



Reduction in Maximum Voluntary Ventilation of lungs of Sand Stone Quarry Workers: A Case study

Authors

Dr. Suresh Kumar Singh¹, Dr. D. Patel², Dr. Gopal Purohit³

¹Department of Civil Engineering, Faculty of Engineering, J. N. V. University, Jodhpur (India)

²Department of Chemical Engineering, Faculty of Engineering, J. N. V. University, Jodhpur (India)

³Sr. Professor, Dept. of Respiratory Diseases & Tuberculosis, Dr.S.N. Medical College Jodhpur (India)

Abstract

This study was designed to assess the impact of high particulate concentration on Maximum Voluntary Ventilation of lungs of sand stone quarry workers. The workers were engaged in different types of activities such as drilling, loading and dressing. These different working conditions had different concentrations of RSPM, leading to different exposure levels in workers. It was found that exposure duration and exposure concentrations were the main factors responsible for damage to the respiratory tracts of the workers. The particles were deposited at various areas of the respiratory system and affect the Maximum Voluntary Ventilation of lungs. It was also revealed from the study that most of the workers suffered from silicosis if the exposure duration was more than 20 years.

Keywords: *Maximum voluntary ventilation (MVV), respirable suspended particulate matter (RSPM), silicosis, respiratory tract*

Introduction

The mining of various minerals and materials is going on since the man has thought about the development. Invention of new tools has increased mining activities but at the same time the pollution level also increased. The increase in the pollution level increases the chances of occupational diseases. The toxicity of the particles retained in the lungs depends upon the chemical composition of the particles and size of the particles [7]. The sand stone quarrying has been established as the largest industry of Jodhpur (India). More than

hundred thousand workers are employed for quarrying and its related activities [2]. The working capacity of workers starts decreasing with the increase of working duration in quarries. This decrease in working capacity is because of the damages in the respiratory tract due to deposition of RSPM. There are variety of measures to assess the functioning of respiratory system which include tests of flows and volumes [3], tests of respiratory muscle strength [4], endurance [1], fatigue [9], and chest wall function analysis [5].

Routine measurements of respiratory function (*i.e.*, volumes, flows and indices of gas exchange) are non specific in relation to diagnosis but give useful indirect information about respiratory muscle performance. More frequently, these measurements are of use in assessing the severity, functional consequences and progress of patients with recognized respiratory muscle weakness ^[3]. Amongst the various tests for flows and volumes, maximum voluntary ventilation (MVV) is a parameter that reflects lung volume changes, respiratory muscle functioning, compliance of the thorax lung complex and airway resistance ^[8]. MVV is defined as the maximum amount of air that a subject can breathe over a specified period of time (12 seconds for normal subjects) and is expressed in L/min ^[6]. It can be used as a tool for assessment of respiratory muscle weakness ^[3].

Observations & Calculations

- I. A comprehensive methodology was adopted for taking the observations. The various steps undertaken are:
- II. Stone quarries were selected to cover all the deposits around Jodhpur.
- III. Selection of workers: Selection of workers was based upon the exposure duration, type of works and socioeconomic factors.

Persons having any hereditary respiratory problem were excluded from the study. Only male workers were considered because female workers working in stone mines were very less in number

- IV. Respirable Particulate concentration in ambient air was measured with the help of 'Fine Particulate Air Sampler' for every activity. These activities are designated as loading, dressing and drilling and the workers who perform these works are called labour, dresser and driller respectively. The concentrations of these activities are designated as 1, 2 and 3 for normal quarry environment (*i.e.* loading and unloading etc), dressing and drilling respectively. Table- 1 gives the average value of RSPM for various activities.
- V. The Maximum voluntary ventilation (MVV), of workers engaged in different type of activities was measured with the help of Spirometer (Spiroweb, manufacture by drcdrecare, Hyderabad, India. The predicted value of Maximum voluntary ventilation (MVVp), (*i.e.* depends upon height, weight and age of human) of each worker was calculated by using ERS -93 Equations by spirometer.

