Ambient Air Pollution And Impairment Of Lung Volumes And Capacities In Young Inhabitants Of Industrial Area Of Kanpur

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Abstracts: Background: Air pollution is one of the major problem faced in developing countries like India. Chronic exposure to air pollutants can leads to hampered day today activity and increased visit to clinics. The pollutant PM10 (particulate matter size less than 10 µ) especially a risk factor associated with decreased lung functions and lung growth. The effect of particulate pollution on lung functions in young ones is still lacking in India especially in Kanpur, a highly polluted city of U.P., India. **Aims and Objective:** The present study was conducted to evaluate the impact of chronic exposure of air pollution on lung functions in subjects of the polluted area of the city. **Material and methods:** One hundred twenty male subjects, in age group of 18 to 30 years from polluted and non-polluted area of Kanpur, India were participated in the study. Anthropometric data were taken. Pulmonary function test was conducted in standing position. Pollution data of study period was taken from Central pollution control board and compared with the National ambient air quality standard.

Statistics: All data presented as mean ± SD and analysed by independent sample t test by using SPSS version 15. **Results:** The anthropometric data were statistically not significant in two areas. The Forced Vital Capacity, Forced Expiratory Volume in 1 sec, Forced Expiratory Flow 25-75% and Peak Expiratory Flow were reduced except the FEV1/FVC ratio which was not statistically significant between the groups. **Conclusion:** The long term exposure of pollutant PM10 could reduce the lung function. By reducing the pollution level a change in lung function and lung growth could be obtained. Thus every attempt should be made towards lowering air pollution like car pool concept, alternate fuels such as CNG or hybrid technology. [Varma S et al NJIRM 2013; 4(4) : 65-70]

Key Words: Air Pollution, Particulate matter, Pulmonary function test, Ambient air pollution, PM10.

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Introduction: Kanpur, the largest industrial city of Uttar Pradesh having the area of 230 Km^2, a population of 2.57 million (2001 census) with the annual growth rate at 2.47 percent, and the population density was 6800 persons/square kilometer. Air pollution in industrial areas of Kanpur exceeds the national ambient air quality standards [1]. Kanpur shows the highest concentration of PM10, where standard is exceeded by more than three times during 2000-2006. The city has tanneries, textiles, fertilizer and leather industries contributing to poor air quality. The Total suspended particle (TSP), Nitrogen oxides (NOx), Sulphur oxides (SOx), and Respirable suspended particulate matter (RSPM) especially Particulate matter with an aerodynamic diameter of 10 pm or less (PM10), remains in atmosphere for longer periods because of its low settling velocity [2] .Continuous exposure to these pollutants are harmful for the various vital system of the body like skin [3], cardiovascular [4], especially the respiratory system [5] as it has to interact directly with the pollutants. Peter H Burri [6] stated that during lung development, stage of late alveolarization (controversial) defines from 3 to 5 years to young adult age and beyond. Also aging phenomenon starts from about 35 years of age to death. A study reported the reduction in annual respiratory growth rates with increased pollution exposure that may reduce the level of lung function attained and lead ultimately to an increased risk of respiratory events in adulthood. In present study we plan to evaluate the effect of air pollution on pulmonary functions of young people residing in industrial zone of Kanpur city.

Material and Methods: The present study was conducted in the industrial area Fazal ganj of Kanpur city, Uttar Pradesh, India on 60 subjects. The controls (n=60) were taken from the IIT zone, Kanpur, which is situated in outskirt of city and almost free from pollution. In last census report (2001), Kanpur's population was 2570000; taking margin of error 10% gives us a sample size of 60.

