OCCUPATIONAL EXPOSURE DETERMINATION TO SILICA DUST IN AN IRON-STONE ORE AND COMPARISON WITH STANDARD

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ABSTRACT

Introduction: Dust is one of the significant factors which cause occupational respiratory diseases among workers.

Objective: The main purpose of this study was to determine the dust concentration, its silica percentage and comparison with standard.

Method: This cross-sectional study was carried out at one of iron-stone ores in Southern Khorasan province. Air dust sampling was done using the NIOSH 7500 method and personal sampling pump with the cyclone in 52 stations in different situations of the mine. Total and respirable dust was determined by gravimetrical method. 5 bulk samples were taken for the determination of silica. Bulk samples determined with X-ray method and compared with standard.

Result: Highest respirable dust concentration was measured in the extraction section (10.6 mg/m^3) and the lowest in the administration (4.02 mg/m3). Also, highest total dust concentration was measured in the crusher section (94.3 mg/m^3) and the lowest in the administration (16.6 mg/m^3). Average percentage of silica in the mine was 15.5%. Either measured respirable and total dust concentration was several times higher than standard concentration.

Conclusion: Percentage of total and respirable dust in all parts of the mine according to the silica percentage was higher than the standard limit. Therefore, it's required to reduce or eliminate workers exposure to silica by using engineering controls, administrative and personal protective measures.

Keywords: Iron-Stone Ore, Total and Respirable Dust, Silica

Introduction

There are plenty of mines in Iran that the beneficiary of these mines is increasing. Iron mines are one of the most important mining in Iran. The mine workers are exposed to dust from mining operations in the iron mine of Sangan (One of the largest mines in the East) in the Khaf region. Silica (Sio2) is one of the minerals that exist in the soil. This mineral composed of one silicon and two oxygen atoms. Silica is colorless, odorless and non-combustible. [1] It constitutes about 25 percent of Earth's crust. Crystalline and amorphous are two major forms of silica that crystalline form comprises alpha-quartz, quartz, tridimite, cristobalit, Kitit, Koesit, astishovit, and Meganit. [1] Silica in quartz alpha form is silicon compounds in the nature and due to its abundance in the nature; often called the quartz crystal silicon.

Exposing to these crystals affects on human health and International Agency for Research Cancer IARC has classified silica as a Group one of carcinogens. [2] There are three general methods for determining the amount of free silica in dust samples, including X-ray diffraction, infrared spectrophotometery, and colorimetric methods. [3] In 1989, these methods were compared by Mr. M. Janko and his Colleague. [3, 4] The results showed X-ray Diffraction is the way that it can be determined crystalline free silica in the samples with sufficient accuracy. [3,4]

Silica dust exposure exists in various jobs such as construction jobs, industrial metal, sandblasting, glass workers, mining, agriculture, etc. [5] OSHA estimates that 2.8 million workers are in contact with silica in America. [6] But there doesn't exist the exact number of workers exposed to dust in Iran. Bank and Colleagues in 1981 evaluated the concentration of free silica in two grinders of silica powder. Concentration of free silica in 85% of respirable dust samples was higher than 0.05 mg per cubic meter and the amount of silica was variable between 95 to 98 percent. [7]

In studies conducted in Iran In 1994 Dehghan studied exposure to free silica in the glass industry workers. He measured 50 samples of total dust and 38 samples of respirable dust in this industry using XRD. The results showed that the average concentration of free silica in total dust in the breathing zone of workers were 9.5 times higher than OSHA standard. [8] Another study in 1997 was determined quartz concentrations in the stone quarry Senjedak Kashmar in Iran with X-ray diffraction method. The results indicate the maximum amount of respirable quartz in hammer station (0.51%) and lowest in graders station (0.19%). [9]

