

A Study on the Amount of Free Silica in the Dusts of Stonecutting Factories and Offering Controlling Solutions

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Abstract

This research aims at determining amount of dispersion of free silica and inhalant dusts and contents of free silica in the inhalant aerosol of stonecutting factories and offering engineering control strategies to omit or decrease distribution of the aerosol containing silica. Using standard method Niosh- 7601, 40 samples of inhalant dusts were taken from 5 stonecutting factories and concentration of inhalant dusts was calculated by weighting. One sample of each stonecutting factory was analyzed by method of UV-VIS to figure out the amount of free silica. Two volume samples were provided and analyzed by X-ray dispersion to determine type of silica in the inhalant dusts. Concentration of inhalant dusts containing free silica in different worksites is 2.232 mg/m³ in average. The most amounts were found in grinding and polishing worksite amounted to 3.3293 with criteria deviation of 0.54 and the least amount was related to entrance door station, amounted to 1.1191 with criteria deviation of 0.25. The most amount of free silica in the worksites was related to worksite No.3, amounted to 12.15

Index terms— silica, stonecutting, dusts, niosh- 7601.

1 Introduction

Human has been faced too many problems and dangers in effort to earn a livelihood for centuries. Fortunately in step with the increasing perils, methods of their prevention and control are developing as well. So that in spite of using dangerous chemicals or physical or biological factors, work places could be turned into healthy places in which workers can benefit from health and long life as similar as other people. Certainly the main provision of controlling dangers and preventing them in the places of work is having full knowledge of those dangers and their quality. Nowadays stonecutting industry makes the most important part of civil and construction affairs. It can be assuredly said that civil processes were completed by stonecutting industry. In the stonecutting factories, workers are exposed to several undesirable and detrimental factors and conditions which sometimes endanger their health seriously. Inhalation of free silica dusts is mentioned as one of those factors. Arising career diseases and complications like silicosis and other pulmonary damages are consequences of inhalation of free silica dusts. Importance of stonecutting and increasing need to its products in Iran, explains necessity of paying attention to the health of professionals of this industry.

On the other hand, noticeable number of workers, exposed or will be exposed to detrimental factors of place of work in stonecutting factories, reflects necessity of carrying out research to study on conditions of place of work and especially to precisely find type and amount of free silica dusts in this industry.

Considering the importance of effects resulted from inhalation of free silica dusts, environmental conditions of work in stonecutting industry from aspects of air pollution by this pollutant and the degree of workers' exposure to it were studied in this paper which was performed within fall of 20011 through spring of 2012 at stonecutting factories of Fadaeian Eslam Street of Tehran. We hope that the results can take effective steps toward improvement of the present status and more health of professionals of this industry.

2 II.

Review of Previous Researches * Banks et.al. figured out concentration of free silica in 2 mills of silica powder in 1981. Concentration of free silica was more than 0.05 mg/m³ in 85% of inhalant dusts samples and it's silica was variable between 95 to 98% (banks&etal). * Fulekar's study in stone-grinding factories of Rajasthan State of India indicated that the mean of total particles concentration in the air of these worksites was 22.5 mg/m³ and the mean of inhalant particles concentration was 2.93 mg/m³ and considering percentage of free silica in dusts (75%) rate of exposure of the professionals was reported as more than allowed limit of professional exposure: PEL=0.36 mg/m³ (fulekar,1999).

3 H

Global Journal of Researches in Engineering XIII Issue v v v III Version I 35 free silica (quartz) in which 60 samples of inhalant dusts, 6 samples as control (check sample) and 12 environmental samples were taken from breathing area of the workers in 5 different worksites in order to analyze concentration of free silica and exposure rate of workers in the construction stone mine. Then the concentration was calculated according to Niosh method: the mean concentration of dusts was the highest in the 5 th station and the 1 st worksite showed the least amount and concentration of free silica in all worksites was less than allowed limit (Sakhaei, Manouchehr, 1998).

* Mr. Sajad Mousavi did study on workers of under construction subway tunnel of Tehran exposed to total dusts and crystal silica (quartz) as M.Sc. thesis of University of Tehran in 2009. In this research, performed by standard method of Niosh-7601, amounts of total dusts and inhalant dusts containing silica exceeded the standards of Iran and ACGIH in all worksites. ??Mousavi, Sajad,2009) III.

4 Stonecutting Factories

In stonecutting factories, there are granite and other construction stones of porcelain type which are cut from larger mineral rocks and brought to stonecutting factories to be prepared for construction. In the stonecutting factories, the stones are cut in different sizes in order to be used in granite stairs and kitchen counter most of which, especially carving granite stairs and kitchen counters, are dry. In the worksites subject of the study, workers cut and carve these stones without using breathing masks and after carving or cutting, these stones are stored in depot or warehouse by the workers and they are finally delivered to the customers.

