gala express road. data collected in February 2020, was analysed to measure the value to dust emissions across different three activates including transportation of construction materials, by heavy trucks, functions of mortar mixers and surface preparation (earthworks). A dust monitoring device (HAZ-DUST EPAM 5000) was used to measure the value of dusts. The device designed to measure ambient air pollution (airborne particles) in mg/m^3. The maximum and minimum values were monitored for five days at intervals of 30 minutes during the day in order to measure each activity separately and monitoring the effect of wind speed and its direction on dust emission from that activities by digital anemometer MS625A – Wind meter that is used to measure air velocity, and wind van will be used to determine the direction of wind. To ensure validity, a repetition of experiment procedures was ensured to avoid errors or any uncontrolled condition that may skew data results.

3. Results

3.1 Experiment findings

The table shows the values of three main activities that generates dusts.

Type of activity	Amount of dust mg/m^3	Risk level
Earthworks – surface preparation	201.9	High

Track out - Transportation of materials by heavy trucks	235.3	High
Function of mortar mixers	174.2	High

Risk levels as demonstrated in the dust monitoring device., as noted in the device dust concertation should not exceeding 12.0 mg/m^3 (Appendix 1).

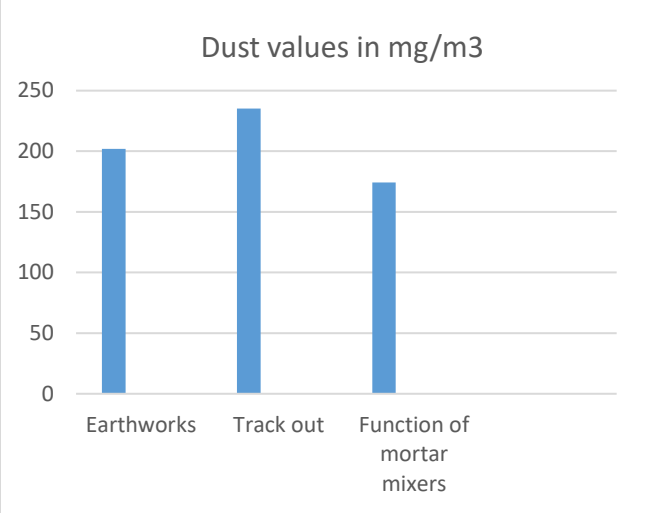

Fig.2 Dust Emission Values

From the chart, it can be inferred that transportation of construction materials, by heavy trucks (track out) has recorded the maximum value of dust emissions by 235.3 mg/m^3, followed by surface preparation (201.9 mg/m^3), and the function of mortar mixers (174.2 mg/m^3), respectively.

3.2 Dust, wind direction and speed

Date	Type of activity	Amount of dust mg/m^3	Wind speed km/hr
31.01.2020	Earthworks – surface preparation	201.9	5.5
	Transportation of materials by heavy trucks	235.3	5.3

	Concrete mixers	174.2	5.3
01.02.2020	Earthworks – surface preparation	198.6	3.5
	Transportation of materials by heavy trucks	221.4	3.5
	Concrete mixers	163.1	3.4
02.02.2020	Earthworks – surface preparation	192.4	3.1
	Transportation of materials by heavy trucks	220.1	3.1
	Concrete mixers	161.4	3.1
03.02.2020	Earthworks – surface preparation	199.8	3.8
	Transportation of materials by heavy trucks	226.1	3.8
	Concrete mixers	166.2	3.8
04.02.2020	Earthworks – surface preparation	192.1	3.1
	Transportation of materials by heavy trucks	222.8	3.2
	Concrete mixers	163.4	3.1

The results show that dust emissions increased significantly with wind velocity increasing. It was obvious that the site become dustier with the increase wind movement, especially in high windy days, for instance, first day measurement recorded the highest amount of dust emissions by a wind speed of 5.5. However, wind direction was stable at north-northeast at all five days.

The first day recorded highest amount of dust and wind speed followed by the fourth day, as these values have decreased in the second, third and fifth day due to the drop-in wind speed values, as shows in the table. In general, the results reflected that construction dust emissions can be influenced by wind speed and wind direction, as it varies from one value to other depending on the weather condition.

