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Assessment of Impact on Peak Expiratory Flow Rate of Lungs of School Children due to exposure to Air Pollutants from Cement Manufacturing Plants

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Abstract

The rapid growth of industries due to frequent technical up gradation and pressure to cater the societal needs, the concept of sustainable development is often overlooked and resulting in various health related impairment. The cement manufacturing sector is considered to be one of the major cause for air pollution due to different hazardous emissions. This particular study is designed to assess the impact of air quality which contains high concentration of respirable suspended particulate matter (RSPM) on Peak expiratory flow rate of lungs of school children exposed to air pollutants from cement plants.

There are only few studies that have established reference standards for pulmonary function of Indian children. Reference standards for pulmonary function that are reported for Indian children are mainly from particular area or parts of the country. There is a paucity of data on pulmonary function in normal school going Indian children residing near cement plants located in various parts of the country. Therefore, pulmonary function tests (Spirometry and peak expiratory flow rates) were carried out in 469 children between 8-18 years of age to derive regression equations to predict pulmonary function impairment. The correlations of peak expiratory flow rates were established through regression analysis. The functions were regressed over all possible combinations of regression variables, i.e. between independent variables (like AQI and Exposure Duration) and dependent variables indices. It would give a direct relation between PEFR of lungs and pollutants.

Keywords: AQI,, PEFR, RSPM, Spirometry , Regression , Exposure duration

INTRODUCTION

I. The cement production from the raw materials like lime stone, clay, and gypsum is invariably a dusty and dirty operation resulting in polluted exposure of all living being close to the cement factories. Among the various investigation modalities available, pulmonary function test (PFT) is an invaluable tool for the assessment of lung function. PFT for lungs can be comparable to the ECG for heart,[12] . The application of PFT in diagnosis and management of respiratory diseases is not yet a routine in our country. Predictive normal values are essential for meaningful clinical interpretation of these tests. Studies carried out in children had projected the equations for predicting different lung functions using height, age and weight as independent variables in India[4,6] and in other countries [2,8] and also showed differences in India and other countries as well as regional differences for spirometric parameters. The study revealed that the main environmental issue associated with cement production is the emission of pollutants (SPM, SO_2 and NO_X) in the atmosphere. These air pollutants have long been associated with prevalence of various diseases in human beings.[7].The study on children also indicated that the impaired lung functions may cause a loss of appetite and limited food consumption, thus limiting the release of energy for metabolic processes reducing the body weight; thus reflecting a poor health status[3]. The use of protective measures is recommended beyond a level of pollution but, in developing countries neither the industries provide these measures nor the public at large prefer to use the same. The effect of pollution and cement dust has led to mild impairment of respiration and a prevalence of respiratory symptoms especially among school children residing near the cement plants. The degree of impairment of the respiratory function has been explained to depend on the years of exposure in different studies. A study on PEFR indicated that the tribal boys in whole achieved higher value in pulmonary function test in comparison to non-tribal boys. However, PEFR value is less in tribal boys in comparison to non-tribal boys which may be due to short height in them.[9] It is established that respiratory disorders are a major group of illness affecting children especially in India and are an important cause of childhood morbidity and mortality.[1] A study suggests that chronic exposure to cement dust has deleterious effect on the lungs. However the exact mechanism (s) by which it does this is unknown. For instance it is yet to be determined whether these effects are due directly to cement dust or mediated by a metabolic product of cement dust.[5] A study on PEFR revealed that male children have higher PEFR values especially after the age of 10 years possibly because of better height, weight and rapid growth of airway passages as age advances and possibly due to the more expiratory muscle effort.[11] The previous researchers have worked on the subject matter of school children either by considering the concentration of different pollutants from cement plants with exposure duration as variable or both together. In this study work we have studied pulmonary function PEFR of school children residing near the cement plants under different exposure duration and different concentration of pollutant.

