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A STUDY ON THE OCCUPATIONAL HEALTH IN THE CONSTRUCTION SITE OF THE NEW ASSIUT BARRAGE

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ABSTRACT

The purpose of the present investigation is to study physical and chemical hazards in the workplaces in additional to Indoor Air Quality (IAQ) within the administration areas. Noise, dust, vibration, heat stress, and illumination were examined in the New Assiut Barrage Project, Egypt. The project is established to enhance irrigation, economy, and development with estimated energy production of 32 Mega Watt. Average measured values of Physical and chemical factors for noise, Total Suspended Particulates (TSP), PM_{10}, and vibration were 79 dB (A), 7 mg/m^3, 2.1 mg/m^3 and 6.4 m/s^2 respectively. IAQ was evaluated by testing the concentrations of PM_{10}, temperature and relative humidity in the offices additional to noise and illumination. Risk assessment of the workplace was carried out to assess the most important hazards that may threaten worker's health. A simple/flexible modified risk assessment model was used in this study to evaluate the occupational hazards caused by chemical and physical factors. The model is divided mainly into two models; based on workplaces factors and IAQ in enclosed areas. Each model has five segments from No risk to Not allowable risk according to the measured values and hazard type. The results of the risk assessment are used to avoid the negative effects of the workplace on the employees as well as to assess the comfortable degree in the administration areas.

Keywords: Noise, Total Particulate Matters, Occupational Health, Construction Barrages, Risk Assessment

1. Introduction

Problems of occupational health both for chemical and physical hazards are companion with the construction projects [1, 2]. Hazard is defined as the potential to cause harm, while risk is known as the possibility of loss, injury, disadvantage, or destruction. Risk assessment is the severity multiplied by the consequences [3-5]. Risk assessment in the construction sites is essential to ensure a safe working environment and to reduce the losses during working activities. Also, keeping good indoor air quality is a prime factor for comfortable and performance of administrators. Several chemical and physical hazards are emitted during the construction of the new Assiut Barrage. The construction works include several activities such as digging, excavating, welding, cutting, drilling, loading, unloading and polishing among others.

Poor air quality in the construction projects occurs primarily due to Total Suspended Particulate matter (TSP) which is created from various activities in the workplace. TSP is a mixture of solid particles e.g., dust, dirt, soot, and smoke, while the more particular health concern is particulate matter with size less than 10 μm (PM_{10}) [6-8]. Several studies have shown that PM_{10} penetrate deeply into the lungs and cause a wide range of health problems such as respiratory illness, asthma, bronchitis and even cancer [9, 10]. Welding is a common unit operation in the construction industry, where frequent changes in location and welding position make it more difficult to control the emitted fumes. Therefore, welders may be exposed to a variety of toxic airborne contaminants including heavy metals and organic volatile materials [11]. Noise exposure is the second risk factor after TSP in the construction sites. The noise-induced hearing loss results from a continuous exposure to high levels of sound [12, 13]. Even though long exposure to high noise levels causes a harmful; it is usually companioning with the vibration problem. Hand Arm Vibration is transmitted from work processes into workers hands and arms. Vibration has negative effects on the mussels, bones, and nerves, and causes white fingers [14].

Indoor air Quality (IAQ) refers to the air quality within and around buildings and construction projects especially as it relates to health and comfort of workplaces occupants. Understanding and controlling common pollutants indoors and outdoors can help in reducing risk of indoor health concerns [15, 16].There is growing public awareness regarding the risk associated with poor indoor air quality in buildings and workplaces. Health risks from indoor air pollution are likely to be greatest in developing countries [17, 18]. The quality of indoor air inside offices, and other workplaces is important not only for workers comfort and performance but also for their health [19]. Poor indoor air quality has been tied to symptoms like headaches, fatigue, trouble concentrating, and irritation of the eyes, nose, throat and lungs [20].