Table 1:Respirable Suspended Particulate concentration

<i>Activity</i>	<i>Respirable Particulate Concentration</i>	<i>Concentration category</i>
Normal Quarry Environment	440 µg/m ³	1
Dressing	1170 µg/m ³	2
Drilling	1730 µg/m ³	3

The effect on respiratory tract is chronic therefore exposure duration was divided in four categories, 0-5 yr., 5-10 yr., 10-15 yr. and >15 yr. and these categories are designated as 1, 2, 3 and 4 respectively. Categories of workers, number of workers in each categories and exposure

categories are given in Table- 2. Control workers were selected for comparison purpose from the same socio-economic background but those are not exposed to high suspended particulate concentration.

Table 2: Category of workers and exposure duration

Category of Workers	Exposure Duration in Years	Number of Workers	Exposure Category
Labour (111)	0-5	28	1
	5-10	26	2
	10-15	26	3
	>15	31	4
Dresser (107)	0-5	29	1
	5-10	26	2
	10-15	25	3
	>15	27	4
Driller (102)	0-5	25	1
	5-10	26	2
	10-15	25	3
	>15	26	4
Control workers	-----	36	-----

Predicted values are designated as MVV_p . The age (A), height (H) and weight of every person were recorded in the spirometer for determination of predicted value of MVV and is found with the help of ERS-93 equation (already incorporated in spirometer programme) . Predicted value of MVV and actual value of MVV both were known by computerized Spirometry and index for decrease in MVV was calculated with the help of equation-1.

Index is developed to find out the extent of damage and percentage of volume reduction in fraction. The reduction in maximal voluntary ventilation of lung is calculated and it is

designated as IMVV and which is calculated with the help of equation-1 and the mean values of index (IMVV) are given in Table 3

$$IMVV = (MVV_p - MVV) / MVV_p \quad \text{-----(1)}$$

Regression Analysis for IMVV

The mean values of index IMVV were calculated and shown in Table 3. The dependent variable IMVV (Reduction in Maximal Voluntary Ventilation) is denoted by 'y'. The independent variable Exposure category is denoted by 'x'. The three equations obtained for different types of stone quarry workers are as follows:

$$\text{Labour: } y_1 = 0.5441 + 0.0173 x \quad \text{-----(2)}$$

Dresser: $y_2 = 0.565 + 0.0276 x$ -----(3)

Driller: $y_3 = 0.6422 + 0.0055 x$ -----(4)

Table 3: Mean values of indices

No. of workers	Worker Category	EXP DUR	EXCAT	PCAT	Mean IMVV
28	Labour	0-5	1	1	0.5666
26	Labour	5-10	2	1	0.5699
26	Labour	10-15	3	1	0.5982
31	Labour	>15	4	1	0.6149
29	Dresser	0-5	1	2	0.5772
26	Dresser	5-10	2	2	0.6419
25	Dresser	10-15	3	2	0.6507
27	Dresser	>15	4	2	0.6664
25	Driller	0-5	1	3	0.6503
26	Driller	5-10	2	3	0.6520
25	Driller	10-15	3	3	0.6535
26	Driller	>15	4	3	0.6682
36	Control Population		-----	----	0.2532

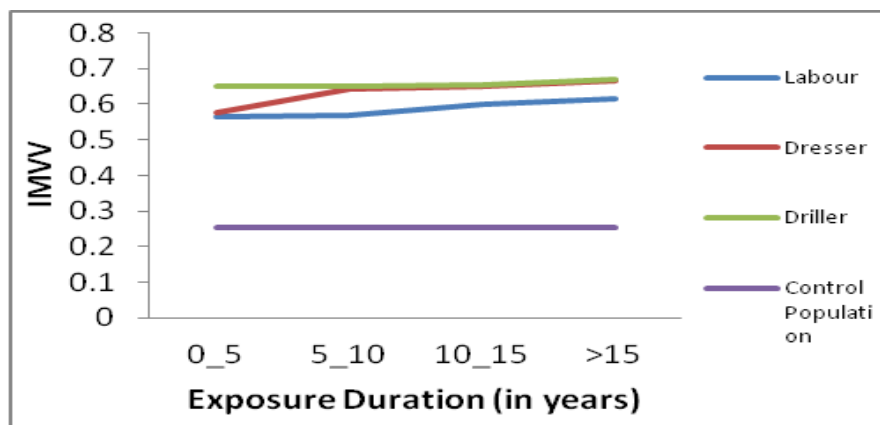


Figure 1: Comparison of IMVV for different types of stone quarry workers for different exposure duration