II. POLLUTANTS FROM CEMENT PLANTS

Cement plants are a significant source of sulfur dioxide, nitrogen oxide and carbon monoxide, apart from particulate matter PM_{10} (RSPM) which are associated with the following health and environmental impacts: Nitrogen oxide (NO_x) can cause or contribute to a variety of health problems and adverse environmental impacts, such as ground-level ozone, acid rain, global warming, water quality deterioration, and visual impairment. Affected populations include children, people with lung diseases such as asthma, and exposure to these conditions can cause damage to lung tissue for people who work or exercise outside. Sulfur dioxide SO_2 in high concentrations can affect breathing and may aggravate existing respiratory and cardiovascular disease. Sensitive populations include asthmatics, individuals with bronchitis or emphysema, children, and the elderly. SO_2 is also a primary contributor to acid deposition, or acid rain. Carbon monoxide (CO) can cause harmful health effects by reducing oxygen delivery to the body's organs and tissues, as well as adverse effects on the cardiovascular and central nervous systems. CO also contributes to the formation of smog (with ground-level ozone), which can cause respiratory problems.

Methods and Observations:

The school children population (469 nos.) in this study consists of the school children residing near the operating cement plants and exposed to different duration depending upon their stay in schools. Total four cement plants operating in different part of India were selected for the study. The name of the cement manufacturing plants are not disclosed in the study because of agreement and understanding with plant authorities. All the school children (male) taken into account in this study were enrolled. They had been exposed to cement dust for a period of 3 to 12 years (mean ± SEM) years. An unexposed or controlled group of school children (male) comprised of the school children belonged to the same socio-economic class as the exposed group, and residing far away from the cement factory. Only subjects who were non smokers and who had no history or signs of chronic cough, bronchitis, bronchial asthma or other signs and symptoms suggestive of respiratory diseases were eligible and selected into both the exposed and unexposed groups. Data collection was effected by way of an interviewer-administered structured questionnaire, to determine the socio-demographic characteristics, years of exposure as deduced from date of their admission in schools. Information on general health, history of past disease(s) and habits such as smoking and alcohol consumption were obtained. Lung function tests were carried out with a Electronic spirometer (Easyone, Swiss make). The procedures were carefully explained and demonstrated to each subject and then the tests were carried out. Peak expiratory flow rate (PEFR) was measured with the help of a trained technician familiar with the procedure. The use of one observer per measurement was maintained throughout the study. Some of the readings were randomly repeated personally to validate their accuracy. The various pollutants such as RSPM, SPM, SO_2, NO_2 and CO were measured and air quality index was calculated and are given in table-2.

The entire data from the schools school going children were pooled to cover a wide range of variability. Regression analysis was done to establish relationship between reduction in PEFR, air quality index (AQI), and exposure duration. Predicted values of PEFR were calculated by ERS-93 equation.[10] The reduction in PEFR was calculated in terms of percentage reduction by equation -1 and is indicated as IPEFR. Average value of IPEFR for various exposure duration and AQI is given in table-1. Average AQI of various industries were calculated by the Central Pollution Control Board (CPCB) of India guidelines and are given in table-2.

Table-1 : Reduction in PEFR, AQI & Exposure Duration

S. No.	NO. OBS	AQI	Exposure Duration (Yr)	IPEFR
1	30	72.50	3	0.0601
2	25	72.50	6	0.0619
3	26	72.50	9	0.0852
4	27	72.50	12	0.1231
5	26	92.50	3	0.0726
6	29	92.50	6	0.0833
7	25	92.50	9	0.1125