1.1. Objectives of this Study

This research was carried out to assess the occupational hazards in the construction site of the New Assiut Barrage and similar future projects to protect workers from occupational illnesses and reduce the losses. In addition the study aims to assess the indoor air quality and the factors of indoor environmental stressors in the offices. Modifying and testing the existing risk assessment models to be suitable and applicable for the Egyptian conditions is the main aim of this study.

1.2. Observations and Questions

In the construction sites several chemical and physical hazards are emitted. In addition, the awareness of workers with the occupational health is weak in developed countries even talk box training is given daily. This problem can be solved if we reduce the chemical and physical hazards from the sources. To reduce these hazards, we have to assess the amount of it by using the suitable risk assessment models. Although, there is several risk assessment models, these models are designed for environment that is different than the Egyptian cases. This research focuses on these models and how to modify them to be suitable and applicable for the Egyptian environments.

1.3. Research hypothesis

The Egyptian environment and working conditions is varying than working conditions in other countries especially the western places. The research hypothecs is that the known risk assessment models for occupational health is not suitable to assess the amount of work hazards in the developed countries and have to be modified. Also, the working methods, the degree of training and the culture of the employees are less quality than that in western countries.

According to these conditions, the expected chemical and physical hazards emitted from the work activities are high and the expected harms on the worker's health are not acceptable.

1.4. Methodology

The methodology of this investigation consists of several steps. The first step is to survey the study area to inspect the different work activities and the types of physical and chemical hazards emitted from each activity. Measurements also were carried out during the working hours to record the levels of hazardous factors. Comparison between the measured levels in the working environment and local legislation was also implemented and discussed. The modified simple risk assessments models was used to determine the amount of threaten on the workers and to help the decision makers to take the suitable corrective measures. This research was applied on the construction site of the new Assiut barrage.

2. Measurements and theoretical models

Methods of measurements and used devices are explained in the following sections. Also, description of the study area and the theoretical risk assessment models are also detailed.

2.1. Study area

Assiut governorate is stretches for about 120 km along the banks of the river Nile. The capital of the governorate is the city of Assiut. It has latitude of 27^{0} $19^{'}$ $60^{''}$ N and a longitude of 30^{o} 49' 60 E. Such location is 365 kilometers south of the capital Cairo as illustrated in Fig. 1. The map in Fig. 1 is created by the author using Geographic Information System (GIS) and the coordinates of the construction site. The old Assiut Barrage was constructed between 1892 and 1902 to sustain a water level difference of about 4 m in order to feed the Ibrahimia Canal. The New Assiut Barrage and its Hydropower Plant was initiated at May, 2012 and it is suggested to end in December, 2017 [21]. The project is considered as one of the most important industrial projects that established to enhance economy and development in Egypt in recent years. The new Barrage is constructed 350 m downstream of the old barrage with power generating capabilities of total capacity 32 MW [22, 29]. The climate in Assiut city is mostly a semi-desert territory, is hot in summer and cold in winter. However, temperatures vary significantly from nighttime to daytime [23].

