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Effect of Cement Dust on Pulmonary Functions of Cement Workers

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Abstract: **Introduction:** Among cement dust, quartz particles are the most harmful and cause pulmonary fibrosis, which is pathologically among the severe and malignant pneumoconioses. Therefore, by measuring the dust and examining the status of lung functions among workers, we can assess the effects of inhaling cement dust. We aimed to assess the effect of cement dust on pulmonary functions among cement workers during 1999-2000 in Khash, Sistan and Baluchestan Province, Iran. **Material and Methods:** The total and inhalation dust of the working environment of different units in this industry was measured by individual sampling pump and silicon by weight method and after correcting the volumes, mg/m^3 of dust was calculated. **Results:** The total dust in different environments was 6.8-95 mg/m^3 and the inhaled dust was 2.5-23 mg/m^3. Due to the percentage of free silica associated with dust, these values are several times the standard values in the workplace. The mean values of respiratory functions (FEV1, FVC, VC) in all cases were lower (P-value<0.005) than the mean values in the control group. The difference in the mean FEF25-75 values between the two groups was not significant (P-value>0.5). Although in the case group (all types of workers) the percentage of people with cough was more than the control group, the difference was not statistically significant (P<0.05). With respect to having sputum in the morning and during the day and night and the type of sputum (green and thick, thin, and no sputum), the case group experienced higher rates of sputum and respiratory symptoms. **Conclusion:** The working environments of cement factories, contrary to what is stated in the toxicology textbooks, requires more attention of health experts and industry managers. Examinations and periodic dust control measures and hiring an occupational health expert is necessary to maintain the health of workers in these environments.

Keywords: Lung; Silicosis; Spirometry

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1. Introduction

Cement is an essential material used in buildings, factories, and industrial settings. The initial composition of cement contains a percentage of quartz (1). The effects of free silica and the resulting disease (silicosis) have been discussed in detail in toxicology and occupational disease textbooks (1). Among cement dust, quartz particles are the most harmful and cause pulmonary fibrosis, which is pathologically among the severe and malignant pneumoconioses (2, 3). This disease is the oldest and most important disease caused by particles affecting the lung. Due to the abundance of dust and the exposure of workers in industries and mines and its effects on human health, the effects of inhaling dust (especially dust containing silica) continue to be widely studied (4, 5).
However, cement dust is classified as inert dust in toxicology textbooks due to structural changes in silica during heat treatment. This issue should not mislead experts and officials (5). In cement factories, more than half of the workers and experts in the pre-heat treatment stages, are exposed to the dust of raw material ccontaining a percentage of quartz (6). They are also exposed tosilica in post-baking stages due to various reasons such as adding pozzolans, not enclosing most of the production parts, etc (7). Therefore, by mea-

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suring the dust and examining the status of lung functions among workers, we can assess the effects of inhaling cement dust (1, 8). We aimed to assess the effect of cement dust on pulmonary functions among cement workers in Khash, Sistan and Baluchestan province, Iran.

2. Material and Methods

The following tools were used in this Cross Sectional study: individual sampling pumps with a flow rate of 1-5 liters per minute, nylon cyclone with a diameter of 10 mm for sampling of inhaled dust, thermometer to measure the ambient temperature at the time of sampling, scale with an accuracy of 0.01 g to measure filters before and after sampling, spirometer, scales for measuring weight, and meters to measure height.

For measuring amorphous silica or other types according to the Occupational safety and Health Administration (OSHA) standards, numbers 7500, 7501, 7601, and 7602 can be used. X-ray scattering is the technique used for measuring using the numbers above. In this study, due to the lack of facilities for measuring silica in the province using different sampling methods, to measure total and inhalation dust, the mentioned standards were used, but sio2 values were not determined. Since sio2 was previously measured in the factory on raw materials, those values were used computationally to evaluate the results. The device used to measure the inhalation dust was a nylon cylinder with a diameter of 10 mm and a PVC filter with a size of 5 microns and a pump with a flow rate of 1.7 liters per minute. The total sampling volume was 400-700 liters according to 7601 and 7602 standards and 400-1000 liters according to 7500 standard. For measurement, individual sampling pumps were first connected to the power supply using their adapters to charge their batteries. The filters were placed in the dispatcher for 12-24 hours, and the next morning the filters were measured using a scale with an accuracy of 0.01 g and their initial weights were recorded.

