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Assessment of respiratory effects of cement dust on exposed and unexposed citizens in Rabak City, Sudan

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Abstract

Globally, the cement industry has been identified as a factor which causes significant pollution. This study is conducted to assess the respiratory effects of cement dust on exposed and unexposed citizens in Rabak city, Sudan. This descriptive cross- sectional study was carried out in Rabak city. 134 samples were taken from the population living near the Factory (exposed) and population living far from the factory (unexposed). The respiratory symptoms experienced, were scored and recorded using BMRC questionnaire on respiratory symptoms. The lung function measurements were performed using a portable Spirometer. The respiratory measurements of the subjects were Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1) and Forced Expiratory Volume ratio (FEV1%). The results of the study showed that: there was significant reduction in the mean values of ventilatory function parameters: FVC (2.9097), FEV1 (2.5718) and FEV1% (87.4743) in the exposed group compared with the FVC (3.1175), FEV1 (2.8296) and FEV1% (90.7985) in unexposed group in the study area ($P < 0.05$). The majority of the exposed citizens were infected by allergy 41.0%. The Factory Management should further provide the latest technologies to reduce industrial emissions to protect the environment and population living around the Factory.

Keywords: Respiratory effects; Cement dust; Exposed citizens; Rabak city; Sudan

1. Introduction

Cement is one of the most widely used substances on earth. Making cement is an energy and resource intensive process with both local and global environmental, health and safety impacts. WHO has estimated that, close to 6.4 million years of healthy life are lost due to long-term exposure to ambient particulate matter worldwide [1].

Cement industry caused environmental impacts at all stages of the process in the area. These include emissions of airborne pollution in the form of dust, gases, noise and vibration when operating machinery and during blasting in quarries, and damage to the countryside from quarrying [2]. Generally cement plants are known to be associated with exposure to quartz, cement, and dust, which can potentially contribute to Chronic Bronchitis, Silicosis and lung diseases.

The impacts of cement industry are countless and it even did not spare humans from its deteriorating impacts and have adversely impacted the health of workers. Exposure to cement pollution has been linked to a number of different health outcomes, starting from modest transient changes in the respiratory tract and impaired pulmonary function, passing to restricted activity or reduced performance, emergency room visits, hospital admissions and death [3][4]. The most severe effects in terms of the overall health burden include a significant reduction in life expectancy of the average population of workers by a month or more, which is linked to the long-term exposure to high levels of air pollution with

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particulate matter from these cement industries [5]. Nanomedicines attained wide acclamation in their initial years, but the transformation from being the proof of concept to successfully marketed products seems very daunting. Although the reason for this may be attributed to slow but incremental character of many present-day technologies, i.e. cement production [6].

Air pollution is an important problem in industrial areas which may have an adverse effect on the health of the population. Air pollution is due to the discharge of toxic fumes, gases, smoke and dusts into the atmosphere. Air pollution in urban regions receiving increasing concern worldwide, especially pollution by gaseous and particulate trace metals [7]. Numerous studies and the lack of effective policies reveal that air pollution continues to threaten public health [8].

In Rabak city residential area neighborhoods close to cement plant are constantly exposed to cement manufacturing dust and fumes. The aim of this study of was to assess the respiratory effects of cement dust on exposed and unexposed population in Rabak city in order to advise facilities to minimize any negative impacts.

2. Material and methods

2.1. Study area

Nile Cement Company Limited is the owner of Rabak cement factory which is located in Rabak city. Rabak cement factory was established in 1967 with a capacity of 350 tons per day. The factory facilities occupy an area at a distance of 8.2 km from Rabak city, 300 km south of Khartoum, the capital of the Sudan, where the raw material for cement production is available.

2.2. Study population

Across- sectional study was carried out at Rabak cement factory**.** Samples including exposed group whom live in areas of about 1.05 to 1.38 km around the cement factory. The unexposed group lived about 4.75 to 8.2 km from the cement factory.

2.3. Selection criteria

The citizens that lived more than 5 years in study areas. Pregnant women, smokers, persons and asthmatic persons were excluded.

2.4. Data collection technique and tools

Data were collection through questionnaires that included questions on anthropometric measurements, period of staying in their area, health impact of cement industry, types and symptoms of respiratory diseases and lung function parameter tests. The questionnaire was filled under close supervision to avoid conflicts by the selected subjects.

2.5. Respiratory system measurements

Using the British Medical Research Council (BMRC) questionnaire on respiratory symptoms [9], the lung function tests were performed using a Spirometer. The measurements of the subjects were force vital capacity (FVC), forced expiratory volume in one second (FEV1), and forced expiratory volume ratio (FEV1%), according to the method described by Miller *et al*., [10] and Alagappan [11]. All respiratory function tests were carried out at a fixed time of the day to minimize the diurnal variations by well trained assistants.

2.6. Data analysis and processing

The Statistical Package for Social Sciences (SPSS) was used. Comparison of demographic data among exposed and unexposed citizens was run using means and standard deviation (SD). Chi square test was also calculated.