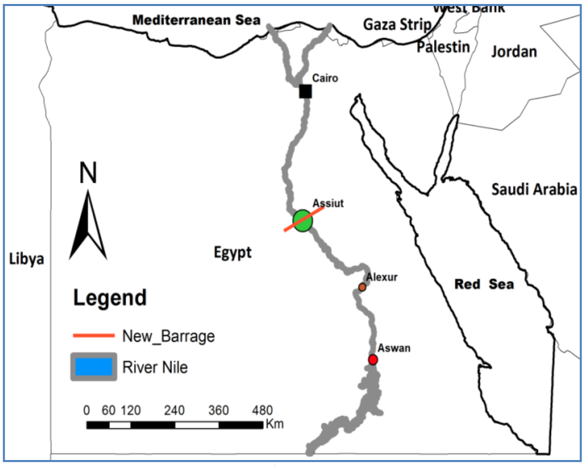

Fig. 1. location of the New Assiut Barrage

2.2. Measurements

The main chemical hazards such as TSP, PM_{10}, and total volatile organic components were measured using advanced devices. Noise, Vibration, and Illumination were also measured in the workplaces along two years. Chemical and physical factors are measuring each three months from November 2015 to the end of the project at different work activities such as drilling, welding, cutting, polishing, loading and unloading among others. Factors of IAQ were measured in the administrated areas such as PM_{10}, temperature and relative humidity expressed as WBGT. In additional, indoor environmental stressors such as lighting intensity and noise were also measured in the administration building.

2.3. Devices used in the measurements

Several advanced devices were used to measure the chemical and physical factors as illustrated in the table (1).

Table 1.
Types of environmental and safety measurements used in this study

Dust Detective: DustPro CEL-712 Casella Co. The device cam measure the following Parameters, TSP, PM_{10} and $PM_{2.5}$	
Sound Level Meter IEC 61672-2002 CLASS 2 -Fast, Slow, Impulse. - Measurement range: from 30dB to 130dB. - A/C/Z frequency	
Heat Stress- TENMARS TM-188D. The device can measure the following parameters for: • Wet bulb globe temperature (WBGT), • Black globe temperature(TG), • Humidity(%RH), • Air Temperature(TA), • Wet bulb(WET) and	

Light intensity meter. The device can measure the intensity of light in (Lux)	
Vibration meter measures hand and arm vibrations in m/s.	

2.4. Theoretical Model of the Risk Assessment

An analytical model based on the simple/flexible risk assessment method of the examined occupational hazards presented by Reinhold and Tint (2009) [24], was modified in this study. The modified model is divided into two sectors; the first model for workplaces and the second for IAQ in the enclosed areas. The model for workplaces is analyzing the risk assessment for several factors such as TSP, PM_{10}, Total Volatile Organic Components (TVOCs), Vibration, and Noise. Instead of using temperature and humidity to examine the indoor air quality, this study used the measured Wet Bulb Globe Temperature (WBGT) [25, 26]. In addition, other factors are added to the indoor air quality study to assess indoor environmental stressors such as illumination intensity and noise levels. Figures 2&3 presented the two modified models and its limited values based on workplaces and enclosed areas respectively. The limit value of each risk degree is assigned according to the impact of chemical or physical hazard on the human health as given by Reinhold and Tint (2009) [24].

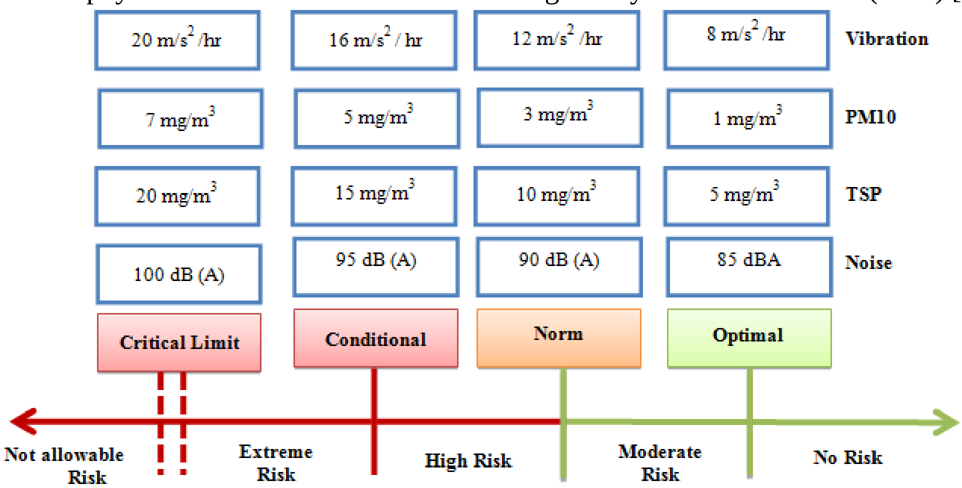

Fig. 2. Risk assessment model applied in workplaces [24, 27]