The ambient air quality data of these areas were taken from the central pollution control board [7]. Approval of Institute's ethical committee was obtained. Subjects were taken randomly. Inclusion criteria were as follows: subject's age between 18 to 30 years, must be a resident (inhabitant) of that area for at least past 5 years. Only males were selected in study as females were hesitant to participate in study. Exclusion criteria for the study were as follows: Smokers, any major chest or spine deformity/surgery, known case of any major respiratory disease like bronchial asthma, chronic obstructive pulmonary disorder, and Industrial workers. Subject's nature of work was considered, if they worked in an industry they were excluded but other information like travel to work place were not taken into account. Detailed information was collected on pre-designed proforma. The complete general, anthropometric and systemic examinations were carried out. Subjects were properly explained about the aim, objective, methodology, expected outcome and implications prior to commencement of this research study.

METHODS:

1. **Anthropometric measurements**

a) **Height measurement :** The subject stands with head, buttocks and the heels are in contact with the wall and arms hang freely by the sides. Head positioned so that the line of vision is at right angles to the body. By using a cardboard on top of head, height was measured in centimetre (to nearest 0.1 cm) using simple measuring tape.

b) **Weight measurement:** By using a weighing machine, weight was measured in light cloths and without shoes to nearest 0.1 kg.

c) BMI measurement

By using formula; BMI = (Weight in kilograms) / (Height in meters) ^{2}

d) **Chest Circumference measurement :** Measurement made at the level of nipple by using simple measuring tape. Readings were taken at the maximal point of quiet respiration.

1. **Pulmonary function test**

Pulmonary function test (PFT), carried out with the help of computerized spirometer. It was a non-invasive and quite accurate method. The instrument used was Spirobang-G. Age, height and weight of subjects were entered in spirometer before taking data. The data was taken in standing posture. The proper demonstration of instrument and procedure were given before the commencement of the study. The subjects were asked to inspire slowly as much air as possible and then expire all of the air as fast as possible; nose must be well fitted to preclude the possibility of losing expired air in to the atmosphere. Three such tests were performed and subjects were coached to improve the efforts. The highest value data set was used for statistical analysis. The following parameters were recorded: Respiratory rate (RR), Tidal volume (TV), Forced vital capacity (FVC), Forced expiratory volume in 1 sec (FEV1), FEV1/FVC ratio, Peak expiratory flow (PEF), Forced expiratory flow at 25-75% of volume as a percentage of VC (FEF 2575), Vital capacity (VC). The recording of Maximum voluntary ventilation (MVV) was done by asking the subject to make series of forced inspirations and expirations breathing as deep and fast as possible for at least 15seconds.

2. **Ambient air quality data collection**

Data was collected from central pollution control board [7]. Study period was from Jan 2009 to Dec 2009. Measured pollutants were sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and respirable suspended particulate matter (RSPM or PM_{10}). Data were measured 24 hourly averaged concentrations of these pollutants. IIT, Kanpur is an education institute with no commercial or industrial activities, about 15 km from the north of the city. M Sharma et al [8] indicated it to be a clean site compared to other locations in the city. Further, UP pollution control board data [9] for year 2011 referring the same.

These data were compared with the National Ambient Air Quality Standards provided by central pollution control board [10] (notification no. B-29016/20/90/PCI-L).

3. **Statistical analysis:**

All data presented as mean ± SD. The data were analyzed for normal distribution and descriptive statistics were used. The all the data were further analyzed by "Independent-sample t test" by using SPSS version 15. A p value of <0.05 was considered statistically significant.

Result: The age, height, weight, BMI and chest circumference were compared between the subjects of two sites of Kanpur city viz. IITK and Fazal ganj. It was found that there was no significant difference between the two groups thus the two groups were comparable (Table - 1).

The comparison of PFT parameters were made between the two groups. It was observed that there was a statistically significant decrease in Forced vital capacity ($p<0.0001$), Forced expiratory volume in 1 sec ($p<0.0001$), Peak expiratory flow ($p<0.01$), Vital capacity ($p<0.01$), and Forced expiratory flow at 25-75% of volume as a percentage of VC ($p<0.05$) in subjects of non-polluted area compared to polluted area. While the difference in Respiratory rate (RR), Tidal volume (TV), Respiratory minute volume (RMV), FEV1/FVC ratio and Maximum voluntary ventilation (MVV) was statistically not significant between the two differently polluted areas (Table - 2).

