

Effect of Reduction in Peak Expiratory Flow Rate on Blood Pressure of Sand Stone Mine Workers

Banna Ram Panwar¹, Anil Vyas², Suresh Kumar Singh³

¹Rajasthan State Pollution Control Board, Jaipur, India

²Department of Chemical Engineering, Jai Narain Vyas University, Jodhpur, India

³Department of Civil Engineering, Jai Narain Vyas University, Jodhpur, India

Email: sksingh.jnvu@gmail.com

Received 29 December 2015; accepted 6 April 2016; published 11 April 2016

Abstract

Peak Expiratory Flow Rate (PEFR) measures the airflow through the bronchi and thus the degree of obstruction in the airways. Exposure to high concentration of respirable suspended particulate matter (RSPM) decreases the PEFR and the decrease depends upon the exposure concentration of particles and exposure duration. The decrease in PEFR is found to be responsible for increase in blood pressure (BP). Relationship between increase in BP and reduction in PEFR is not exactly linear but it can be considered as liner. It is noticed that if PEFR is reduced to about 50% to 60% in that case sudden increase in BP is recorded and behaviour of BP rise has complex pattern. It is also an established fact that if PEFR is reduced more than 50%, this is treated as severe respiratory problem. There are many factors (*i.e.* smoking habits, medical treatment, physiology, etc.) which may govern the increase of BP in this condition. Estimated relationship is found as: $ISBP = 0.213 + 0.263 IPEF$, $IDBP = 0.102 + 0.176 IPEF$.

Keywords

PEFR, BP, SBP, DBP, RSPM

1. Introduction

Particulate matter is the main component of air pollution in sand stone opencast mines. Various activities are going on in these mines which include drilling, blasting, cutting, dressing and loading & unloading etc., hence ambient particulate matter concentration is very high. Sand stone mine workers are exposed to various concentration of particulate matter during the working hours depending upon their work categories. The deposition of RSPM in the respiratory tract can damage the system thereby reducing the PEFR of the lungs and adversely affecting the working of respiratory system. Mine/Quarry workers are exposed to particulate matter of different concentration and size, which leads to deterioration of their pulmonary and cardiovascular functions. Burnett *et al.* (1999); Morris (2001) suggested that adverse effects of air pollution included an increase in cardiovascular

and respiratory deaths among elderly people as well as increased hospital admissions for heart and respiratory diseases [1] [2]. Singh *et al.* (2007) assessed the reduction in forced vital capacity of lungs of sand stone quarry workers exposed to high respirable suspended particulate concentration. He found that exposure duration and exposure concentrations were main factors responsible to damage respiratory tract of worker [3]. Kumar *et al.* (2014) performed pulmonary function test on quarry workers and controlled population. On comparing pulmonary functions between quarry workers and controls, it was concluded that the exposure to dust containing silica in quarry workers led to deterioration of pulmonary function and it was correlated with the duration of the exposure [4]. Linn *et al.* (1999) analysed effects of air pollution on blood pressure in a population based sample as well as in a panel of asthmatic subjects found an increase in systolic blood pressure with elevated concentrations of particulates [1] [5]. Brook *et al.* (2004) published its first scientific statement of American Heart Association (AHA) regarding air pollution and cardiovascular disease. He discussed that short term exposure to particulate matter air pollution contributed to acute cardiovascular morbidity and mortality and exposure to elevated PM level over the long term can reduce life expectancy by a few years [6]. According to Bellavia *et al.* (2013), short-term exposures to fine (<2.5 μm aerodynamic diameter) ambient particulate-matter (PM) have been related with increased blood pressure (BP) in controlled-human exposure and community-based studies. However, whether coarse (2.5 to 10 μm) PM exposure increases BP is uncertain [7]. This study aims to assess the change in blood pressure due to their resultant decrease in Peak expiratory flow rate (PEFR) caused due to particulate exposure duration and concentration in quarry/mine workers of Jodhpur region.

2. Method & Methodology

The sandstone quarrying/mining process is done manually and mechanically but the involvement of workers in both the cases is significant. There are three types of workers, in the quarrying process:

- 1) Driller: These sets of workers are employed for blasting, and drilling operations.
 - 2) Dresser: These are the workers employed for doing finer work, by chiselling, cutting or dressing the stone pieces for decorative works.
 - 3) Labours: These sets of workers are employed for loading & unloading operations and are exposed to normal quarry environment.
- a) The workers were selected for the study from various stone quarries. The selection of workers was based upon the exposure duration, type of work, socioeconomic factor, and previous diseases. The workers having hereditary respiratory & cardiovascular problems were not taken for study. Only male workers have been considered in this study.