The temperature and pressure of the measuring environment were recorded and in each place it was connected to an individual silicone sampling pump with a filter and to another holder with a filter. The sampling system was attached to the waist of the worker with a special belt and the holder or silicone was attached to the respiratory area of the person. Also,10 filters were used as controls. All samples were collected at time intervals of 4 and 7 hours with a sample volume of 408 liters to 714 liters. At the end of each sampling, the filters were placed inside the desiccator and weighed at a time equivalent to the time it took for the filter to settle before collecting the sample.

The secondary weight of the filter was measured and recorded. Weight difference was obtained and after correcting the sampled volume based on the available temperature and pressure, the mg/m^3 of total dust and amount of inhalation were calculated. A spirometer was used to measure pulmonary functions and a total of 180 samples and 170 control samples were measured. For spirometry, the necessary coordination was performed with a pulmonologist. After a complete test of each person in terms of how the person acts and cooperates during the measurement, the spirometry results were printed. To measure each sample correctly and completely, in some cases the measurement was repeated up to 10 times. The results of the measurements were entered into the SPSS software version 10 and analyzed using t test, chi-square test and analysis of variance. Spirometry results were also compared by the following three methods: Comparison of the mean respiratory functions of dust-exposed individuals with the control group, Comparison between the average respiratory functions of exposed individuals with predicted values, and Comparison between the mean ratio of the percentage of respiratory functions with the predicted values and the control group.

3. Results

The results of dust weight measurement in different parts of the factory after the necessary calculations were measured as the mean dust (mg/m^3) and total and inhaled dust (table 1). Since various repair, operation, electrical, mechanical, laboratory, and central control engineers move around the entire production line as needed, they cannot be examined in a specific group, so a few measurements were measured in the public area of various workshops such as kilns and clinker cement mills.

Before measuring the lung functions of the workers and the control group, 28 questions regarding their age, work experience, smoking history, etc., were asked. Tables 2 and 3 show the results of smoking history and subjective symptoms, respectively. The results obtained regarding age, height, duration of addiction and number of cigarettes per day show that there was no significant difference between the two groups in this regard (table 2, P-value<0.05). Therefore, the differences in the lung functions of the case and control group will not be because of these factors. Regarding the questions related to cough, sputum and shortness of breath, chi-square test was performed between the case group and the control. We found that the case group's sputum status was significanlt more severe than the control group (table 2).

In the case group, with respect to the different working categories (mine productivity, control, repair shop, electricity, warehouse, facilities), we found that respiratory symptoms (cough, sputum, and shortness of breath) were seen more frequently in miners was more than the productivity groups, but it was not statistically significant (Chi-square test, P<0.05).

Although in the case group (all types of workers) the percentage of people with cough was more than the control group, the difference was not statistically significant ($P<0.05$). With respect to having sputum in the morning and during the day and night and the type of sputum (green and thick, thin, and no sputum), the case group experienced higher rates of sputum and respiratory symptoms (table 3).

The mean values of respiratory functions (FEV1, FVC, VC) in all cases were lower than the mean values in the control group. The difference in the mean FEF25-75 values between the two groups was not significant. But in other cases, the difference between the means between the case and the control group and the mean of the predicted values was significant ($P<0.05$). Also, the difference between the mean percentage of FEV1 / FVC in the case group was not significant (table 4).

Analysis of variance between the mean differences of respiratory functions measured between workers in different units in the case group (mine, productivity, etc.) showed that despite the low mean of respiratory functions measured in some parts, such as the mine compared with other parts (In all cases), there was no statistically significant difference between different parts but the difference between the mean values of respiratory functions of the case groups (in total) and the control was significant.