8	28	92.50	12	0.1457
9	29	125.00	3	0.1031
10	25	125.00	6	0.1291
11	25	125.00	9	0.1428
12	27	125.00	12	0.1525
13	28	141.00	3	0.1109
14	29	141.00	6	0.1359
15	26	141.00	9	0.1797
16	26	141.00	12	0.1866
17	38	Control Population	xxxxx	0.0432

$$IPEFR = (PEFR_P - PEFR) / PEFR_P \qquad \text{------} \quad (1)$$

Where

$PEFR_P$ = Predicted Peak Expiratory Flow Rate

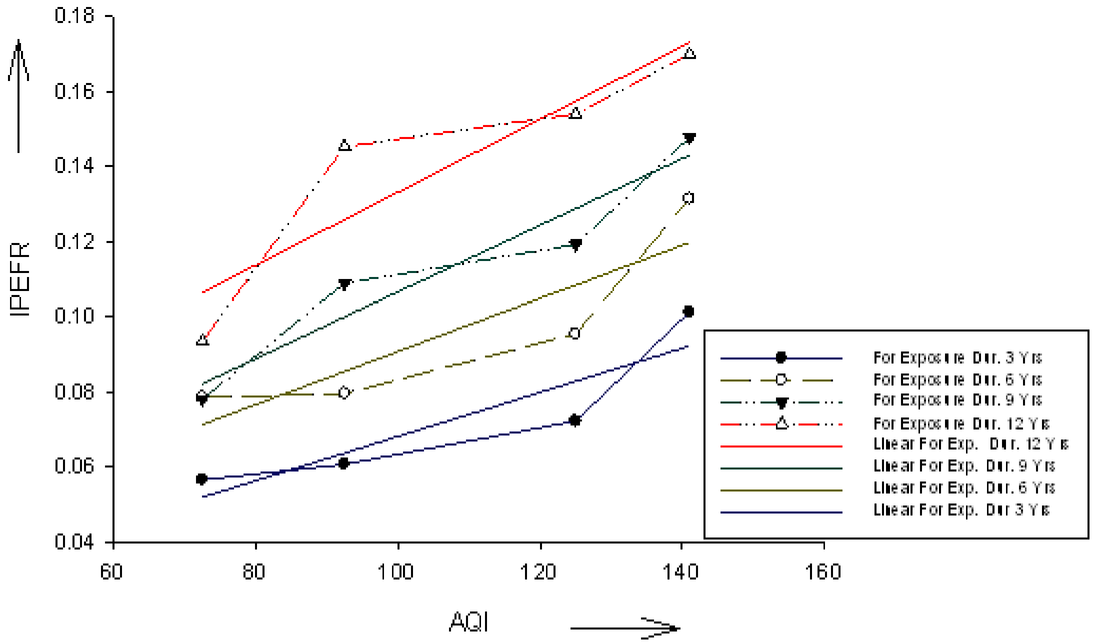
PEFR = Measured Predicted Peak Expiratory Flow Rate

Table 2: Air Quality Index (AQI)

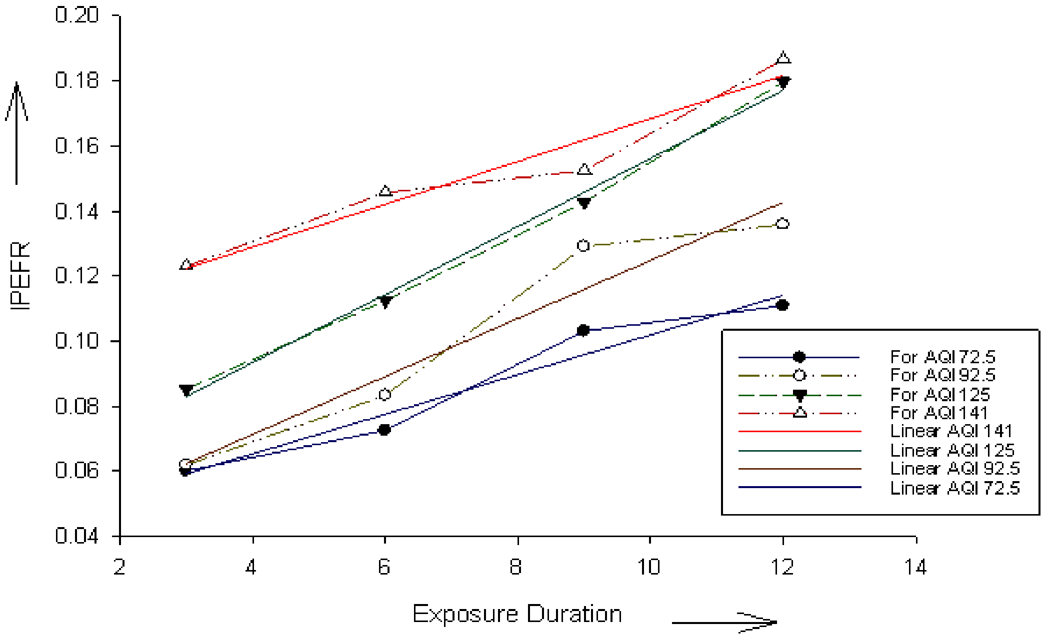
S.N	Sampling Industry	AQI
1	Industry-1	72.5
2	Industry-2	92.5
3	Industry-3	125
4	Industry-4	141