The control workers were selected from the same category of life style, socioeconomic standard but are not exposed to pollution for comparison purpose.

- b) RSPM concentration was measured during various activities in the mines and average concentrations of RSPM for various activities are given in **Table 1**.
- c) The systolic blood pressure (SBP) and diastolic blood pressure (DBP) and PEFR of population under consideration was measured with the help of Multiparameter Monitor and Spirometer respectively. Total numbers of workers of various categories, involved in this study are given in **Table 2**.
- d) The PEFR of a person depends upon its age, height and weight, and the reduction IN PEFR due to damage depends upon the concentration of particulate matter and duration of exposure. Therefore, it is not possible to find out the generalised reduction due to pollution. Hence index is developed to find out the extent of damage in terms of percentage of reduction in fraction. The index is designated as IPEF. Similarly, indices were also calculated for Systolic blood pressure and Diastolic blood pressure and are represented as ISBP (percentage increase in systolic blood pressure in fraction) and IDBP (percentage increase in diastolic blood pressure in fraction) respectively. These indices were calculated from equations given below and are given in **Table 3**.

$$\text{IPEF} = (\text{PEFR}_p - \text{PEFR}) / \text{PEFR}_p$$

$$\text{ISBP} = (\text{SBP} - 120) / 120$$

$$\text{IDBP} = (\text{DBP} - 80) / 80$$

where:

PEFR_p = Predicted value of Peak expiratory flow rate of lungs,

Table 1. Various types of activities and RSPM concentration.

S.N	Activity	RSPM Concentration ($\mu\text{g}/\text{m}^3$)
1	Normal Quarry Environment	460.00
2	Dressing	970.00
3	Drilling	1890.00

Table 2. Category of workers and exposure duration.

Category of Workers	Exposure Duration in Years	Number of Workers	Exposure Category
Labour	0 - 5	30	1
	5 - 10	27	2
	10 - 15	36	3
	>15	27	4
Dresser	0 - 5	32	1
	5 - 10	27	2
	10 - 15	36	3
	>15	30	4
Driller	0 - 5	33	1
	5 - 10	30	2
	10 - 15	28	3
	>15	34	4
Control workers	-----	36	-----

Table 3. Mean values of indices (decrease in PF values & increase in blood pressure).

S.N	No. of Obs.	Worker Category	Exposure Duration (Yrs)	Exposure Concentration	Mean IPEF	Mean IDBP	Mean ISBP
1	30	Labour	0 - 5	460.00 $\mu\text{g}/\text{m}^3$	0.345	0.163	0.305
2	27	Labour	5 - 10	460.00 $\mu\text{g}/\text{m}^3$	0.444	0.177	0.327
3	36	Labour	10 - 15	460.00 $\mu\text{g}/\text{m}^3$	0.499	0.179	0.326
4	27	Labour	>15	460.00 $\mu\text{g}/\text{m}^3$	0.621	0.185	0.326
5	32	Dresser	0 - 5	970.00 $\mu\text{g}/\text{m}^3$	0.526	0.18	0.361
6	27	Dresser	5 - 10	970.00 $\mu\text{g}/\text{m}^3$	0.572	0.184	0.326
7	36	Dresser	10 - 15	970.00 $\mu\text{g}/\text{m}^3$	0.583	0.205	0.364
8	30	Dresser	>15	970.00 $\mu\text{g}/\text{m}^3$	0.538	0.213	0.377
9	33	Driller	0 - 5	1890.00 $\mu\text{g}/\text{m}^3$	0.523	0.195	0.338
10	30	Driller	5 - 10	1890.00 $\mu\text{g}/\text{m}^3$	0.525	0.215	0.382
11	28	Driller	10 - 15	1890.00 $\mu\text{g}/\text{m}^3$	0.576	0.221	0.397
12	24	Driller	>15	1890.00 $\mu\text{g}/\text{m}^3$	0.673	0.232	0.419
13	36	Control Population			0.229	0.146	0.307

PEFR = Measured value of Peak expiratory flow rate of lungs,

SBP = Measured value of Systolic blood pressure,

DBP = Measured value of Diastolic blood pressure.

2.1. Analysis

Regression & Graphical analysis is done to establish the relationship between decrease in peak expiratory flow

rate and increase in systolic and diastolic blood pressure.

2.1.1. Analysis for IPEF & ISBP

Following statistical parameters were found and F-test and t-test was applied.

$R = 0.637$, $R^2 = 0.405$, $F = 6.818$, t (for β_1) = 2.611.