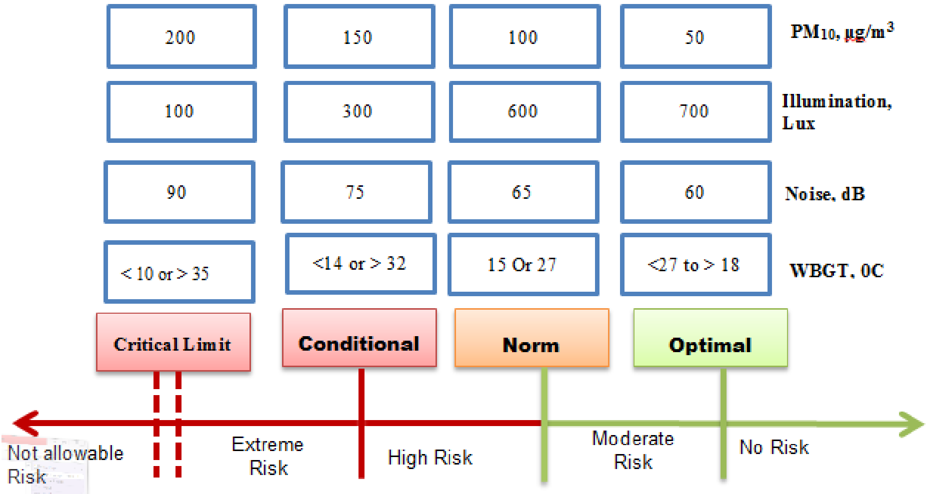

Fig. 3. Modified risk assessment model applied for IAQ factors in addition to noise levels and intensity of light in administration areas [24, 27]

3. Results and Discussion

Assessment of the occupational health in workplaces was carried out to stand with the most important hazards that may threaten workers and help to avoid defects on working operations and to protect workers from occupational illnesses and reduce the losses of working days. The main construction works in the new Barrage include constitute the hydraulic gates, construct the two navigation routes, construct traffic bridge, filling the west bank, and lining the downstream island. Workers activities during the normal shifts are welding, cutting, drilling, loading and unloading among others. Workers are subjected to various chemical and physical hazards such as dust, fumes, noise, and vibration that emitted from work activities. The emitted factors are measured periodically by the Health, Safety and Environment (HSE) team. Also a certified company is carrying out the measurements each three months. Minimum, maximum and average of chemical and physical factors are presented in Table (2) in addition to the accepted limits by Environmental Egyptian Law (EEL4/94) [30] and Egyptian Labor Law (ELL12/2003) [31]. The statistics include the measurements from November 2015 to the end of 2016. The measurements were compared with the Threshold Limit Value -Time Weighted Average (TLV-TWA). TLV-TWA is average concentration for a normal 8 hour workday or 40-hour workweek to which nearly all workers may be repeatedly exposed, day after day, without adverse effect [28].

Table 2.
Statistical analysis of the measured chemical and physical factors

	Factor	No of Measurements	Min	Max	Average	TLV-TWA
Working areas	TSP, mg/m^3	24	0.09	95.4	6.9	10
	PM_{10}, mg/m^3	24	0.03	28.6	2.1	3
	TVOCs	11	0.50	4.82	2.2	50
	Noise, dB	50	54.6	106.5	79.6	90
	Vibration	7	1.3	22.1	6.4	5
	Illumination	10	279	827.6	588.9	323

	Factor	No of Measurements	Min	Max	Average	TLV-TWA
	WBGT, ^{0}C	3	12.4	15.9	14.5	15 W, 25 S
Administration Area	PM_{10}, μg/m^3	12	70	95	114	100
	Noise, dB	21	46.1	66	54.8	65
	Illumination	21	766	1755	1089.4	753
	WBGT, ^{0}C	5	16.3	21.8	18.3	15 W, 27 S