5 IV.

Silica Forms * Crystal form (Crysalln) which is seen as 3 forms of quartz, tridimite and cristobalite, depended on temperature of formation time.

* Microcrystal form (micro) including small crystals of quartz attached to each other by amorphous silica.

* Amorphous form (amorph) in which different molecules have dissimilar spatial relation with each other and as a result there is no specific regular pattern between the molecules (lanyer,1978).

V.

6 Free Silica Dispersion Origins

Too many industries like tunnel construction, mining, foundry, buildings stone-working, earthwork, plastic production, glass-working industries, sandblast and ballasting, sand mines, pottery, construction operation, digging, agriculture, hammering, ceramic and brick making, stonecutting, Portland cement production, production of washing materials, etc. are origins of dispersion of free silica in the air.

7 VI.

8 Materials & Methods

This study has been planned as descriptivecross-sectional including the following stages:

1. Preliminary investigation and gathering necessary basic information of the research
2. Planning for number of required samples considering number of all worksites and work process in the worksites
3. Sampling according to standard method of Niosh-7601 and transferring samples to the laboratory
4. Weight analysis of the samples
5. Analysis of percentage and concentration of free silica by visible spectrophotometry according to method of Niosh-7601
6. Determination of type of free silica in volume samples for XRD analysis according to method of Niosh-7601

9 VII. Preliminary Study and Gathering

Basic Information Required for the Research a) Library and data study was performed to get information about process of the work and required instruments and samples analysis Method of work in the worksites were examined as well which resulted to figuring out type of consuming stones and conditions of work and totally 8 worksites were identified in the stonecutting factories as a result of studying worksites of the factories including: entrance door stations, peak offload, raw stone depot, primary cut (single-cut), secondary cut, grinding and polishing, product depot, loading, locations of sampling were planned, the workers' breathing protection instruments, function

of cutting machines, stonecutting factories air conditioners, and number of persons who are exposed to dusts and free silica were examined and it became clear that 8-10 persons were exposed to dusts in average. After inspecting status of the worksites located at the region subject of study, 5 worksites were selected to be studied. Considering the mean and criteria deviation of concentration of aerosol containing free silica in other studies and using statistical relation, 40 samples should be gathered. Therefore 8 samples were taken from each worksite according to process of work in the worksites and one out of each 8 samples was analyzed for percentage of free silica.

b) Applied instruments and materials

d) Sampling according to Standard Method of Niosh-7601

According to aims of the study, sampling of inhalant dusts was performed in 8 regions of each worksite.

At first 37mm filters, with aperture size of 0.8 μ , were weighted by a scale, with accuracy of 0.0001 gr. and then they were put in silicon support and sampling pump was fixed on a 1.5 m stand (at the same breathing height of the workers). According to method of Niosh-7601, the pump Debi was set on 1.7L/min and sampling was carried out during 8 hours.

At the beginning and by the end of sampling by the sampling pump, Debi monotony was watched. By the end, the sampling pump was removed from the stand and filters (real and check samples) were put in the support to be transferred to the laboratory and then the filters were weighted in the laboratory. It is worthy to note that to correct sampled air volume to volume in standard conditions, temperature and pressure quota were measured during sampling and the mean was calculated. Controls were treated like the real samples. In this way, the support of the controls was removed in the environment and quickly was placed on it without sampling. Then they were packed and transferred to the laboratory with real samples. Exactly the same stages were passed for real samples and controls. In the laboratory, controls were essentially used to estimate pollutants in the sampling filters. Results of controls should be deducted from results of tests performed on the real samples in order to get more accurate results. (6) ? Weight analysis of the samples * Weighting filters: In this research, visible spectrophotometer was used to calculate concentration of crystal silica in the samples. In this method, total weight of dusts should not be more than 2 mg. Sampling filters and control were weighted by digital scale before and after sampling. To find type of free silica in the stones used in the stonecutting factories, volume sample should be prepared from the dusts taken from cutting operation in the stonecutting factories and considering that there are 2 types of granite stones in these factories, 2 volume samples were prepared. After preparation of these samples by 40 μ sieve, they were delivered to XRD analysis laboratory in the Research Center of Inorganic Materials Process of Iran to determine type of silica using standard method of Niosh-7500.

b) Analysis by XRD

Generator of X-ray is set on 40 KV and 40 Ma. One standard sample is transferred to the sample support in the system by pincers and the support is placed in the container.