Estimated Coefficient $b_0 = 0.213$ & $b_1 = 0.263$.

F test

$H_0: \beta_1 = 0$ against $H_1: \text{not all } \beta_k = 0: (k = 1)$.

$F_{k, n-k-1, \alpha} = 4.96$ (critical value from standard tables). Here, $F_{\text{calculated}} > F_{Fk, n-k-1, \alpha}$.

Hence, reject H_0 at α (value = 0.05) level of significance individual of significance β 's be tested by "t-Test".

t-Test

$H_0: \beta_j = 0$ against $H_1: \beta_j \neq 0: (j = 1)$.

The calculated values for t-statistics' for β_1 is: t (for β_1) = 2.611.

The value of $F_{n-k-1, \alpha/2} = 2.23$ Here $t > t_{n-k-1, \alpha/2}$; therefore reject H_0 .

Hence, $\beta_1 \neq 0$, Hence the estimated b_0 and b_1 are $b_0 = 0.213$ & $b_1 = 0.263$.

Thus, estimated multiple regression equation for ISBP can be expressed as:

$ISBP = 0.213 + 0.263 \text{ IPEF}$

2.1.2. Analysis for IPEF & IDBP

Following statistical parameters were found and F-test and t-test was applied.

$R = 0.699$, $R^2 = 0.489$, $F = 9.552$, t (for β_1) = 3.091.

Estimated Coefficient $b_0 = 0.102$ & $b_1 = 0.176$.

F test $H_0: \beta_1 = 0$ against $H_1: \text{not all } \beta_k = 0: (k = 1)$.

$F_{k, n-k-1, \alpha} = 4.96$ (critical value from standard tables). Here, $F_{\text{calculated}} > F_{k, n-k-1, \alpha}$.

Hence, reject H_0 at α (value = 0.05) level of significance individual of significance β 's be tested by "t-Test".

t-Test

$H_0: \beta_j = 0$ against $H_1: \beta_j \neq 0: (j = 1)$.

The calculated values for t statistics' for β_1 is: t (for β_1) = 3.091.

The value of $t_{n-k-1, \alpha/2} = 2.23$, Here $t > t_{n-k-1, \alpha/2}$; therefore reject H_0 .

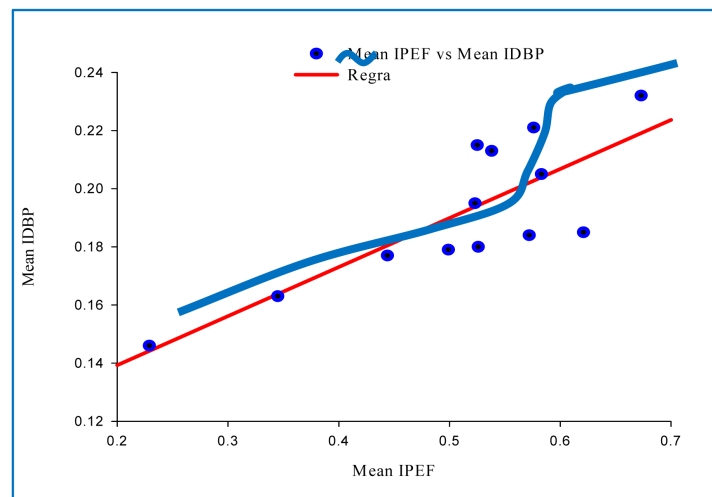
Hence, $\beta_1 \neq 0$. Hence the estimated b_0 and b_1 are $b_0 = 0.102$ & $b_1 = 0.176$.

Thus, estimated multiple regression equation for IDBP can be expressed as:

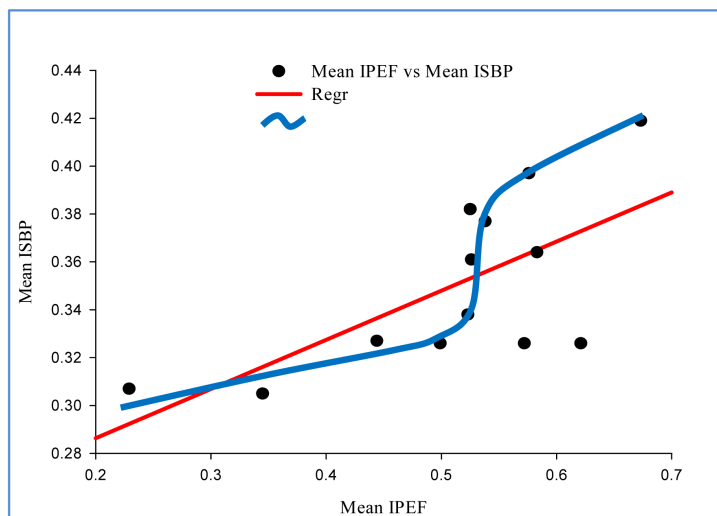
$IDBP = 0.102 + 0.176 \text{ IPEF}$

2.1.3. Graphical Analysis

It can be observed from **Graph 1 & Graph 2** that if PEFR is reduced to about 50% to 60% in that case sudden



Graph 1. Relationship between mean IDBP & mean IPEF.