3.3 Findings from Questionnaire Survey

According to findings, the questionnaire was completed successfully by 25 workers, of whom 100% male. Many respondents were (76%) workers, (20%) truck drivers, (4%) operator mangers. In general, (81%) of workers were above 25 years of age, while (19%) were older years 35 years

S. No	Factors	Level of Agreement
Awareness of Construction Dust		
1.	Level of awareness towards dust related issue, regulations and its control measure	Very aware 4%, Slightly aware 8%, 4% Unsure, 84% Unaware
2.	Requirement of visual attention towards the risk of construction activities	Yes – 83%, No -17%
3.	Health surveillance check	Yes 0%, No-100%
Construction Activities		
4.	Highest dust emission	Track out 79%, Site preparation – 9%, Mixer – 8%, Other 4%
5.	Control measures for noise	Water suppression – 10%, PPE – 9%, Health Surveillance – 4%, Use of barriers – 2%
6.	Respiratory equipment	All times – 92%, Sometimes – 8%

7.	PPE	Disposal mask – 100%
8.	Need for dust control	Yes – 100%
Involvement of workers in HSE practices		
9.	Involvement of dust related discussion/meeting	Never – 84%, Rarely 12%, Sometime 4%
10.	Induction on dust	No – 100%
11.	Toolbox talk	Yes – 15%, No – 85%
12.	Need for HSE practices to reduce dust	Yes - 87%, No – 13%

3.4 Determination of Dust in Construction Activities

The results show that there is a clear relationship between dust emissions and wind speed, as increased wind speed can lead to increase the value of dust emissions due to the fast movement of dust particles in the air. It is important to manage several effective dust control measures in more windy days, such as take rests or break and apply water suppression system to minimize the levels of dusts on the site.

The data show that the dust in transportation of construction materials, by heavy trucks (track out) has recorded the maximum value of dust emissions, followed by surface preparation (earthworks), and the function of mortar mixers, respectively. There is a significant need to set up a series of actions to control dust emissions, as the results indicated that the majority of values have accessed the safety standard measurement (12.0 mg/m3), which can impact worker's health, during their 6 months period of work. The results show that the impact of hazardous dust is high, specifically, workforces have an incredibly risk of developing severe respiratory diseases. These findings support the statement of Health and Safety Executive [12] that tiny dust particles can get deep into

the respiratory system to cause a number of severe effects including lung cancer and asthma attacks. In this context, there is a need for regular health surveillance to check and detect any ill-health impact, at an early stage to provide a set of effective control measures to protect workers and evaluate sever dust related risks. The issue of track out and earthworks activities can be managed easily by improving the condition of roads in construction area by the use of sprinkle water systems into dry surfaces to reduce the release of visible hazardous dust. The key important measure in minimizing the effects of dust in transporting, it to practice covered trucks, as this stage will reduce the amounts of high emissions during the routine movement of construction materials. Setting up a mesh or wall will also prevent the diffusion of dust during the use of construction machinery and equipment such as mortar mixers. The function of some construction machinery would be controlled by increasing the safe distance between the machinery and worker, as well as use suitable respiratory protective mask to reduce the exposure of tiny hazardous dust. In addition, facilitate the use of standard electrical machines instead of manual operations, which have sprinkle system to damp down the dust. Having a good management will enhance the role of safety practices in which can cover a range of planned procedures including arrangement of safety inductions, in which the issue of dust will be monitored efficiently. Significantly, this will reflect a positive overview amongst workers to perform their work in a safe manner. Apart from this, supervisors should have a proper attention to deal with various construction activities by monitoring the site to set up daily records of the occurrence of dusts, it causes, the time of emissions and resolutions.

