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Assessment of Air Quality and Respiratory Health Status within an Institutional Area

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ABSTRACT

The present study was carried out to assess air quality and respiratory health status at Delhi University. Delhi University is an open campus and surrounded by commercial areas, residential, traffic intersection and major road network which are probably the main source of air pollution in this campus. The pollutants considered for this study were four criteria pollutants (NO_2, SO_2, PM_{10} and $PM_{2.5}$) along with pulmonary function test for diagnosing any obstruction caused by air pollution. Sampling site has been monitored for 4 hours basis at Department of Environmental Studies within 2 months (February and March). Temporal and Spatial variation of pollutants was performed by Excel, Air quality index was computed by mathematical equation established by EPA and pulmonary function test was conducted by using spirometer as tool. The results revealed that a fine and coarse particulate matter concentration was 2.56 times higher than permissible limit established by Central Pollution Control Board (CPCB) in India. Apart from this finding, NO_2 and SO_2 concentration in this University remain under permissible limit. Among 50 students participated in pulmonary function test, the study has found 2% student has severe obstruction (FEV1/FVC, <=30 %< 50%), 20% students have moderate obstruction (FEV1/FVC, <=50 %< 80) and 78% have mild obstruction this could be because of long exposure to high concentration of particulate matter.

INTRODUCTION

Air pollution is defined as any biological, chemical and physical substances that may present in an atmosphere in such concentration that it may degrade and deteriorate quality of air and is harmful to the living organisms and surroundings. Air pollution has become very serious challenge global, regional and local public health problem after industrial revolution. High demand of energy in Industries, domestic and transportation system are the main source of air contamination (Chaloulakou *et al*., 2003). Most major cities (like Delhi) around the world experience periods of elevated air pollution levels, based on National Air Quality Standards (Kumar *et al*., 2015). Long and short exposure to air pollutants can affect human health in different ways leading to the increase of morbidity and mortality rate. Today, air pollution is the largest environmental risk factor (WHO, 2014). It is estimated worldwide 3 million people die annually prematurely from lung cancer, cardiovascular, respiratory diseases, although Western Pacific and South East Asia are the most affected and 799000 deaths are estimated to occur South Asia alone (WHO, 2016). In Delhi, 7350-16200 premature deaths due fine particulate matter were estimated in 2010 (Guttikunda and Goel, 2013). Nitrogen oxide, Sulphur dioxide, Particulate matter, Ozone and Carbon monoxide are the major pollutants responsible for short term and long-term effects such as respiratory problems, premature deaths, eyes and throat irritation and chronic obstructive pulmonary disease etc (Ghorani-Azam *et al.*, 2016). Many research works were taken place in major parts of the world to address this issue and to spread awareness to the public of air pollution and health impacts. The major source of these pollutants are the local activities including Transportation, burning fossil fuel, mismanagement of wastes, construction activities and majorly dispersion of pollutants coming from neighboring regions through meteorological phenomena including wind movement (Zhang *et al*., 2015). Air pollution is a global problem that imposes massive economic and social external costs at local, regional and global scale (Patankar and Trivedi, 2011). However, studies on air pollution and human health has increased over the years but research on institutional air quality and its effect on students' health is still scanty. The institutions' performance are the main driver and indicator of development of any nation where the workers and academicians and students spend at least 5 days per week to fulfil their responsibility, therefore, they require proper physical environment such good quality of air to perform their task properly. Earlier study has already shown that students' absence rates were found to be higher in schools with poor air quality than in schools without such problems (Mendell *et al*., 2013). If the youths in developing countries hold such inferior

health status, the social and economic development of that nation is more questionable. Thus, it is important to study the quality of air within institutional areas and what are their effects on the academicians and students health so that necessary steps can be taken for awareness and improving the quality of life. The present study, therefore, evaluates respiratory health status in institutional area and also monitors the criteria pollutants such as SO_2, NO_2, PM_{10} and $PM_{2.5}$.

MATERIALS AND METHODS

1. Site Selection

The University of Delhi, is a collegiate public central university, located in New Delhi, India 28.69^{o}N 77.21^{o}E. It is an open campus and surrounded by commercial areas, residential areas, traffic intersect, and major roads networks resulting in large footfall and pollution load in this area (Figure No.1).