X.

a) The Results of Weight Analysis of Inhalant Dusts

Concentration of inhalant dusts were calculated and presented by weighting method for each sampling station separately. Some parameters used in the calculations are as follows: According to table 7, contents of inhalant dusts and silica in μ g, amount, type, percentage and concentration of free silica in μ g in comparison with maximum concentration of inhalant dusts and silica are obtained in mg/m³ in professional standard of Iran.

b) The Results of Instrumental Analysis by UV-VIS Spectrophotometry

In this table, concentration of silica in professional standard of Iran in mg/m³ is showed as 0.1 in all worksites and also maximum concentration of inhalant dusts is showed as fixed amount in mg/m³ in each worksite of the stonecutting factories.

Discussion

In worksites No.1 to 5, maximum allowed concentration of inhalant dusts were measured as 1.11, 1.077, 1.075, 1.61 and 1.58 mg/m³ respectively, however concentration of inhalant dusts in 85% of the subject worksites was more than allowed concentration standard and the remaining 15% of the worksites showed the maximum allowed limit of concentration.

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18 G

The highest concentration measured in this study was 3.910 mg/m³ and the highest percentage of silica, i.e.12.5%, was related to grinding and polishing worksite No.3 and the least concentration was measured as 1.005 mg/m³ and the least percentage of silica, i.e.4.25%, was related to entrance door worksite No.4.

According to the results of statistical test, there is significant difference between concentration of free silica in the samples and standard level. Allowed concentration of silica in professional standard of Iran is 0.1 mg/m³.

In fact, free silica in inhalant dusts of these worksites turns them from ineffective and or annoying dusts to toxic dusts and increases change of suffering pulmonary problems in proportion to percentage of free silica and intensity and duration of exposure to such dusts.

Therefore more polluted worksites must be given priority in taking engineering control measures. Considering the results of tables 1 to 6, concentration of inhalant dusts in sampling worksite of grinding and polishing is more than other worksites. In other words, the most dispersion of aerosol containing free silica happens in grinding and polishing worksite and also secondary cut worksite.

The least concentration of aerosol is related to entrance door and peak offload worksites. Statistical relation shows that concentrations of inhalant aerosol among different worksites of a factory are significantly different from each other and prioritization of management and engineering control actions should be based on these findings. According to XRD analysis, the consumed stone contains free silica of quartz type which pathogenic effects are less than cristobalite. However it's pathogenic effects is emphasized as well because of increase, fashion and more application of crystal form of free silica than other forms. According to table 6, mean concentration of dusts resulted from free silica in all worksites of study is 2-3 times more than maximum allowed limit in stonecutting factories.

19 XII.

20 Conclusion

Findings of this study indicate that air pollution as inhalant dusts dispersed in stonecutting factories contains free silica of crystal or quartz type and percentage of free silica in dusts of different worksites is measured so that concentration of dispersed dusts is more than allowed concentration. Meanwhile, dispersion of dusts in secondary cut worksites is noticeable from concentration and percentage of free silica aspects and it seems that there is probability of suffering from pulmonary problems among professionals and persons exposed for long term and work conditions of subject worksites are not appropriate from viewpoints of air pollution control and protection of workers' health against inhalation of aerosol containing free silica. Therefore taking appropriate control actions to decrease rate of dusts dispersion and also to decrease their concentration around the worksites seems to be necessary.

21 XIII.

22 Proposals

According to the results and prioritization of control measurements among worksites of study and factories, preventive control actions should be predicted, planned and taken as management, engineering and individual in proportion to the work conditions in order to omit or decrease health risks resulted from inhalation of free silica dusts in the place of work. Principles of preventions may be summarized as follows:

In general, control methods including: process correction, engineering control, promotion of method of work, and using individual instruments may be used in 3 levels of control in the origin aiming at omission or decrease in producing pollution, control in dispersion path aiming at omission or minimizing pollution area, and finally control in exposure level aiming at omission or minimizing persons' exposure.

23 Resources

1 2 3

¹? Membranous filter with 37 mm in diameter and 0.8 micron powder

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Figure 1: *



1

Figure 2: A?? 1 :



2

Figure 3: ?? 2 :



Figure 4: A



1

Figure 5: Figure 1 :

23



Figure 6: Figure 2 :Figure 3 :

4



Figure 7: Figure 4 :A



5

Figure 8: Figure 5 :



6

Figure 9: Figure 6 :

* Reagents:

1. Silica standard

A: Quartz (1958, 2951, 2950, 1878a SRMs), B: Crystobalite (957, 2960, 1879 SRMs) C: Tridimite