3.5 Workers' knowledge on the status of dust emissions

According to results, 84% respondents indicate that there is a poor risk awareness among the workers. The finding demonstrated that workers did not notice any signs of improvements begin

made by the Site manager in terms of construction risk awareness, and construction regulations, even they did not receive health surveillance checks in terms of lung illnesses. On the other hand, the data indicates that dust is not seen as a priority hazard concerned in construction site, as workers paid more attentions towards the danger of falls hazards, as showed in text free box of the questionnaire. 83% respondents viewed the need of control dust emissions as a priority. In relation to the gained data, there is a priority for health issues to minimize the dust and find suitable health care for works through involving them into monthly health checks. overall, the results show that older workforces have less risk-awareness attitude compared to younger workers, who have much more progressive attitude and some awareness of dust issue and its health and safety risks. There is a need to promote a positive work culture, as indicated by the questionnaire, however, this must have done by provide the correct instructions, information equipment and training to raise the rate of awareness and worker's concern about the issue of dust activities.

3.6 Construction activities and its suitable control measures

79% of Workers agreed that transportation of construction materials produce large amounts of dust compared to other activity at the site. This reflects the need to control the value of dusts during track out activities. According to results, water can be used effectively to damp down the dust emissions; the majority of workers indicate a positive view on reducing dust effects through water suppression, due its effectiveness. As stated by ikeuchi, [14] water suppression has a set of importance benefits including improve the nature of working environment, as well as it considered as an easy maintenance and low cost control measure, which prevents a range of hazardous airborne contamination and avoid dust defects. According to results, respiratory protection equipment, particularly disposable mask is often used to protect workers from dust risks. All workers agree that water suppression and personal protective equipment pays as a key role

measurement in minimizing the emissions of dust particles during the construction stages. As mentioned by OSHA the use of disposable mask seems to be more useful than other equipment due to various features, as its require no maintenance and cleaning, as well as its light weight and more comfortable to use and wear. In general, managers should also ensure the fit of equipment on workers to perform their work in a proper manner.

3.7 Involvement of workers into construction dust risks and HSE practices

Data shows that there is an inadequate management arrangement to follow the instruction given and there is an effective lack of workforce involvement into dust-related issues. The results also indicate that workforce involvement is far from the regular management routine. The management should provide a planned strategy to protect the workers and involve them into regular health and safety program as many of these comments could be covered by toolbox talks and indications.

4.CONCLUSION

The results highlight a number of issues that needs to be addressed effectively, in this context; the questionnaire has introduced an overview of the way that construction workers manage dust issues. The findings reflect a negative picture of numerous issues. In details, it reveals the poor awareness of dust risks amongst workforces and the inadequate management of controlling dust hazards in terms of the variation of designing much more measures to minimize dust emissions.

Responses indicate the need to improve dust control management, which still weak compared to other hazards in the site. For instance, improve the knowledge of several types of dusts such as silica to cover its impacts on workers and construction culture, as well enhance the encouragement of toolbox talk and inductions regularly.

The results show that the dust in transportation of construction materials, by heavy trucks (track out) has recorded the maximum value of dust emissions, followed by surface preparation (earthworks), and the function of mortar mixers, respectively. In this context, this reflects the need to provide a set of control measures to reduce hazardous dusts and manage construction activities to produce less dust by monitoring the nature of activities and equipment. Furthermore, increased wind speed can influence the value of dust emissions to cause serious health effects on workers, as recorded; transportation of construction materials has the highest value of wind speed and dust emissions across all activities.

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Appendix 1

AQI Standards

AQI Category	Index Values	Previous Breakpoints (1999 AQI) ($\mu g/m^3$, 24-hour average)	Revised Breakpoints ($\mu g/m^3$, 24-hour average)
Good	0 - 50	0.0 - 15.0	0.0 – 12.0
Moderate	51 - 100	>15.0 - 40	12.1 – 35.4
Unhealthy for Sensitive Groups	101 – 150	>40 – 65	35.5 – 55.4
Unhealthy	151 – 200	> 65 – 150	55.5 – 150.4
Very Unhealthy	201 – 300	> 150 – 250	150.5 – 250.4
Hazardous	301 – 400	> 250 – 350	250.5 – 350.4
	401 – 500	> 350 – 500	350.5 – 500

Note: the data in tabel are from *Revised Air Quality Standards For Particle Pollution And Updates To The Air Quality Index (AQI*), (The National Ambient Air Quality Standards for Particle Pollution,nd)