ORIGINAL REPORT

Dust Exposure and Respiratory Health Effects in Cement Production

Hossein Kakooei[1], Abdollah Gholami[1], Mehdi Ghasemkhani[1], Mostapha Hosseini[2], Davoud Panahi[1], and Golamreza Pouryaghoub[3]

[1] Department of Occupational Health, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran
[2] Department of Biostatistics, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran
[3] Center for Research on Occupational Diseases, Tehran University of Medical Sciences, Tehran, Iran

Received: 25 Feb. 2011; Received in revised form: 15 Aug. 2011 ; Accepted: 9 Nov. 2011

Abstract- Dust can be produced by almost all production processes in Portland cement factory. Dust exposure potentially can affect respiratory function. But evidence for respiratory effect of cement dust exposure has not been conclusive. In this study we assessed effect of cement dust exposure on respiratory function in a cement production factory. A respiratory symptoms questionnaire was completed and pulmonary function tests were carried out on 94 exposed and 54 non exposed workers at a cement factory in the east of Iran. Additionally, respirable dust level was determined by the gravimetric method. X-ray fluorescence (XRF) technique was performed to determine the silica phases and the SiO_2 contents of the bulk samples. The arithmetic means (AM) of personal respirable dust were 30.18 mg/m^3 in the crushing, 27 mg/m^3 in the packing, 5.4 mg/m^3 in the cement mill, 5.9 mg/m^3 in the kiln and 5.48 mg/m^3 in the maintenance that were higher than threshold limit value (TLV) of the American Conference of Governmental Industrial Hygienists (ACGIH) which is 5 mg/m^3. This value in the unexposed group was 0.93 mg/m^3. In this study cough, sputum, wheezing and dyspnea were more prevalent among exposed subjects. Exposed workers compared to the unexposed group showed significant reduction in Forced Expiratory Volume in one second (FEV_1), Forced Vital Capacity (FVC), and Forced Expiratory Flow between 25% and 75% of the FVC ($FEF_{25-75\%}$) ($P<0.05$). It can be concluded that in our study there was close and direct association between cement dust exposure and functional impairment among the cement factory workers.
© 2012 Tehran University of Medical Sciences. All rights reserved.
Acta Medica Iranica, 2012; 50(2): 122-126.

Keywords: Portland cement dust; Respirable dust; Respiratory symptoms; Respiratory impairment; Iran

Downloaded from http://journals.tums.ac.ir/ on Friday, April 18, 2014

Introduction

Portland cement production is a dusty process. Portland cement is manufactured from a clay and limestone mixture that is calcined in kiln. Portland cement silicate is a class of hydraulic cements containing tri- and dicalcium silicate ($2CaO.SiO_2$ and $3CaO.SiO_2$) in addition to aluminum, tricalcium aluminate and iron oxide. The final product usually contains 60 to 70% calcium oxide, 19 to 24% silicon dioxide (including about 5% free), 4 to 7% aluminum trioxide, 2 to 6% ferric oxide and less than 5% magnesium oxide (1). The volume of cement production in Iran is high (60 million tons per year). About 27000 workers are working in cement production factories in Iran. Occupational exposure to cement dust is likely to vary in different production operations and process (2-5). Several clinical and epidemiological studies have shown an increased incidence of respiratory impairment and high frequency of respiratory symptoms among cement production workers (6-8) but there are some negative studies (9-11). The objectives of this study were to investigate the relationship between occupational exposure to Portland cement dust and respiratory health problem.

Materials and Methods

The present study was conducted at a local cement producing factory in Iran during the year 2008-2009. This factory is located in Ghaen, which is about 100 kilometers on the outskirts of Birjand. It is the biggest cement company in the east of the country, currently producing about 1000,000 tons of Portland cement annually, and it has around 340 workers. The main

Corresponding Author: Golamreza Pouryaghoub
Center for Research on Occupational Diseases, Tehran University of Medical Sciences, Tehran, Iran.
Tel: +98 21 6405588, 912 1790814, Fax: +98 21 6405588, E-mail: pourya@sina.tums.ac.ir

Downloaded from http://journals.tums.ac.ir/ on Friday, April 18, 2014

production process include, crushing, raw milling, calcination in a rotary kiln, cement milling, packing and maintenance. The raw material limestone (60%) and red soil (40%) are crushed before entering the raw mill. It is ground to fine particles. The ground materials enter the rotary kiln (with calcining, transition and burning zones) where it is burning at 1300-1450 ºC to form clinker. The clinker is mixed with gypsum (4-5%) and ground in the clinker mill into Portland cement. The final product is stored in silos, and then distributed in bulk or packed.