In the Emarat zinc and lead mine study, the total amount of dust in the drilling section was 15.44 mg/m3 and 14.35 mg/m3 in the excavation section. The amount of respirable dust in the drilling section was 2.81 mg/m3 and 2.69 mg/m3 in the excavation section. [10] In Another study that was conducted in the Semnan Ferrosilis mine, workers exposed to silica levels greater than the occupational limit. [11]

This study was done emphasized the free silica dust is one of the hazardous occupational agents. Allowable limit amount of silica in these dusts is different. Inhalable and respirable dust standard based on the OSHA formula is obtained. [12, 13]

Respirable dust concentration standard in mg/m^3:

$$OSHA\ (PEL) = \frac{10}{\%\ Sio\ 2 + 2}$$

Inhalable dust concentration standard standard in mg/m^3:

$$OSHA\ (PEL) = \frac{30}{\%\,Sio\ 2 + 2}$$

The aim of this study was determination and comparison of occupational exposure standard to silica dust based on the OSHA standard formula.

Material and Method

In this cross-sectional study was conducted in the Sangan iron ore mine. Total and respirable dust samples from the NIOSH 7500 method using SKC sampling pumps with flow rate 1/7 liter per minute.

Sampling for inhalable and respirable dust measurements were performed separately. For respirable dust filter size 37 mm with 0.8-pour was done without Cyclone and for respirable dust filter holder with 25 mm membrane filter to remove dust with a poor 0.8 and non - respirable size (greater than 5 microns) of the cyclone was used.

For confounding factors to remove moisture filter out 24 hours before and after sampling in the desiccators were. Filtered was weighted by a digital scale with precision satriuse 0/00001g. The sampling pump was calibrated by a soap bubble flow meter. The correct volume of air at standard conditions of the following formula was used. [13]

$$VSTP = VMeas \times \frac{Pbar - Pw}{760} \times \frac{298}{273 + t}$$

V STP= Volume per litter of air at standard conditions**.**
V Mes= Environment in terms of liters of air volume sampled
P bar= terms of barometric pressure in millimeters of mercury in the sample
Pw = Saturated vapour pressure in millimeters of mercury sampling**.**
T = Temperature of ambient air samples in terms of degrees Celsius.
And concentration of dust of the following formula was used: [14]

$$C\ 1 = \frac{W\ 2 - W\ 1}{V}$$

C= Concentration of dust (mg/m3)
W = Filter the sample weight per mg
W1= Weight of filter before sampling in terms of mg
V = Volume of air sampled per liter

To determine the percentage of silica in soil samples from the mine to 5 mass (Bulk) from different parts of the mine (including mountain slash, drilling, core making, stone breaking and road) were sampled Samples were analyzed by X-ray diffraction (XRD).

The following formula was obtained in 52 samples:

$$N = \frac{Z(1-\frac{\alpha}{2})^2 \times \sigma^2}{d^2} = \frac{(2^2 \times (1/8)^2}{./5^2} = \frac{12.96}{/25} = 51.84$$

The samples from different parts of the mine mountain slash, various crushers, loading crushers, construction and administrative and the number of samples based on the number of employees within each mining area determined by the following formula [15]:

$$nhi = \frac{(Nhi / N \times Shi)}{\sum (Nhi / N \times Shi)} \times 52$$

In this regard nhi is the estimated number of samples, Nhi number of workers in each working group and N is the total number of workers, Shi The standard deviation for each working group is calling.

For this formula determined 19 samples for mountain slash, 19 samples for various crushers, 9 samples for administration and 5 samples for road.

Statistical method: statistical analysis was done by means of the statistical package for social sciences (SPSS and the t test was used to analyze results.

Results

Mean concentration of total dust in different part of mine are presented in Table1.

Table1 goes here.

Also, mean concentration of respirable and non respirable dust in different part of mine and its comparison to standard are shown in Tables 2, 3 respectively.

Table 2-3 go here.

Average percent of crystallised silica in mine ore was 15.5%. Upon to OSHA formula, occupational exposure allowable level to respirable and total dust achieved 0.57 and 1.71 mg/m3 respectively.