Data was collected from Jan 2009 to Dec 2009. During this period, 24 hourly averaged pollutants concentration varies. For SO_2 from 5.7 to 11.2 µg/m^3 (8.08 ± 1.06); for NO_2 from 24.4 to 41.2 µg/m^3 (33.36 ± 3.90), while RSPM (PM10) concentration varies from 191 to 279 µg/m^3 (231.72 ± 16.35), at Fazal ganj. On comparison with National Ambient Air Quality Standards, RSPM level was very high at Fazal ganj while level of other pollutants like SO_2, nitrogen dioxide (NO_2) were within normal limits of National Ambient Air Quality Standards (Table - 3).

Table -1: Anthropometric parameters (Values expressed in Mean ± SD)

	IITK (n=60)	Fazal Ganj (n=60)	P value
Age (year)	24.3 ± 4.04	24.73 ± 3.67	0.540
Height (cm)	169.2 ± 6.74	168.58 ± 10.86	0.709
Weight (Kg)	60.92 ± 10.57	63.30 ± 10.85	0.225
BMI	21.42 ± 4.33	22.51 ± 4.73	0.187
Chest circumference (cm)	87.62 ± 8.27	85.33 ± 8.06	0.128

Table - 2: Flow rates and lung volumes in subjects from two areas of Kanpur (Values expressed in Mean ± SD)

	IITK (n = 60)	Fazalganj (n = 60)	P value
RR (/min)	14.52 ± 1.82	14.90 ± 2.90	0.388
TV (Litre)	0.41 ± 0.06	0.42 ± 0.04	0.332
RMV(Litre)	5.91 ± 0.65	6.02 ± 0.74	0.365
FVC (Litre)	4.10 ± 0.58	3.65 ± 0.58	0.0001
FEV1 (Litre)	3.78 ± 0.61	3.42 ± 0.31	0.0001
FEV1/FVC ratio	0.94 ± 0.22	0.96 ± 0.17	0.680
PEF (Litre/sec)	8.04 ± 0.74	7.71 ± 0.63	0.010
FEF 2575 (Litre/sec)	4.22 ± 0.35	4.34 ± 0.33	0.057
VC (Litre)	*4.00 ± 0.32*	3.85 ± 0.39	0.018
MVV (Litre)	114.50 ± 7.44	116.93 ± 11.35	0.168

Table – 3: National Ambient Air Quality Standards

Pollutant	Time weighted average	Industrial, Residential, Rural and other area	Ecologically sensitive area	Methods of measurement
Sulphur dioxide (SO_2), µg/m^3	Annual 24 hours	50 80	20 80	-Improved West and Gaeke -Ultraviolet fluorescence
Nitrogen dioxide (NO_2), µg/m^3	Annual 24 hours	40 80	30 80	-Modified Jacob & Hochheiser -Chemi-luminescence

Particulate matter (size less than 10 µg) or PM_{10} µg/m^3	Annual 24 hours	60 100	60 100	-Gravi-metric -TOEM -Beta attenuation