3. Results

Anthropometric parameters for the total number of exposed and unexposed groups are shown in table (1) indicate that there was no significant differences between the means of anthropometric parameters (age, weight and height) in both groups. It was also noticed that, females were the majority of the participants (56.7%), (54.5%) among exposed and unexposed groups, as shown in Table (2).

Table 1 Anthropometric measurements of exposed and unexposed groups to cement dust in Rabak City

Anthropometric parameters	Exposed group	Unexposed group
	Means ± SD	Means ± SD
Age/years	34.62 ± 11.44	35.22 ± 12.08
Weight/kg	63.75 ± 13.544	64.17 ± 13.538
Height/ cm	168.18 ± 9.451	167.90 ± 9.236

Table 2 Gender of exposed and unexposed groups to cement dust in Rabak City

Sex	Exposed Group		Unexposed Group	
	Frequency	Percent	Frequency	Percent
Male	58	43.3	61	45.5
Female	76	56.7	73	54.5
Total	134	100.0	134	100.0

The majority of the citizens (86.6%) from the exposed group answered that the factory has effects on their health compared to (9.0%) in the unexposed group as shown in Table (3). There was a statistical significance difference between the exposed and unexposed groups on the impact of cement industry on their health $p<0.05$.

The most common types of respiratory diseases that affect the exposed citizens were: Allergy (41.0%), followed by respiratory infection (27.6%). On the other hand the types of respiratory diseases in the unexposed group included allergy (3.7%) and respiratory infection (2.2%), as shown in Table (4).

Table3 Impact of the cement factory in health of the subjects in Rabak City

Answer	Exposed group		Unexposed group	
	Frequency	Percent	Frequency	Percent
Yes	116	86.6	12	9.0
No	18	13.4	122	91.0
Total	134	100.0	134	100.0

Table 4 Type of respiratory disease within subject groups in Rabak City

Types of respiratory diseases	Exposed group		Unexposed group	
	Frequency	Percent	Frequency	Percent
Inflammation of throat	24	17.9	3	2.2
Respiratory infection	37	27.6	3	2.2
Allergy	55	41.0	5	3.7
No Respiratory Disease	18	13.4	123	91.8
Total	134	100.0	134	100.0

The most common symptoms of respiratory diseases in the exposed citizens were dry cough or sneezing (42.5%), difficulty in breathing and dry cough or sneezing (33.6 %), difficulty in breathing (6.0%), pains in chest (2.2%) and

Whistling in the chest (2.2%). The main symptoms of respiratory disease among unexposed citizens were dry cough or sneezing (4.5%), difficulty in breathing and dry cough and sneezing (3.0%) as shown in Table (5). The results indicate a significant difference between exposed and unexposed groups regarding the present symptoms of the respiratory disease; they were getting ($p< 0.05$).

Most types of respiratory diseases that affected the exposed citizens were allergy (35.1%) followed by pneumonia (17.2%), asthma (10.4%), inflammation of the throat (6.7%). On the other hand, the unexposed groups' family members were infected by allergy (16.4%), asthma (4.5%) and pneumonia (2.2%) as shown in Table (6).

Table 5 Symptoms of the respiratory diseases in subject groups in Rabak City

Symptoms	**Exposed group**		**Unexposed group**	
	Frequency	**Percent**	**Frequency**	**Percent**
Difficulty in breathing	8	6.0	1	0.7
Pains in chest	3	2.2	0	0.0
Dry cough or sneeze	57	42.5	6	4.5
Whistling in the chest	3	2.2	0	0.0
Difficulty in breathing and dry cough or sneeze	45	33.6	4	3.0
No Symptoms	18	13.3	123	91.8
Total	134	100.0	134	100.0

Table 6 Types of respiratory disease in subject groups in Rabak City

Types of respiratory diseases	**Exposed group**		**Unexposed group**	
	Frequency	**Percent**	**Frequency**	**Percent**
Asthma	14	10.4	6	4.5
Pneumonia	23	17.2	3	2.2
Inflammation of throat	9	6.7	0	0.0
Allergy	47	35.1	22	16.4
No Illness	41	30.6	103	76.9
Total	134	100.0	134	100.0

The majority of exposed citizens (85.8%) thought that cement dust was the main cause of the respiratory diseases they got in Rabak city, while (81.3%) in the unexposed area thought that there are other factors responsible for the presence of respiratory diseases shown in Table (7).

Table 7 The causes of respiratory diseases in subject groups in Rabak City

Causes of respiratory diseases	**Exposed group**		**Unexposed group**	
	Frequency	**Percent**	**Frequency**	**Percent**
Cement dust	115	85.8	25	18.7
Other	19	14.2	109	81.3
Total	134	100.0	134	100.0

The mean values of lung function parameters for the total number of exposed and unexposed groups are presented in Table (8). The statistically significant reduction was demonstrated in the mean values of ventilator function: force vital capacity (FVC) =2.91 and force expiratory volume in one second (FEV1) = 2.57 in the exposed group compared with the mean values of ventilatory function: force vital capacity (FVC) =.31 and force expiratory volume in one second (FEV1) = 2.83 in unexposed groups in study the area. The study also shows the mean values of FEV_1/ FVC ratio was significantly higher in the unexposed group = 90.88 compared with exposed group = 87.47.