4. Discussion

As previously explained, the aim of this study was to investigate the effects of cement dust on the respiratory functions of exposed workers in Khash cement factory. According to various standards, the effects of dust are mostly evaluated based on the percentage of silica in it, so that according to the OSHA, the standard amount is calculated from the following formula: mg/m^3 dust= 30 $mg/m^3 \div$ (%sio2+3). In this formula, if the percentage of silica is zero, the standard value of 10 mg/m^3 would be obtained. The amount of inhaled dust is also obtained according to the following formula: Mg/m^3 dust = 10 $mg/m^3 \div$(%sio2+2).

The ACGIH standard also sets the recommended level of 10 mg/m^3 for total dust and 5 mg/m^3 for inhaled dust in the absence of free Sio2 in the dust. Since the amount of Sio2 is measured using the X-ray diffraction method and it was not possible to measure it in the province and according our evaluations (9), the percentage of silica in minerals of this factory had been studied before, in this study, total dust using Individual sampling was performed according to the OSHA standard (10, 11). According to the measurements made in almost all parts, even if the assumption of the absence of free silica in the dust sample (incorrect assumption) is correct, the amount of environmental pollution is still many times the standard value (in some parts about 10 times higher) but according to the mentioned study, the average percentage of quartz in the raw materials (minerals) used in the factory based on the percentage of materials used would be approximately 10% (12, 13). If in standard formulas, this number is calculated, the recommended amount of 10 mg/m^3 total dust and 5 mg/m^3 inhaled dust would be very high (10).

Due to the fact that in the design of the factory by foreign companies, it has been tried to keep the dust in the normal recommended range by installing appropriate ventilation systems (14). Unfortunately, due to improper use, local weather conditions, not employing an occupational health engineer in the factory and ignoring the issue of occupational health or the ignorance of the authorities about this, the measured amounts of dust were several times the recommended values (15). If appropriate and practical ways to control dust and maintain the health of workers is implemented by occupational health engineers, pollution would be reduced effectively (15).

Silica is found in most natural stones, and the types that are often more or less pure are quartz and silica sand, and all workers are exposed to a percenage of silica in different parts of the factoy such as kilns, soil storages, raw material silos, and raw material storages (16). Meanwhile, due to the climatic conditions of the region (strong winds), and the negligence of the factory officials to create suitable barriers and a suitable space for work (all the surrounding area is open), many workers work in enclosed spaces (17). Tin this w,the amount of pollution in the environment will increase several times, and people will not be immune to pollution (spirometric results show this fact). On the other hand, pozzolan is a material that does not enter the sintering system and clinker and is added directly to the ground cement. And according to the studies done in the factory, it has a percentage of silica. This mineral also exposes workers to a percentage of silica in open storage and dust caused by weather currents as well as in the production line after cooking (18).

Silica is one of the most dangerous dusts and a harmful substance for the lungs. Silicosis, the disease caused by it, is one of the most dangerous diseases caused by dust. Unfortunately, the symptoms of this disease are late and appear after years and there is no cure (19). Therefore, the factory officials should not ignore the danger caused by silica and should try to maintain the health of the worker by hiring an expert and giving priority to the issue of occupational health and request the help of the university, As mentioned, the symptoms of dust (especially containing free silica) are late (19). The factory was founded in 1995 and most workers and employees were exposed to harmful dust during this period. Low work experience and the presence of many symptoms based on the results of statistical analysis, disregard for the health status of the environment shows that in most cases the severity of sympoms was significantly related to the workers' years of work experience in the factory (19).

The results of spirometry tests showed that the difference between the mean values of lung functions measured by exposed workers and the control group and the predicted values was significant. A high percentage of spirometry results were in the range of threatening diseases compared to the control group. Dust measurements showed that the environment was unhealthy for exposed workers. Because a number of workers stated that they had long-standing bloody sputum (mostly among miners), and given that silicosis is usually associated with tuberculosis, these people required x-rays and blood sputum tests, which was coordinated with the health center of Khash city. One of the limitations of the study was that the participants were difficult to train for the spirometry tests and also we could not gather them in certain days to perform the test.