Discussion: In our study most of the parameters including FVC, FEV1, FEF25-75% and PEF are reduced except the FEV1/FVC ratio, which was showing no statistically difference between the groups, indicating restrictive lung impairment. While the reduced value of PEF indicates obstructive lung disease. So, the mixed pattern of obstructive and restrictive lung impairment was found in subjects lived in high air pollution. These can be attributed to the adverse effects of air pollutants especially PM10, SO2 and NO2 in industrial areas. The average ratio of FEV1/FVC at both sites was statistically not significant ($p = 0.68$). The absence of a relationship between FEV1/FVC ratio with particulate air pollution was also reported by sharma Mukesh et al [8] and Forbes LJ et al [11] for PM10.The results showing a higher air flow limitation with higher particulate pollution. Similar results were observed by Wojciech Lubinski [12] (Poland) and by Nadia Ait Khaled et al [13] (developing countries). This could be due to the lodging of larger particles in upper respiratory tract that leads to local inflammation and mucus secretion, Also results in constriction of airways thus lowering the PEF value. While a study on five areas of Delhi [14] showed no significant difference however the trend was towards lower values. This could be resulted by either due to almost equal air pollution levels in different zone or some other unknown potential confounders. Dockery et al [15] found no associations between pollutant concentrations and any of the pulmonary function measures considered (FVC, FEV1, FEV0.75, and MMEF) in a cross-sectional study of children participating in the six cities. They also suggest that children with hyperreactive airways may be particularly susceptible to other respiratory symptoms when exposed to these pollutants. Longitudinal studies demonstrated that exposure to particulate pollution is associated with reduction in the growth of lung functions [16, 17] and consequently development of respiratory symptoms, decreased lung function, increased hospital admissions. This may be due to the fibrous tissue formation in the alveolar septa and the fibrotic lesions of the small airways, leading to permanent debility. This view is supported by our cross sectional study showed a decline in lung functions in air polluted area subjects as compared to non-exposed subjects. Furthermore, Avol EL et al [18] studied the respiratory effect of relocating to areas of differing air pollution levels in 110 children. They found that as a group, subjects who had moved to areas of lower PM10 showed increased growth in lung function and subjects who moved to communities with a higher PM10 showed decreased growth in lung function. A stronger trend was found for subjects who had migrated at least 3 year before the follow-up visit. Later a study by Bayer-Oglesby L et al [19] on decline of ambient air pollution levels and improved respiratory health in Swiss children, found that the reduction of air pollution exposures contributes to improved respiratory health in children. Also no adverse effects of PM10 were observed for allergy associated health outcomes (Asthma, hay fever and sneezing during pollen season).Decrease of flow rates especially FEF 25-75% is the first measurable sign of the initiation of bronchitis and lung obstructive disease mainly affecting smaller airways [14]. The FEF 25-75% was statistically significantly reduced in particulate polluted exposed area than in non-exposed area. Sharma M et al [8] studied effects of particulate air pollution on the respiratory health of subjects who live in three areas in Kanpur. They estimated that an increase of the pollutant PM10 could reduce the mean peak expiratory flow rate, forced vital capacity and forced expiratory volume in 1 second values but the average ratio of FEV1/FVC were similar at the three sites. This further confirms our results.

Limitations and strength: The sample size was small thus warranted a larger study. Also we had taken only male subjects so the difference of effect in sex was not evaluated. It is cross sectional study so it is almost impossible to predict that if the effect on pulmonary function level in adulthood reflects growth deficits experienced during childhood and whether these subjects enter the declined pulmonary function phase with a reduced pulmonary function. On the other hand, we had taken such type study in very highly polluted Kanpur city in which these kind of analysis was not done yet. In addition, we excluded all persons that had moved within the last 5 years thus ensuring that the subjects were chronically exposed to the air pollution measured by the health authorities. We also had taken age, height, and weight and chest circumference to avoid any confounding factor affecting.

Conclusion: Our study had a unique opportunity to investigate the chronic effect of different level of air pollution on pulmonary function parameters in healthy non-smoker men. The long term exposure of the pollutant PM10 could reduce the forced vital capacity and FEF 2575, vital capacity and the peak expiratory flow rate. To improve quality of life, all attempts should be made to reduce air pollution. This is further supported by Frye C et al [20] suggesting reduction of air pollution in a short time period may improve children's lung function. Adoption of various strategies like use of mask, Car pool concept, use of CNG vehicles, strictly follow BS-IV norms throughout country and subsequently introduction of BS-V norms, relocation of factories to the outskirt of cities, regular medical checkups especially for those who are at risk. Also, further intensive research effort in this area of environmental health is needed by various possible approaches.