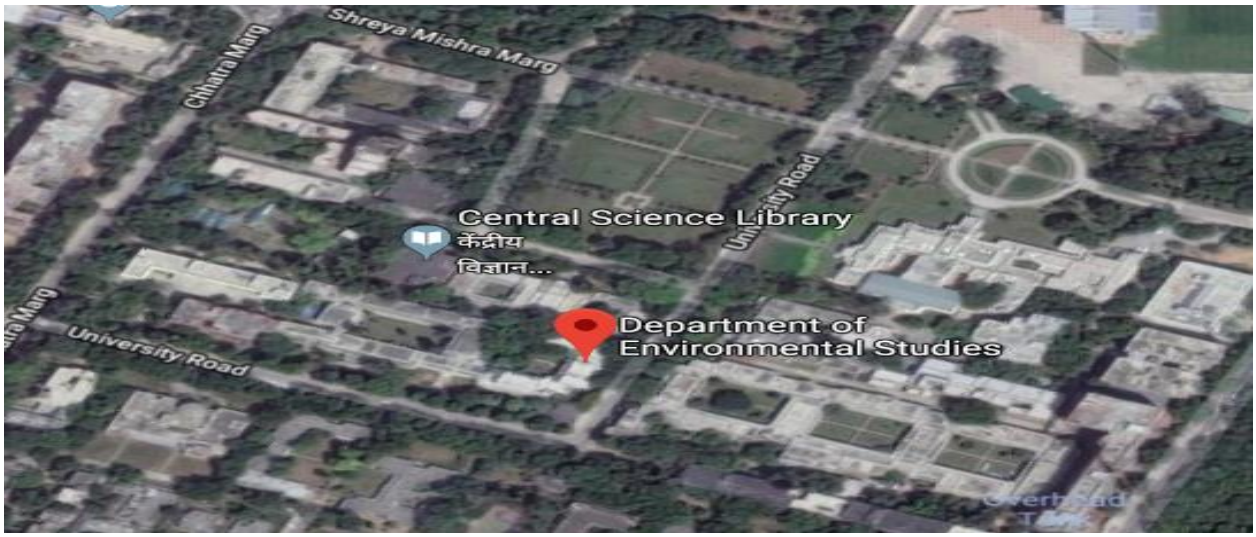

Figure No.1: Satellite View of Department of Environmental Studies University of Delhi (Google Maps).

The main aim of the undertaken work was to estimate the air quality at University of Delhi where academicians, researchers and students spend majority of their daily time. The Primary monitoring of criteria air pollutants (SO_2, NO_2, PM_{10}, and $PM_{2.5}$) along with pulmonary function test (PFT) of 50 participants was conducted in Delhi University, north campus to relate the effect of institutional air quality on the respiratory health of students.

Data was generated through primary monitoring of criteria pollutants PM_{10}, $PM_{2.5}$, SO_2 and NO_2 in the outdoor environment in Delhi University at selected site (Environmental Studies Department) from February to March 2018. Monitoring program was conducted for four hours from 1100 to 1500 once a week (number of observation (n) is seven). Student health assessment was checked through pulmonary function test by using spirometer as a tool. This test was performed to check the lung function of an individual. This test defines whether respiratory system of a person is obstructed or not. The obstruction is defined based on the ratio of FEV1/FVC i.e. Forced expiratory volume in the first one second of expiration by forced vital capacity. Through this ratio severity of individuals to chronic obstructive pulmonary disease (COPD) can be diagnosed. 50 students with similar age (20-30) group were chosen randomly at University Delhi.

2. Techniques and analysis of pollutants

SO_2 analysis

Sulfur dioxide is absorbed by sodium tetrachloromercurate solution to form a stable compound called dichlorosulphitomercurate. P-rosaniline hydrochloride is added to form a colored complex, the intensity of which gives the amount of absorbed sulfur dioxide measured spectrophotometrically at maximum wavelength of 560nm.

Formula

Volume of air (liters) = Average flow rate * sampling time.

NOx concentration (µg/m3) = C*A*1000*D/ (V*B)

Where,

C= curve value (calculate using standard graph)

A= Volume of Absorbing Reagent (ml)

V= Volume of Air Sampled (ml)

B= Volume of aliquot taken for analysis

D= Dilution factor* (if required)

NO_2 analysis

Nitrogen oxides reacted with sodium hydroxide to form stable compound of sodium arsenite. Phosphoric acid, sulphanilamide and N (1-naphthyl) ethylenediamine dihydrochloride (NEDA) were added to form colored complex. Optical density of solution was measured by spectrophotometer at 540nm.