In this study, 94 male workers (production line workers) were selected in a group–based strategy as exposed group. Similarly, 54 male workers were selected as unexposed group from administrative section employees.

The American Thoracic Society's Questionnaire on Respiratory Symptoms (ATS 1978), with minor modifications, was used in the study. Pulmonary function test including FEV1, FVC, PEF, and FEF_{25-75} indexes were performed with the worker in standing position using a portable calibrated Vitalogrph spirometer (Vitalograph-COMPACT, Buckingham, England) according to the ATS recommendation for acceptability and reproducibility (12). Lung function tests were performed with the assistance of a trained, skilled occupational health expert under supervision.

Catching 148 personal samples were planned for both administrative office and production sites (crusher, kiln, cement milling, packing and maintenance). Respirable dust was collected on cellulose acetate filter with pore size of 0.8 µm placed in a 37-mm cyclone (Casella, London, UK) connected to a SKC sampling pump with flow rate of 0.2 l/min, calibrated by a digital automatic calibrator. The samples were transported to Tehran and were analyzed quantitatively at Occupational Health lab, Tehran University of Medical Sciences. Gravimetric analysis using a microbalance with a detection limit of 0.01 mg was employed.

The x-ray fluorescence (XRF) technique was used to determine and estimate the silica phases and the SiO_2 content of the bulk sample.

A database file created and all statistical analyses were carried out with the Statistical Package for Social Sciences (SPSS) version 13.5 for Windows. $P<0.05$ was considered statistically significant.

Results

All of 148 subjects (94 exposed and 54 unexposed) were male. Table 1 shows a summary of the demographic parameters of the exposed and unexposed groups. As shown in the table, there was no clinically or statistically significant difference between two groups.

Worker of crushing and packing had higher respirable dust exposure than the cement mill, kiln, maintenance and administration (Table 2). The mean air concentration of respirable dust for exposed group was 11.96 mg/m^3 (SD=14.69) that exceeded the recommended TLV based on the ACGIH for nuisance respirable particles, which is 5 mg/m^3 (13). To estimate the silica phases and the SiO_2 content of the bulk materials 16 bulk samples collected and XRF technique was used. Results are illustrated in Table 2.

Respiratory symptoms questionnaire was completed by 56 exposed and 35 unexposed subjects. Table 3 illustrates the frequency of abnormal respiratory symptoms among exposed and unexposed subjects. Exposed workers had more dyspnea, sputum, wheezing and cough than the control group. But these differences were not statistically significant (Table 3).

Pulmonary function parameters are measured for all exposed (n=94) and unexposed (n=54) subjects. Mean FVC and FEV_1 for exposed group were 3.86 and 3.10 with predicted values equal to 4.85 and 3.71 respectively. These indices for unexposed group were 4.17 and 3.42 with predicted values as same as exposed group. The results indicated that the exposed workers had significantly lower ventilatory indices than the unexposed workers (Tables 4).

Table 1. Compression of demographic variables between exposed and unexposed groups.

	Exposed (n=94)			Unexposed (n=54)			*P* value
	Mean	**Min.**	**Max.**	**Mean**	**Min.**	**Max.**	
Height (meter)	1.70	1.58	1.90	1.70	1.55	1.90	0.7
Age (year)	41.7	26	62	40.9	27	53	0.37
Weight (kilogram)	75.7	52	105	77.2	52	105	0.4
Working duration (year)	14.8	3	25	14.2	2	27	0.51
Smoking (pack year)	4.24	0	13	4.49	0	15	0.7

Downloaded from http://journals.tums.ac.ir/ on Friday, April 18, 2014

Table 2. Respirable dust (mg/m^3) and Sio_2% content of bulk materials in the cement factory.