Table 8 The comparison of lung function parameters in exposed and unexposed subjects in Rabak City

Lung function parameters	Exposed group	Unexposed group
	Mean + SD	Mean + SD
FVC	2.91 + 0.73	3.12 + 0.84
FEV1	2.57 + 0.67	2.83 + 0.77
FEV1%	87.47 + 7.86	90.80 + 6.60

FVC: force vital capacity; FEV1: force expiratory volume in one second

4. Discussion

The exposed and unexposed citizens were matched in age, height and weight, hence, there were no statistical significant differences between the two groups in terms of anthropometric parameters. The majority (86.6%) living in surrounding cement factory said that the cement industry has impacted on their health, due to the emission of cement dust, in contrast to people living far from the cement factory whose majority (91.0%) said there was no health effect. This study was confirmed with Muhammad [12] who said that cement dust at workplace and residential areas around the cement factory could result to adverse health effects in both cement industry workers and inhabitants of adjoining areas. Also the study agreed with the previous studies conducted by Aydin *et al*., [3] who said that the impacts of cement industry are countless and it even did not spare humans from its, deteriorating impacts and have adversely impacted the health of workers.

The study found that the people who lived near cement factory were affected by many types of respiratory diseases such as allergy, respiratory infection and inflammation of the throat more than people who lived far from the factory. This may be clearly due to the exposure to the cement dust. People living in areas with more cement factories, are at particular risk of respiratory diseases [13].

Also the study illustrated that the common types of respiratory diseases that the population is suffering from it included allergy 41.0%, respiratory infection 27.6%, and inflammation of the throat 17.9%. The study also found that there was statistically significant differences between the populations lived near the cement factory and people who lived far from the factory in the presence of respiratory diseases ($p < 0.05$). The study agrees with Sultan *et al*, [14] who reported that occupational and environmental exposure to cement dust has an effect on human health leading to respiratory health problems. Also, Mohammed Ali [15] has revealed that people of the cement dust zone are badly affected by respiratory problems, gastrointestinal diseases, thus supporting the researcher's suggestion that exposure to cement dust affects the respiratory system.

People who lived near the Rabak cement factory were significant ($p<0.05$) affected by respiratory symptoms such as dry cough 42.5%, difficulty in breathing 33.6% and chest pain 2.2% more than the people who lived far away from the cement factory these effects are presumably associated with the exposure to cement dust and may be related to the basic reactions caused by the cement dust, which irritate the respiratory tract. The results were consistent with several studies that demonstrated linkages between cement dust exposure, chronic impairment of lung function and respiratory symptoms in human population [16][4]. The study indicated that majority of exposed subjects (69.4%)said that their families were affected by respiratory disease such as allergy (35.1%), pneumonia (17.2%), asthma (10.4%) and inflammation of throat (6.7%) in contrast to the majority of the unexposed subjects (76.9%) who were not affected. A statistical significant difference between exposed and unexposed subjects was found in this study ($p <0.05$) regarding respiratory diseases in their families. This finding confirmed the study performed by Pope and Dockery (2006) in which the allergic reactions which create many breathing problems, from simple runny noses to life-threatening respiratory arrest was noticed. Rahmani [17] suggested that, the cement dust or constituents of cement causes pathogenesis of various lung diseases including chronic bronchitis, asthma, lung cancer, pneumonia and tuberculosis.

The findings of the lung function parameters: (FVC) 2.9097, (FEV1) 2.5718 and (FEV1%) 87.4743 were found in exposed populations compared to mean values of (FVC) 3.1175, (FEV1) 2.8296 and (FEV1%) 90.7985 in populations lived far from the cement factory. This variation is presumably due to the presence of cement industry near the residences of the populations. The reduction in ventilator lung function observed in this study confirmed the earlier studies that have demonstrated linkages between cement dust exposure, chronic impairment of lung function and respiratory symptoms in human population [18][19].

5. Conclusion

A significant differences were found between the accumulated gravimetric concentrations of cement dust and the prevalence rate of lung function (respiratory symptoms and ventilator function parameters) on the occupational populations (exposed population) more than the unexposed population.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors (Mazahir, Abdelaal and Amna) declare no conflicts of interest regarding the publication of this paper.

Statement of ethical approval

The study was ethically cleared and endorsed by the Research Committee of the Institute for Environmental Studies, University of Khartoum. The cement factory manager also officially endorsed the study. All participants were informed about the aims of the study and his/her role as a participant, and then a verbal consent was taken. These formalities were done before launching the program of data collection.

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