5. Conclusion

It is hoped that the factory officials will pay attention to this and similar issues and take a positive and effective step in creating a healthy work environment.

6. Appendix

6.1. Acknowledgements

None.

6.2. Author contribution

All the authors have the same contribution.

6.3. Funding/Support

None.

6.4. Conflict of interest

No conflict of interest.

References

1. Adeyanju E, Okeke CA. Exposure effect to cement dust pollution: a mini review. SN Applied Sciences. 2019;1(12):1572.
2. Zeleke ZK, Moen BE, Bråtveit M. Cement dust exposure and acute lung function: a cross shift study. BMC pulmonary medicine. 2010;10(1):19.
3. Rahmani AH, Almatroudi A, Babiker AY, Khan AA, Alsahly MA. Effect of exposure to cement dust among the workers: an evaluation of health related complications. Open access Macedonian journal of medical sciences. 2018;6(6):1159.
4. Meo SA, Al-Drees AM, Al Masri AA, Al Rouq F, Azeem MA. Effect of duration of exposure to cement dust on respiratory function of non-smoking cement mill workers. International journal of environmental research and public health. 2013;10(1):390-8.
5. Richard EE, Augusta Chinyere N-A, Jeremaiah OS, Opara UCA, Henrieta EM, Ifunanya ED. Cement dust exposure and perturbations in some elements and lung and liver functions of cement factory workers. Journal of toxicology. 2016;2016.
6. Mbelambela EP, Eitoku M, Muchanga SMJ, Villanueva AF, Hirota R, Pulphus TY, et al. Prevalence of chronic obstructive pulmonary disease (COPD) among Congolese cement workers exposed to cement dust, in Kongo Central Province. Environmental Science and Pollution Research. 2018;25(35):35074-83.
7. Omidianidost A, Gharavandi S, Azari MR, Hashemian AH, Ghasemkhani M, Rajati F, et al. Occupational Exposure to Respirable Dust, Crystalline Silica and Its Pulmonary Effects among Workers of a Cement Factory in Kermanshah, Iran. Tanaffos. 2019;18(2):157.
8. Akiibinu MO, Oduola T, Akinola F. Immunomodulatory effects of cement in exposed workers. African Journal of Biochemistry Research. 2019;13(4):38-43.
9. Abrons H, Petersen M, Sanderson W. Chest radiography in Portland cement workers. Occupational Health and Industrial Medicine. 1998;2(38):92.
10. Park H, Hwang E, Jang M, Yoon C. Exposure assessment of elemental carbon, polycyclic aromatic hydrocarbons and crystalline silica at the underground excavation sites for top-down construction buildings. PloS one. 2020;15(9):e0239010.
11. Beaucham C, King B, Feldmann K, Harper M, Dozier A. Assessing occupational erionite and respirable crystalline silica exposure among outdoor workers in Wyoming, South Dakota, and Montana. Journal of Occupational and Environmental Hygiene. 2018;15(6):455-65.
12. Esswein EJ, King B, Ndonga M, Andronov E. Respirable crystalline silica is a confirmed occupational exposure risk during hydraulic fracturing: What do we know about controls? Proceedings from the Silica in the Oilfield Conference. Journal of occupational and environmental hygiene. 2019;16(10):669-74.
13. Grant MP. Evaluation of silica exposures during dowel drilling. 2020.
14. Fedan JS, Hubbs AF, Barger M, Schwegler-Berry D, Friend SA, Leonard SS, et al. Biological effects of inhaled hydraulic fracturing sand dust. II. Particle characterization and pulmonary effects 30 d following intratracheal instillation. Toxicology and Applied Pharmacology. 2020;409:115282.
15. Society AT. Occupational contribution to the burden of airway disease [American Thoracic Society statement]. Am J Respir Crit Care Med. 2003;167:787-97.
16. Cohen RA, Patel A, Green FH, editors. Lung disease

caused by exposure to coal mine and silica dust. Seminars in respiratory and critical care medicine; 2008: © Thieme Medical Publishers.