Highest respirable dust concentration was measured in the extraction section (10.6 mg/m3) and the lowest in the administration (4.02 mg/m3).

Also, highest total dust concentration was measured in the crusher section (94.3 mg/m3) and the lowest in the administration (16.6 mg/m3). Average percentage of silica in the mine was 15.5%. Either measured respirable and total dust concentration was several times higher than standard concentration. Mean dusts comparisons with standard are shown in Figures 1-2.

Figures 1-3 go here

Discussion

As respects, allowance of occupational exposure dust containing silica dust depends on the percentage of free silica. According to the results the percentage of silica and determining occupational exposure limit Concentration of respirable dust in all sections of the mine, higher than the OSHA, s standard limit, was about the dust Inhalable and respirable dust too. And its causes can be pointed to the type of equipment and machines.

T-test results also showed; between the standard rate and the amount of respirable dust and inhalable dust, there are significant differences. ($P<0.001$) Dust in all parts of the mining operation is higher than the permitted limit,

That these results are shame's Samadi and colleagues found that the results of research on Emarat lead & zinc mine and they also consistent with amount of dust And the amount of dust in the working drill 5 / 1 and the excavation of the 7 / 4 times the standard achieved. [10] In a study on the Metal and non metal mines in China, The average concentration inhalable quartz dust More mines in less than (0.05 milligrams per cubic meter and the amount of free silica in the sample reported more than 0.1 milligrams per cubic meter). [10] That the study results are significant differences.
This difference is probably related to the existing control system or climate to disperse the dust; and in another study (Dehdashti and colleagues) in the study of manufacturing companies was done in Semnan. The levels of respirable silica dust between 2.1 to 6.2 milligrams per cubic meter announced, the limit for silica dust was more than permitted limit. [16]

Conclusion

As respects the percentage of silica in mine soils and the amount of dust in workplace air. The mine workers are exposed to dust concentration are higher than permitted limit. And maximum concentration of total dust 55 times and minimum 9.5 and was inhalable dust maximum 18 times and minimum 6 times of permitted limit. For prevention of nosoconiosis caused by this dust**,** Must be used control methods to prevent production and spread of dust in the mine; And given that various operations such as drilling, core making, etc. will be done outdoors, Must be used control methods such as: automated systems, The wet process or use of bag filters, According to the process. And With the notice to the mine area and the around office and management building, the Amounts of dust are higher than permitted limit. And so season's regional wind in Respiratory protection equipment should be used in all parts of the mine.

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Conflict of Interest: The authors declare that there is no conflict of interests.

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Tables

Table1: Crystallized silica percent in bulk samples

Silica Percent	Sampling Section
14.7%	mountain slash
15.6%	excavation
15.4%	crusher
15.2%	road

Table 2: Respirable dust level in different mine sections (mg/m^3) and comparison to standard

P-VALUE	Allowed concentration (OSHA standard)	Maximum concentration	Minimum concentration	S.D.	Concentration mean	Samples No	Sampling Section
<0.001	1.71	141	12.5	8.2	87.2	19	excavation
<0.001	1.71	125	11.2	7.46	94.3	19	crusher
<0.001	1.71	38	6.8	4.3	16.6	9	Administration
>0.001	1.71	98	8.2	9.8	62.4	5	road

Table 3: Inhalable dust level in different mine sections (mg/m^3) and comparison to standard

P-VALUE	Allowed concentration (OSHA standard)	Maximum concentration	Minimum concentration	S.D.	Concentration mean	Samples No	Sampling Section
>0.001	0.57	23.8	2.3	5.78	10.4	19	excavation
>0.001	0.57	21.2	2.3	5.6	9.8	19	crusher
>0.001	0.57	6.4	1.8	1.5	3.5	9	Administration
>0.001	0.57	14.2	3.7	4.7	7.9	5	road