2. 2-Hydrofluoric acid 48%

3. Autophosphoric acid 85%

4. Aqueous ammonia

5. Hydrochloric acid 1/10 in ammonia

6. Sulfuric acid 10N

7. Concentrated Nitric Acid

8. Concentrated Perchloric acid for PVC filters

9. Boric Acid 5%

IX. Determination of type of free Silica in Volume Samples for XRD Analysis According to Method of NIOSH-7601

[Note: a) Providing volume sample]

Figure 10:

1

Worksite	Different Worksites of Stonecutting Factories					Upper limit	Ar
	Number of Samples	Mean	Criteria Devia- tion	Confidence Limit 95%	Lower limit		
Entrance Door	5	1.1191	0.25	1.12	1.51		0.7
Peak Offload	5	1.2192	0.27	1.02	1.41		0.8
Raw Stone Depot	5	2.353	0.41	2.18	2.82		1.9
Primary Cut	5	2.556	0.45	2.23	2.87		1.9
Secondary Cut	5	3.2912	0.52	2.91	3.70		2.5
Grinding & Polish- ing	5	3.3293	0.54	2.93	3.72		2.5
Product Depot	5	1.8254	0.42	1.52	2.12		1.1
Loading	5	1.6204	0.40	1.50	2.10		1.0

Figure 11: Table 1 :

2

No. of Work-site	Name of Worksite	Content of Dusts (mg)	Contents of Silica (?g)	Percentage of free silica in inhalant dust
1	Product Depot	1	70	7
	Entrance Door	0.7	51	.285
2	Secondary Cut	1.7	124	7.30
	Peak Offload	0.5	21	4.30
3	Raw Stone Depot	1.1	73	6.636
	Grinding & Polishing	1.9	231	12.15
4	Loading	0.7	50	7.14
	Entrance Door	0.4	17	4.25
5	Peak Offload	0.6	40	6.66
	Primary Cut	1.2	76	6.33

Figure 12: Table 2 :

3

No. of Work-site	Mean concentration	stonecutting factories		Amplitude of Changes in Concentration	Min. Max.	Maximum concentration inhalant dust
		Criteria	Devia- tion			
1	2.5685	1		1.3	4.05	1.11
2	2.745	0.93		1.526	4.851	1.077
3	2.3	0.84		1.3	3.617	1.075
4	2.193	0.84		1.075	3.2	1.61
5	2.056	0.71		1.1	3.01	1.158

Figure 13: Table 3 :

2

Iran.

$\text{SiO}_2\% = \frac{\text{Silica Content (mg)}}{\text{Content of inhalant dusts (mg)}} \times 100$

Figure 14: Table 2 -

4

No. of Work-site	Name of Worksite	Contents of Silica (?g)	Silica concentration	Silica concentration in professional standard of Iran
1	Product Depot	70	0.151	0.1
	Entrance Door	51	0.111	0.1
2	Secondary Cut	124	0.264	0.1
	Peak Offload	21	0.0451	0.1
3	Raw Stone Depot	73	0.157	0.1
	Grinding & Polishing	231	0.5	0.1
4	Loading	50	0.109	0.1
	Entrance Door	17	0.037	0.1
5	Peak Offload	40	0.0872	0.1
	Primary Cut	76	0.164	0.1

Figure 15: Table 4 :

5

No. of Work-site	Name of Worksite	Type of Silica (?g)	Maximum concentration of inhalant dusts (mg/m ³)
1	Product Depot	Quartz	7
	Entrance Door	Quartz	7.285
2	Secondary Cut	Quartz	7.3
	Peak Offload	Quartz	4.2
3	Raw Stone Depot	Quartz	6.636
	Grinding & Polishing	Quartz	12.15
4	Loading	Quartz	7.14
	Entrance Door	Quartz	4.25
5	Peak Offload	Quartz	6.66
	Primary Cut	Quartz	6.33

Figure 16: Table 5 :

6

Name of Worksite	concentration in different stonecutting worksites				
	Number of Worksite	Mean concentration	Criteria Deviation	Amplitude of Changes in Concentration Min. M	
Entrance	5	1.1191	0.25	0.77	1.64
Door					
Peak	5	1.2192	0.27	0.87	1.74
Offload					
Raw Stone	5	2.353	0.41	1.91	3.37
Depot					
Primary Cut	5	2.556	0.45	1.96	3.42
Secondary	5	3.2912	0.52	2.57	4.02
Cut					
Grinding & Polishing	5	3.3293	0.54	2.59	4.11
Product	5	1.8254	0.42	1.10	2.61
Depot					
Loading	5	1.6204	0.40	1.06	2.57

Figure 17: Table 6 :

7

standard of Iran

Figure 18: Table 7 :

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