17. Pérez-Ramos IM, Matías L, Gómez-Aparicio L, Godoy Ó. Functional traits and phenotypic plasticity modulate species
18. coexistence across contrasting climatic conditions. Nature communications. 2019;10(1):1-11. Fitzpatrick R, Boyley MM. For the attention of the National Dust Diseases Taskforce Dear Professor Brendan Murphy, Thank you for the opportunity to raise concerns regarding the health risks of environmental silica silica-related diseases from non-occupational exposure. It seems absurd that we are still having this discussion about a condition that has been well-known for. 2019.
19. Coates RJ. Introduction to the summary of notifiable noninfectious conditions and disease outbreaks—United States. MMWR Morbidity and mortality weekly report. 2016;63.

Table 1: Results of measuring dust in different sections of Khash Cement Factory.

Location of measurement	Dust measured (mg/m^3)	
	Total dust	Inhaled dust
Mine (place of raw material)	95	23
Crusher (control part)	15	3.3
Soil storage	6.8	3
Furnace, clinker, cement mill and public yard of workshops	15	3.7
The central building	10	2.5
Packing	41	4.5
Home loader	35	4.2

Table 2: History of smoking in the case and control groups.

Parameter Group	History of smoking						Numberof cigarrettes per day		Duration of addiction		Age		Height	
	Previous smoker		Current smoker		None									
	No	%	No	%	No	%	X	∂	X	∂	X	∂	X	∂
Case	22	12.2	47	26.1	111	61.7	4.5	7.7	3.8	6.5	32.6	6.6	171.8	6.8
Control	27	15.9	41	24.1	102	60	4.5	7.5	3.5	6.2	32.4	6.4	170.9	6

X= Mean ; ∂= SD

Table 3: Frequency distribution of subjective symptoms in the case and control group.

Groups /Symptoms	Answers	Case group		Control group		P-Value
Cough when waking up (morning)	yes	26	4.14	18	6.10	P<0.27
	No	154	6.85	152	4.89	
Cough during the day and	yes	35	4.19	21	4.12	P<0.07
	night	No	145	6.80	149	6.87
Cough at least for 3 months	yes	15	3.8	10	9.5	P<0.37
	for 2 consecu-	No	165	7.91	160	1.94
	tive yrs					
Cough for several yrs	1-5 yrs	23	8.12	6	5.3	P<0.005
	>5 yrs	5	8.2	3	8.1	
Years of coughing with	1-5 yrs	45	25	19	2.11	P<0.001
sputum	>5 yrs	6	3.3	2	2.1	
Having sputum when	yes	56	3.31	34	20	P<0.01
waking up in the morning	No	124	9.68	136	80	
Sputum during the day and	yes	48	7.26	25	7.14	P<0.005
night	No	132	3.73	145	3.85	
Sputum color	Bloody	40	2.22	14	2.8	P<0.001
		27	15	4	19	2.11
		7	4	3 4.2		
Sputum type	Thick	41	3.18	10	9.5	P<0.000
	Watery	33	8.22	27	9.15	
	None	106	9.58	133	2.78	
Level of shortness of breath	1	36	20	69	6.40	P<0.001
	2	121	2.67	94	3.55	
	3	23	8.12	7	2.4	

Table 4: The difference between the mean percentage of FEV1 / FVC in the case and control groups.

Groups /Lung functions	Case group(n=180)		Control group (n=170)		Predicted(standard) 180 people		P-Value
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	
VC (liter)	3.83	0.64	4.23	0.6	4.94	0.44	<0.005
FVC (liter)	3.45	0.61	3.97	0.66	4.94	0.44	<0.005
FEV1 (liter/second)	3	0.56	3.49	0.58	3.86	0.35	<0.005
FEF25-75	3.81	0.99	4.33	1.26	4.2	0.36	<0.005
FEV1/FVC %	89	5.85	88	6.3	78	3.9	<0.5