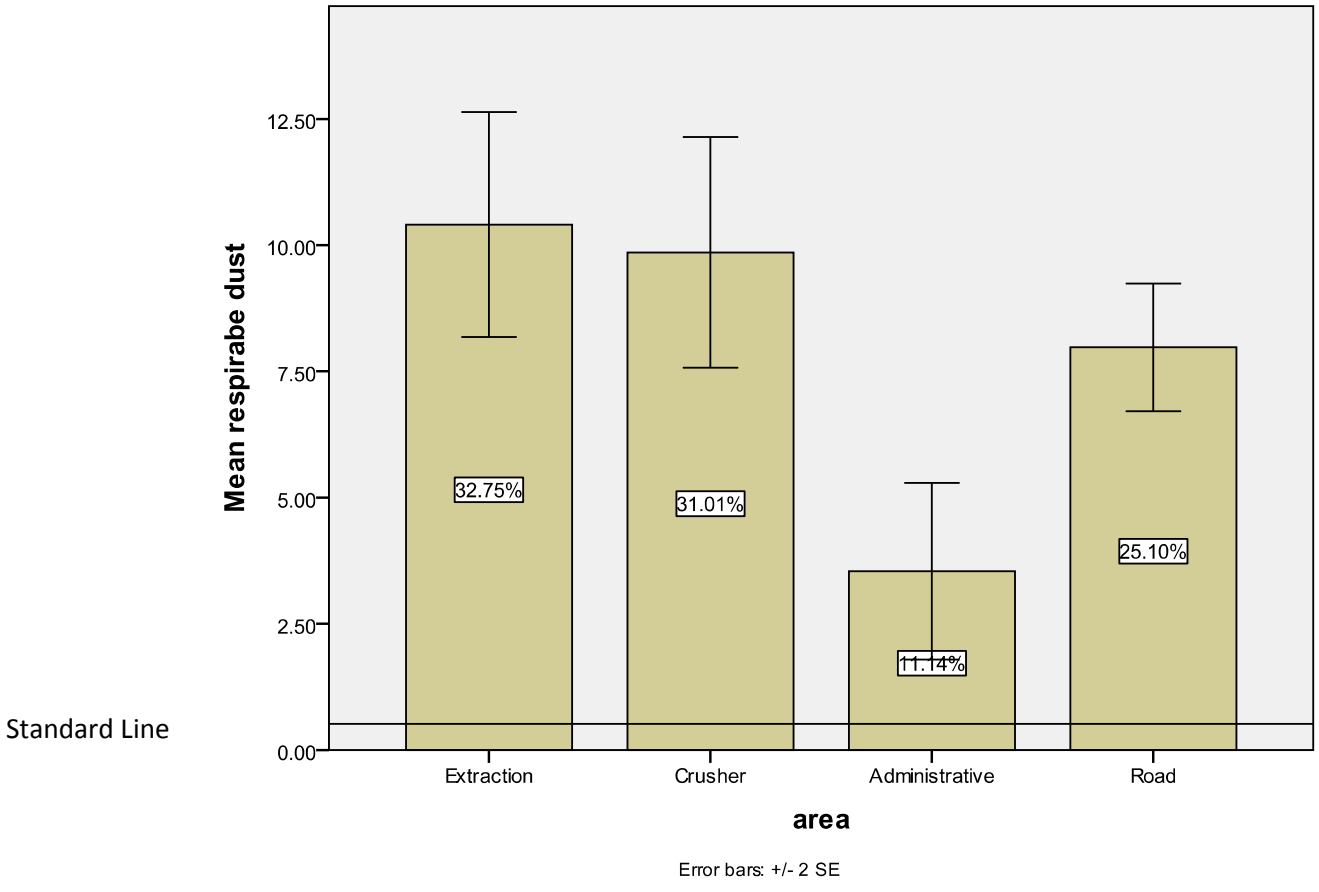

Figure 1: Mean respirable dust + 2SE and comparison to OSHA standard (mg/m^3)