	Number of sample	Mean (SD)
Respirable dust		
Ore crushing	15	30.2 (22.1)
Kiln	21	5.9 (3.7)
Packing	9	27 (16.6)
Cement mill	10	5.4 (4)
Maintenance	39	5.5(4.3)
Administration	54	0.9 (0.8)
Sio_2% content		
Lime stone	4	7 (.8)
Bauxite	4	27 (2.2)
Kiln feed	4	15 (1.4)
Clinker	4	22 (1.4)

Table 3. Frequency of respiratory symptoms among exposed and unexposed subjects.

Symptom	Exposed (n=56)		Unexposed (n=35)		*P* value
	Number	Percent	Number	Present	
Cough	34	60.7	15	42.9	0.1
Wheezing	23	41.1	9	25.7	0.14
Sputum	21	37.5	9	25.7	0.25
Dyspnea	25	44.6	11	32.4	0.25

Table 4. Pulmonary function indices and abnormal pulmonary function parameters frequency in exposed and unexposed workers.

Indices	Exposed		Unexposed		*P* value
	Measured	Predicted	Measured	Predicted	
FVC	3.86	4.85	4.17	4.85	0.006[a]
FEV_1	3.1	3.71	3.42	3.71	0.000[a]
FEV_1/ FVC	0.79	---	0.82	---	0.006[a]
FEF_{25-75}	3.13	4.23	3.94	4.25	0.000[a]
Abnormal parameters	number	percent	number	percent	
FVC[b]	55	58.5	12	22.2	0.000
FEV_1[b]	46	48.9	4	7.4	0.000
FEV_1/FVC[c]	38	40.4	16	29.6	0.19

a: comparison for measured values

b: measured indices less than %80 of predicted values

c: measured FEV_1 less than %80 of measured FVC

Discussion

In our study, there were no significant differences in the major confounding variables of demographic, cigarette smoking and duration of work between exposed and unexposed subjects. Workers who work in crusher and packing process are exposed to the highest AM concentrations of respirable cement dust (30.17 mg/m^3 and 27.72 mg/m^3) while the cement mill and maintenance process workers were exposed the lowest one (5.4 mg/m^3). This variation in dust exposure in different parts of the factory was predictable and is consistent with previous studies (2-5). Data analysis exhibited that the mean respirable dust concentration in exposed group exceeded the ACGIH TLV of 5 mg/m^3 (13). The levels of respirable cement dust observed in the current study are higher than observed in developed countries such as United States (14) and Norway (11). In our study the frequency of wheezing, cough, dyspnea and chronic phlegm among the exposed workers were higher than control group in parallel to other reports (15,16) but these differences were not statistically significant. This may be because of low sample size in our study.

Downloaded from http://journals.tums.ac.ir/ on Friday, April 18, 2014

The major finding of this study is that the lung function parameters FVC, FEV_1 and $FEF_{25\text{-}75\%}$ were significantly lower in exposed workers compared to control group. This is consistent with the finding of Poornajaf *et al.* (17), Ali *et al.* (18), Merenu *et al.* (19), Alakija *et al.* (20) as well as Omer *et al.* (21). In contrast, some other studies did not find such effects probably due to low respirable dust exposure among the cement workers (10,11,14). However, the frequency of abnormal FEV_1/FVC ratio did not differ statistically significant in the exposed workers compared to the control group. It may be the reflection of this fact that occupational inhalation exposure to cement dust is likely to induce restrictive rather than obstructive ventilatory impairment. This result is in agreement with the finding of El Badri1 and Saeed (21). Data and information presented in current study might be useful for national programs of health surveillance and retrospective exposure assessment. In conclusion, exposure to airborne respirable cement dust was high in our study. This may be attributed in part to the fact that the process flow and machinery are often old and assembled without effective dust control devices such as electrostatic precipitator. It can be also concluded that exposure to the cumulative cement dust is associated with chronic ventilatory function impairment. Data and information presented in current study might be useful for national programs of health surveillance and retrospective exposure assessment. With respect to high dust exposure in our study national programs of cement dust exposure assessment and health surveillance are strongly recommended.

Acknowledgment

We thank the general manager, head of board of management of cement factory, the occupational health director, and particularly the workers who participated in carrying this study.