Graph 2. Relationship between mean ISBP & mean IPEF.

increase in blood pressure is recorded and behaviour of blood pressure rise has complex pattern. It is also established fact that if PEFR is reduced more than 50%, this is treated as severe respiratory problem. It can also be concluded that workers may start taking medicines to control BP.

3. Conclusions

Sand stone mine/quarry workers inhale air which contains high amount of RSPM and these small particles are deposited in the respiratory system at various places. The deposition of RSPM in the respiratory tract can damage the system thereby reducing the PEFR of the lungs. Based on the study carried out in the present work the important conclusions drawn are as follows:

- 1) Increase in exposure duration increases the DBP & SBP when exposed to constant concentration of RSPM.
- 2) Increase in exposure concentration of RSPM increases DBP & SBP when exposed to constant exposure duration.
- 3) Reductions PEFR is also responsible for increase of DBP & SBP. Relationship between increase in blood pressure and due to reduction in PEFR is not exactly linear but it can be considered as liner. It is noticed that if PEFR is reduced to about 50% to 60% in that case sudden increase in blood pressure is recorded and behaviour of blood pressure rise has complex pattern. It is also an established fact that if PEFR is reduced more than 50%, this is treated as severe respiratory problem. The relationships between percentage increase in DBP & SBP due to percentage increase in decrease of PEFR are:

$$\text{ISBP} = 0.213 + 0.263\text{IPEF}, \text{IDBP} = 0.102 + 0.176\text{IPEF}$$

Presently workers are exposed to high concentration of RSPM in stone mines/quarries and deposition of sand stone particles in respiratory tract is not causing various respiratory diseases but indirectly it is affecting cardiovascular system. Hence it is urgent need to develop some techniques to reduce the RSPM in the working place and provide good working environment.

References

- [1] Linn, W., Gong, H., Clark, K. and Anderson, K. (1999) Day to Day Particulate Exposure and Health Changes in Los Angeles Area Residents with Severe Lung Disease. *J. Air Waste Manage. Assoc.*, **49**, 108-115. <http://dx.doi.org/10.1080/10473289.1999.10463890>
- [2] Borja-Aburto, V.H., Castillejos, M., Gold, D.R., Bierzwinski, S. and Loomis, D. (1998) Mortality and Ambient Fine Particles in Southwest Mexico City, 1993-1995. *Environ. Health Perspect.*, **106**, 849-855.
- [3] Singh, S.K., Chowdhary, G.R., Chhangani, V.D. and Purohit, G. (2007) Quantification of Reduction in Forced Vital Capacity of Sand Stone Quarry Workers. *International Journal of Environmental Research and Public Health*, **4**, 269-300. <http://dx.doi.org/10.3390/ijerph200704040005>

- [4] Kumar, C.H.K., Reddy, N.M., Singh, M.S.B., Krishna, B., Sasikala, P., Shravya Keerthi, G., Siva Kumar, A.V. and Kareem, S.K. (2014) Deterioration of Pulmonary Function in Stone Quarry Workers. *Biomedical Research*, **25**, 261-266
- [5] Ibald-Mulli, A., Steiber, J., Wichmann, E., Koenig, W. and Peters, A. (2001) Effects of Air Pollution on Blood Pressure: A Population Based Approach. *Am. J. Public Health*, **91**, 571-577. <http://dx.doi.org/10.2105/AJPH.91.4.571>
- [6] Brook, R.D. (2008) Cardiovascular Effects of Air Pollution. *Clin. Sci. (Lond)*, **115**, 175-187. <http://dx.doi.org/10.1042/CS20070444>
- [7] Bellavia, A., Urch, B., Speck, M., Brook, R.D., Scott, J.A., Albeti, B., Behbod, B., North, M., Valeri, L., Bertazzi, P.A., Silverman, F., Gold, D. and Baccarelli, A.A. (2013) DNA Hypomethylation, Ambient Particulate Matter, and Increased Blood Pressure: Findings From Controlled Human Exposure Experiments. *Journal of the American Heart Association*. <http://dx.doi.org/10.1161/JAHA.113.000212>