Analysis:

Graphical Analysis: The graphical analysis indicates that relationship between decrease in PEFR increases if, exposure duration increases or if, Air quality index (AQI) is increasing. It is also evident from graph -1 and graph-2 that for increase in IPEFR, best fit curve is linear.



Graph-1: Reduction in PEFR (IPEFR , at Y-axis) and AQI (X-axis) for different Exposure Duration



Graph-2: Reduction in PEFR (IPEFR , at Y-axis) and Exposure Duration (X-axis) for different AQI

Regression Analysis for reduction in PEFR (IPEFR) : Statistical analysis is done to verify the significance if dependent parameters (AQI & Exposure Duration) on independent parameter IPEFR (Reduction in PEFR).

Table 3: Regression Analysis for IPEFR Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
3	.974(a)	.948	.940	.0095097

a Predictors: (Constant), EXPDUR , AQI

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta	B	Std. Error
1	(Constant)	-.046	.011		-4.105	.001
	AQI	.001	.000	.713	11.297	.000
	EXPDUR	.007	.001	.663	10.506	.000

a Dependent Variable: IPEFR

ANOVA(b)

Model		Sum of Squares	Df	Mean Square	F
1	Regression	.022	2	.011	118.993
	Residual	.001	13	.000	
	Total	.023	15		

a Predictors: (Constant), EXPDUR , AQI b Dependent Variable: IPEFR

F test

H_o: $\beta_1 = \beta_2 = 0$ against H_1 : not all $\beta_k = 0$:(k= 1, 2)

ANOVA table gives the value of calculated 'F' i.e. F=118.993 and

$F_{k, n-k-l, \alpha} = 3.59$ (critical value from standard tables).

Here, $F_{calculated} > F_{k, n-k-l, \alpha}$

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 $H_1 : \beta_j \neq 0 : (j = 1,2)$

The calculated values for't - statistics' for β_1 and β_2 are given in ANOVA table.

t (for β_1) = 11.297

t (for β_2) = 10.506

The value of $t_{n-k-1,\, \alpha/2} = 2.11$

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

Hence, $\beta 1 \neq 0$ and $\beta_2 \neq 0$

As the estimated b_0, b_1 and b_2 are

b_0 = (-) 0.046

b_1 = 0.001

b_2 = 0.007

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

$$Y_P = 0.001X_1 + 0.007X_2 - 0.046$$

Where, $Y_P =$ IPEFR, X_1 = Exposure duration and X_2 = Air Quality Index.

From statistical analysis it is evident that if exposure duration is increasing and AQI remains constant , the reduction in PEFR is increasing and at the same time if exposure duration is constant and AQI is increasing , the reduction in PEFR is again increasing. It indicates that reduction in PEFR depends on air quality index and exposure duration. The value of R^2 is 0.940 which means that about 94.0 % of variation in dependent variable (i.e IPEFR) is due to independent variables (i.e AQI and exposure duration).