*Heat stress measurements are carried only in the last winter (2017), W=winter, S=Summer

Total Suspended Particulates (TSP) was measured in the working environment in several sites and at different activities. The locations of measurements included workshops, warehouses, and various locations within the construction area. The maximum measured value in the construction area was greater than the allowable limit assigned by EEL4/94 [30]. During the polishing, the recorded TSP was 95.4 mg/m^3 that meet Not Allowable risk based on the risk assessment model presented in Fig 2. At assembling navigator gates, the measured values of TSP were 13.6, 12.9, and 6.7 mg/m^3 in different times where the activities included drilling, welding, and cutting respectively. The recorded values in these places match High Risk to Moderate Risk according to the risk assessment model. PM_{10} is called also respirable dust; its recorded values are ranging from 0.03 mg/m^3 to 28.6 mg/m^3. The greatest measured value was found during polishing process that meets Not Allowable risk according to the model presented in Fig 2. In addition, significant values were found at other working activities, for example 4.08, mg/m^3 3.88 mg/m^3, and 2.7 mg/m^3 are recorded during gates construction that meet Moderate to High risk on the workers.

Noise induced hearing loss is inherent in the construction projects; therefore noise levels are measured usually in the various workplaces. Maximum noise levels were found during cutting processes and recorded more than 106 dB(A) as shown in Table (2). Fourteen average readings were more than the permissible levels (90 dB) assigned by national legislation that meet High to Not Allowable risk on workers based on the model in Fig 2. Vibration usually is produced companion with the noise; Hand and Arm vibration is measured periodically to assess the amount of its physical hazard on workers. Working on vibration machines is usually occurring for short times not than 15 minutes continuously. A maximum-recorded value was 22.1 m/s^2 while the rest of measurements were less than the permissible levels. As most of the cutting machines are fixed devices on the ground, threaten by vibrations is not expected.

Total Volatile Organic Compounds (TVOCs) are produced mainly from welding workings. TVOCs contain different types of elements, where their measurements were less than the assigned limit (50 mg/m^3) as presented in Table (2). The intensity of illumination also assessed in the workplaces to evaluate the comfortable of workers. All the recorded values were within the permissible limits. Heat Stress expressed as WBGT was thought by site managers that it has no important effects on workers. However, in the arid areas like Upper Egypt, heat stress may impose heat strain on the workers especially in the summer season. Unfortunately, WBGT was measured only in the last winter and the results are presented in Table (2). Minimum value of WBGT is recorded 12.4 ^{0}C that less than the accepted limit for winter (15 ^{0}C). Warm clothes is required for workers as they working under the water level of the Nile river where the temperature is lower than the acceptable limit and the air conditioning is unsuitable to be installed during the construction stages.

Indoor Air Quality (IAQ) is the first factor that affects the performance and comfortable of employees. The main measured parameters of IAQ in this investigation are Heat Stress expressed as WBGT and PM_{10}. Also, indoor environmental stressors such as lighting intensity and noise level in the enclosed offices were measured and their values are presented in Table (2). Measurements of IAQ factors in the enclosed administration area are carried out each three months except Heat Stress that had no concern or measured until the last winter of 2017. Most of measured physical hazards levels are within the accepted limits. The maximum noise levels recorded 66 dB while the accepted limit is 65 dB. In addition, illumination intensity is sufficient and within the accepted values as shown in Table (2). All the offices are supplies with air conditioning that provide the places with required heat in the winter and cooling system in the summer. In some places, PM_{10} recorded values were greater than the acceptable levels as given in Table (2). The main source of PM_{10} is the safety shoes and clothes of managers or engineers when they are coming from the construction site loaded with dust particles. Although, the maximum measured value was slightly greater than the acceptable limit and meet Moderate risk according to the risk model in Fig 2. Double door is required to decrease its concentrations to the accepted value inside the offices.