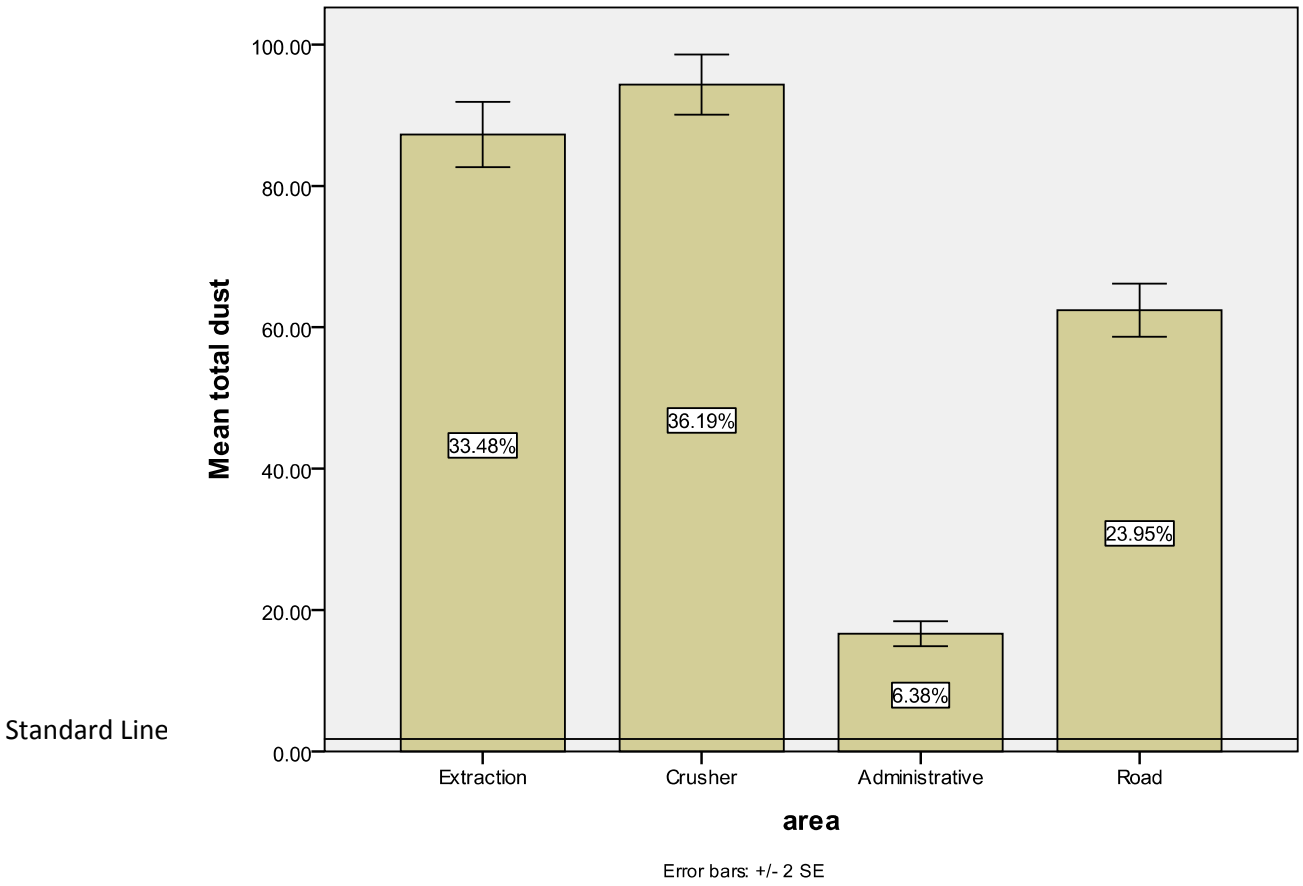

Figure 2: Mean Total dust + 2SE and comparison to OSHA standard (mg/m^3)