CONCLUSIONS:

Long term and chronic exposure to cement dust has adverse effect on lung function however, the effect is marginal but, can be fatal if ignored for the long time period in certain cases. It is concluded in a study that long-term exposure to cement dust does not lead to higher morbidity of severe respiratory disease than other types of blue collar work [13]. In this study about 2% to 14% reduction in PEFR is observed. It is suggested and recommended that to safeguard the health of workers, school children residing in nearby area and the host community around in general, the cement factory management embark on safety training in work environment and conduct health education programs for school children and for other inhabitants residing near to cement plants, on safety precautions & practices to cement dust exposure. The cement plants should also acquire latest pollution control gadgets and ensure the strict compliance with their use. Also regular monitoring of cement dust levels and other associated pollutants in and around the cement factory environment should be the regular practice by use of innovative pollution control devices. From the findings it can be concluded that administration should not allow residential colonies and schools within the cement industry premises.

REFERENCES

[1] A.Srivastava,R.K.Kapoor,N.Shukla, Departments of Pediatrics and Physiology, King George's Medical College, Lucknow, Pulmonary Function Tests in normal Indian Children and changes in respiratory disorders, Indian Pediatrics,Volume 32,June,1995: 1-2,

[2] Gonnett GJ, Quak SH, Wong ML, Teo J, Lee BW. Lung function reference values in Singaporean children aged 6-18 years. Thorax. 1994;49:901–5.

[3] M. K. Bhasin and Sweta Jain, Biology of the Tribal Groups of Rajasthan, India: Pulmonary Functions: Their Relation with Anthropometric Variables, Anthropologist, 9(4): 267-272 (2007)

[4] Mallik SK, Jindal SK. Pulmonary function tests in healthy children. Indian Pediatr. 1985;22:677–81.

[5] Merenu I.A., Mojiminiyi F.B.O., Njoku C.H., Ibrahim M, The Effect of Chronic Cement Dust Exposure on Lung Function of Cement Factory Workers in Sokoto, Nigeria, African Journal of Biomedical Research, Vol. 10 (2007); 139 – 143

[6] Nair RH, Kesavachandran C, Sanil R, Sreekumar R, Shashidhar S. Prediction equation for lung functions in south Indian children. Indian J Physiol Pharmacol. 1997;41:390–6.

[7] Rai Priyanka, Mishra RM and Parihar, ISSN 2277-2502 Vol. 2(ISC-2012), 229-233 (2013) Res.J.Recent.Sci. International Science Congress Association 229 Quantifying the Cement Air Pollution related Human Health diseases in Maihar city, MP, India

[8] Shamssain MH. Forced expiratory indices in normal black southern African children aged 6-19 years. Thorax. 1991;46:175–9.

[9] Uma Sinha and S.K.Nag, A Comparative Study of PulmonaryFunction of Urban Tribal and non –Tribal boys of Tripura, Indian J.L.Sci.1(2) : 25-28, 2012

[10] User manual (1999), 'RMS Medspiror', Recorders & Medicare System, (European Respiratory Society, ERS-93) 181/5 Phase I, Industrial Area,

Chandigarh (India).

[11] U.Bedi ,B.K.Dang, A study of peak expiratory flow rate in normal healthy children of Punjab, DOI:10.19056/ijmdsjssmes/2016/v5i1/83573

[12] Vijayasekaran D, Subramanyam L, Balachandran A, Shivbalan S. Spirometry in clinical practice. Indian Pediatr. 2003;40:626–32.

[13] Vestho J, Rasmussen FV , Long-term exposure to cement dust and later hospitalization due to respiratory

[14] Disease, Int Arch Occup Environ Health. 1990;62(3):217-20.