References:

1. Air Quality Assessment, Emissions Inventory and Source Apportionment Studies for Kanpur City. Central pollution control board. http://www.cpcb.nic.in/Kanpur.pdf. Accessed on 27th oct 2012.
2. Onursal Bakir, Gautam SP. Vehicular Air Pollution Experience from Several Latin American Urban Centres. World Bank publications: Technical Paper No. 737; Washington DC, USA, 1997.
3. Goldsmith LA. Skin effects of air pollution. Otolaryngol Head Neck Surg. 1996 Feb;114(2):217-9.
4. Atkinson RW, Carey IM, Kent AJ, van Staa TP, Anderson HR, Cook DG. Long-term exposure to outdoor air pollution and incidence of cardiovascular diseases. Epidemiology. 2013 Jan;24(1):44-53.
5. Arbex MA, Santos UD, Martins LC, Saldiva PH, Pereira LA, Braga AL. Air pollution and the respiratory system. J Bras Pneumol. 2012 Oct;38(5):643-655.
6. Peter H. Burri. Structural Aspects of Postnatal Lung Development – Alveolar Formation and Growth. Biol Neonate 2006;89:313–322.
7. Ambient air quality data of Kanpur. Central pollution control board. http://www.cpcb.nic.in. Accessed on 11th Jan 2010.
8. Sharma M, Kumar VN, Katiyar SK, Sharma R, Shukla BP, Sengupta B. Effects of particulate air pollution on the respiratory health of subjects who live in three areas in Kanpur, India. Arch Environ Health. 2004 Jul;59(7):348-58.
9. Ambient air quality data. Uttar Pradesh pollution control board. http://www.uppcb.com/ambient_quality.htm accessed on dated 21 dec 2012.
10. National Ambient Air Quality Standards. http://cpcb.nic.in/National_Ambient_Air_Quality_Standards.php. Accessed on 11th Jan 2010.
11. Forbes LJ, Kapetanakis V, Rudnicka AR, Cook DG, Bush T, Stedman JR, Whincup PH, Strachan DP, Anderson HR. Chronic exposure to outdoor air pollution and lung function in adults. Thorax. 2009 Aug;64(8):657-63.
12. Lubiński W, Toczyska I, Chciałowski A, Płusa T. Influence of air pollution on pulmonary function in healthy young men from different regions of Poland. Ann Agric Environ Med. 2005; 12(1): 1–4.
13. Aït-Khaled N, Enarson DA, Ottmani S, El Sony A, Eltigani M, Sepulveda R. Chronic airflow limitation in developing countries: burden and priorities. Int J Chron Obstruct Pulmon Dis. 2007;2(2):141-50.
14. Goyal A, Khaliq F. Pulmonary functions and ambient air pollution in residents of Delhi. IJMS. 2011; 2(2): 96-100.
15. Dockery DW, Speizer FE, Stram DO, Ware JH, Spengler JD, Ferris BG Jr. Effects of inhalable particles on respiratory health of children. Am Rev Respir Dis. 1989; 139(3): 587-94.
16. Heydarpour Fereidoun, Mousavinasab Seyed Nourddin, Nahidi Ahmad Rreza, Alipour Mohsen, Rostami Ahmad, Heydarpour Pouria. The effect of long-term exposure to particulate

pollution on the lung function of Teheranian and Zanjanian students. Pak J Physiol 2007; 3(2):1-5.
17. Sunyer J. Lung function effects of chronic exposure to air pollution. Thorax. 2009 Aug;64(8):645-6.
18. Avol EL, Gauderman WJ, Tan SM, London SJ, Peters JM. Respiratory effects of relocating to areas of differing air pollution levels. Am J Respir Crit Care Med. 2001 Dec 1;164(11):2067-72.
19. Bayer-Oglesby L, Grize L, Gassner M, Takken-Sahli K, Sennhauser FH, Neu U, Schindler C, Braun-Fahrländer C. Decline of ambient air pollution levels and improved respiratory health in Swiss children. Environ Health Perspect. 2005 Nov;113(11):1632-7.
20. Frye C, Hoelscher B, Cyrys J, Wjst M, Wichmann HE, Heinrich J. Association of lung function with declining ambient air pollution. Environ Health Perspect. 2003; 111(3): 383-7.

Conflict of interest: None
Funding: None