4. Conclusion and Recommendations

Construction projects are essential for development and enhance the economic for any country. During the implementation of projects, assessment of chemical and physical hazards is a vital factor to decrease the acute chronic diseases, and losses of working days. Risk assessment model for construction works is required to determine the degree of threaten on the workers, to help the managers to take the corrective actions before accidents and to prevent the expected losses. The modified risk assessment model is suitable for this study in addition to similar construction sites to assess the degree of risks in the workplaces. Measured concentrations of TSP and PM_{10} were more than the permissible limits and can create health hazards on the employees. Failure of respiratory system can be avoided by reducing the direct exposure of workers to dust and airborne particles and provide them with suitable protective personnel equipment like masks and air supplies. Personal Protective equipment has to be provided for all workers especially air masks to reduce the negative effects of working activities on the workers. Also, workers have to obey the safety rules and they need more training and awareness with the importance of the safety issues.

From this study we recommend to use the risk assessment models to determine the amount of threatens on the work's health due to the working conditions. Also, continuous measurements of the chemical and physical factors are essential in any construction site to assess the amount of emission from different activities. Although, Personal Protective Equipment (PPE) is the last defense for protecting workers, I recommend that any employer have to provide their employees with the suitable PPE. Heat stress has to be measured expressed as WBGT during summer seasons and application the limits of EEL4/1994 [30] is essential to protect the workers from heat stroke.

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دراسة حول الصحة المهنية في موقع إنشاء قناطر اسيوط الجديدة

الملخص العربي

الغرض من هذا البحث هو دراسة مدى تعرض العاملين في مواقع الإنشاء لمخاطر العمل الفيزيائية و الكيميائية المنبعثة من الأنشطة المختلفة. كذلك دراسة جودة الهواء للإداريين داخل مواقع الإنشاء. في هذه الدراسة تم تقييم الضوضاء, الأتربة, التعرض الشخصي للاهتزازات, الوطأة الحرارية و شدة الاستضاءة في بيئة العمل لموقع انشاء خزان أسيوط الجديد. أقيم المشروع ليحل محل القناطر القديمة و ذلك بهدف خدمة الري و توليد طاقة كهربائية نظيفة تقدر ب 32 ميجا وات. متوسط قياسات العوامل الكيميائية و الفيزيائية في بيئة العمل كانت 79 ديسيبل للضوضاء، 7 مجم/م^3 للأتربة الكلية, 2.1 مجم/م^3 الأتربة المستنشقة و 6.4 م/ث^2 للاهتزازات. كذلك تم دراسة جودة الهواء في الأماكن الإدارية بقياس الأتربة المستنشقة و الوطأة الحرارية. كما تم قياس عوامل الضغط البيئية متمثلة في مستوى الضوضاء و شدة الاستضاءة. تقييم المخاطر على الصحة المهنية في بيئة العمل تمت دراستها عن طريق إستخدام نموذج لتحديد مقدار الخطورة لكل عنصر. تم استخدام نموذج سابق بعد تعديله ليتوافق مع الحالة المصرية و حالة الدراسة. النموذج يتكون من جزئيين رئيسيين أولهما يستخدم في بيئة العمل و الآخر يستخدم في المناطق الادارية. يقسم كل واحد منهم الى خمس درجات من ناحية الخطورة تبدأ ب **لا يوجد** و تنتهي ب **خطورة غير مقبولة**. النموذج المعدل و نتائجه طبق على حالة الدراسة في هذا البحث و يمكن استخدامه في مواقع العمل المصرية لدراسة تأثر مدى تعرض العاملين لمخاطر الصحة المهنية.

الكلمات الدالة: الضوضاء - الصحة المهنية - الأتربة الكلية المعلقة - مواقع الأنشاء- تقييم المخاطر