References

1. Stellman JM, editor. Encyclopedia of Occupational Health and Safety. 4th ed. Geneva: International Labour Office; 1998.
2. Mwaiselage J, Bråtveit M, Moen B, Yost M. Variability in dust exposure in a cement factory in Tanzania. Ann Occup Hyg 2005;49(6):511-9.
3. Ballal SG, Ahmed HO, Ali BA, Albar AA, Alhasan AY. Pulmonary effects of occupational exposure to Portland cement: a study from eastern Saudi Arabia. Int J Occup Environ Health 2004;10(3):272-7.
4. Mirzaee R, Kebriaei A, Hashemi SR, Sadeghi M, Shahrakipour M. Effects of exposure to Portland cement dust on lung function in Portland cement factory workers in Khash, Iran. Iran J Environ Health Sci Eng 2008;5(3):201-6.
5. Zeleke ZK, Moen BE, Bråtveit M. Cement dust exposure and acute lung function: a cross shift study. BMC Pulm Med 2010;10:19.
6. Mwaiselage J, Bråtveit M, Moen BE, Mashalla Y. Respiratory symptoms and chronic obstructive pulmonary disease among cement factory workers. Scand J Work Environ Health 2005;31(4):316-23.
7. Mwaiselage J, Bråtveit M, Moen B, Mashalla Y. Cement dust exposure and ventilatory function impairment: an exposure-response study. J Occup Environ Med 2004;46(7):658-67.
8. Al-Neaimi YI, Gomes J, Lloyd OL. Respiratory illnesses and ventilatory function among workers at a cement factory in a rapidly developing country. Occup Med (Lond) 2001;51(6):367-73.
9. Antao VC. Lung diseases associated with silicates and other dusts. In: Rom WN, Markowitz SB, editors. Environmental and Occupational Medicine. 4th ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2007. p. 525-42.
10. AbuDhaise BA, Rabi AZ, al Zwairy MA, el Hader AF, el Qaderi S. Pulmonary manifestations in cement workers in Jordan. Int J Occup Med Environ Health 1997;10(4):417-28.
11. Fell AK, Thomassen TR, Kristensen P, Egeland T, Kongerud J. Respiratory symptoms and ventilatory function in workers exposed to portland cement dust. J Occup Environ Med 2003;45(9):1008-14.
12. American Thoracic Society (ATS). Standards for the diagnosis and care of patients with chronic obstructive pulmonary disease. Am J Respir Crit Care Med 1995;152(5 Pt 2):S77-121.
13. American Conference of Governmental Industrial Hygiene (ACGIH). Threshold limit values for chemical substances and physical agents biological exposure indices. Threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists; 2008.
14. Abrons HL, Petersen MR, Sanderson WJ, Engelberg AL, Harber P. Respiratory symptoms, ventilatory function and environmental exposure in Portland cement workers. Br J Ind Med 1988;45(6):368-75.

15. Yang CY, Huang CC, Chiu HF, Chiu JF, Lan SJ, Ko YC. Effects of occupational dust exposure on the respiratory health of Portland cement workers. J Toxicol Environ Health 1996;49(6):581-8.
16. Noor H, Yap CL, Zolkepli O, Faridah M. Effect of exposure to dust on lung function of cement factory workers. Med J Malaysia 2000;55(1):51-7.
17. Poornajaf A, Kakooei H, Hosseini M, Ferasati F, Kakaei H. The effect of cement dust on the lung function in a cement factory, Iran. Int J Occup Hyg (IJOH) 2010;2:74-8.
18. Ali BA, Ballal SG, Albar AA, Ahmed HO. Post-shift changes in pulmonary function in a cement factory in eastern Saudi Arabia. Occup Med (Lond) 1998;48(8):519-22.
19. Merenu IA, Mojiminiyi F, Njoku CN, Ibrahim M. The effect of chronic cement dust exposure on lung function of cement factory workers in sokoto, Nigeria. Afr J Biomed Res 2007;10(2):139-43.
20. Alakija W, Iyawe VI, Jarikre LN, Chiwuzie JC. Ventilatory function of workers at Okpella cement factory in Nigeria. West Afr J Med 1990;9(3):187-92.
21. El Badri OA, Saeed AM. Effect of exposure to cement dust on lung function of workers at Atbara cement factory. Kharoum Med J 2008;1(2):81-4.

Downloaded from http://journals.tums.ac.ir/ on Friday, April 18, 2014