Conclusion

The major air pollutant in the sand stone quarries is respirable suspended particulate matter (RSPM). The study was conducted to assess the effect of RSPM concentration and exposure duration on Maximal Voluntary Ventilation of lungs of the sand stone quarry worker. The MVV of lungs is directly associated with the damage in muscles of lungs and is related to chest wall compliance. The Maximal Voluntary Ventilation of lungs decreases

as the exposure duration increases for a particular concentration of RSPM. The Maximal Voluntary Ventilation of lungs also decreases as the concentration of RSPM increases for particular exposure duration. For the exposure duration of 0-5 year the decrease in the Maximal Voluntary Ventilation is about 56% and this increases as the exposure duration increases. For exposure duration of 5-10 years the decrease in MVV is 61%, as this is a chronic problem and if the

exposure duration increases further than the condition of lungs may deteriorate further and the problem may become very serious. The decrease in MVV is 63% and 66% for the exposure duration of 10-15 years and >15 years respectively. Decrease in the MVV is high in the initial stage. It indicates that high exposure to RSPM is very dangerous for the health of lungs as it deteriorates the capacity of muscles and if muscles capacity is decrease it directly affect the working of lungs. Study indicates that after 20 years of working in sand stone mine lungs are so damaged that workers are forced to leave the work.

References

1. Clanton, T., Calverly, P.M. and Celli, B.R.: Tests of respiratory muscle endurance. ATS/ERS statement on respiratory muscle testing. *American Journal of Respiratory and Critical Care Medicine*, 166, 559-569,2002.
2. Directorate of Mines & Geology: "Sand Stone of Rajasthan". *Directorate of Mines & Geology, KhanijBhawan, Udaipur (India)*. 2000.
3. Gibson, G.J., Whitelaw, W. and Nikolaos, S.N.:Tests of over all respiratory function. ATS/ERS statement on respiratory muscle testing. *American Journal of Respiratory and Critical Care Medicine*, 166, 521-526, 2002.
4. Green, M., Road, J. and Sieck, G.C.: ATS/ERS statement on respiratory muscle testing. *American Journal of Respiratory and Critical Care Medicine*, 166, 528-542, 2002.
5. Loring, S.H., Troyer, A. and Grassino, A.E.: Assessment of Chest Wall Function. ATS/ERS statement on respiratory muscle testing. *American Journal of Respiratory and Critical Care Medicine*, 166, 580-586, 2002.
6. Millre, M.R., Hankinson, J. and Brusasco, V.: Maximum voluntary ventilation. Standardisation of spirometry: SERIES "ATS/ERS task force: Standardization of lung function testing". *European Respiratory Journal*, 26, 331-334, 2005.
7. Nemery, B.; Behr, J.; Bourke, S.; et. al: "Interstitial lung disease induced by exogenous agents: Factors governing Susceptibility." *EurRespi Journal*,18 (suppl-32):30-42, 2001.
8. Sheldon, R.L.: Pulmonary Function Testing. In Wilkins, R.L., Krider, Susan, J., *Clinical assessment in respiratory care*. 4th Edition, Mosby, St. Louis, 141-160, 2000.
9. Supinski, G.S., Fitting, J.W. and Bellemare, F.: Assessment of Respiratory Muscle fatigue. ATS/ERS statement on respiratory muscle testing. *American Journal of Respiratory and Critical Care Medicine*, 166, 571-578, 2002.
10. User Manual. "SPIROWEB" *Version-1.1*".drcdrecare, 3-5-780/11, Kingoti, Hyderabad (India) 1999.