Formula

Volume of air (liters) = Average flow rate * sampling time.

NOx concentration (µg/m3) = C*A*1000*D/ (V*B*0.82)

Where,

C= curve value (calculate using standard graph)

A= Volume of Absorbing Reagent (ml)

V= Volume of Air Sampled (ml)

B= Volume of aliquot taken for analysis (ml)

D= Dilution factor*(if required)

0.82= Sampling efficiency

3. Analysis of particulate matter (PM_{10} and $PM_{2.5}$) in ambient air using Gravimetric Method

PM_{10} and $PM_{2.5}$ were sampled by using high volume sampler and low volume sampler respectively, after checking any physical damage of filter paper and coding the filter (filter ID), initial weight was recorded. The filter was placed on the sampler and sampler was run for 4 hours. After sampling time, the final weight of filter paper was recorded and kept in a proper container (zip bag).

Formula

Volume of air (liters) = Average flow rate * Sampling time

SPM (µg/m3) = (final weight- Initial weight) *10^6/Volume of air

4. Pulmonary Function Test

Spirometry is the most common of the pulmonary function test (PFTs), measuring lung function specifically the amount (volume) and speed (flow) of air that can be inhaled or exhaled. In spirometry is an important tool used for generating pneumotachographs useful for assessing condition such as asthma, chronic obstruction pulmonary disease (COPD) and chronic bronchitis etc. The targeted participants in this research were students of Delhi University. 50 students with similar age class (20-30 years) were participated according to their availability. The volunteers were chosen randomly. The participants were chosen based on the time they have been studying in Delhi University (at least for 2 years). The test was performed by using spirometer and its accessories including software, mouthpiece, noise clips and chair. Spirometer is a displacement gasometer consisting of an inverted bell resting upon or sealed by liquid (or other means) and capable of showing the number of gazes added to or withdraw from the bell by the displacement (rise or fall) of the bell.

RESULTS AND DISCUSSIONS

The average in PM_{10} and $PM_{2.5}$ concentration during sampling period (7 weeks) were found to be 286.4µg/m3 and 176.4µg/m3, respectively (Figure No.2 & 3). The concentration is 2.56times higher than permissible limit of 100µg/m^3 for PM10 and 60µg/m^3 for $PM_{2.5}$ established by Central Pollution Control Board. Construction activities, commercial activities, transportation system it could be the main source of high concentration of particulate matter (fine and coarse) in this university. Apart from these activities stated above, meteorological conditions including average temperature, wind speed and relative humidity during sampling time were also playing important role in particulate matter concentration. Sampling was conducted during late winter month (February) where the temperature was very low leading to reduction of mixing height which is responsible for dispersion of pollutants. (Jayamurugan *et al.*, 2013) had found that the lower the temperature, the higher the pollutant will be accumulated in atmosphere as it lowers planetary boundary layer of pollutants and high humidity reduces the amount of solar radiation reaching to the ground surface resulting the formation of inversion layer and dispersion of pollutants become less. In wintertime, particulate matters are becoming heavier and concentrate to the ground surface therefore it cannot move for long distance.

The maximum average Concentration of Nitrogen dioxides (NO_2) and Sulfur dioxide (SO_2) during the study period was recorded in Delhi University with 57.4µg/m3 and 44.7µg/m3, respectively (Figure No.4 & 5). The results show the recorded concentration is below the permissible limit of 80 µg/m^3 for 24 hours and 50 µg/m^3 annual established by National Ambient Air Quality Standards guidelines. The sampling site in this study is a non-residential academic campus area and according to National Ambient Air Quality Standards, the values should be 50µg/m^3 for annual and 80µg/m^3 for 24hours. Delhi University is a green area where the plants play important role for filtering and deposition of pollutants. According to Guttikunda between 1998 and 2003, Supreme Court has taken different measures of abating SO_2 concentration including the coal and fuel oil based industries, brick kilns were shifted to the outskirts (Guttikunda and Goel, 2013). This helped to improve air quality in Delhi in the early 2000. Badami reported low concentration of SO_2 in Delhi might be the results of reductions in sulfur content fuel, which was reduced by 80% between 1999 and 2000 (Badami, 2004). Based on the findings very low concentration of NO_2 and SO_2 present in Delhi University campus despite the way automobiles travelling frequently around and vicinity of this institution. Based on the present study, the major problem at Delhi University is high concentration of particulate matter (fine and coarse) and many students are not aware and there is no specific program to increase awareness.

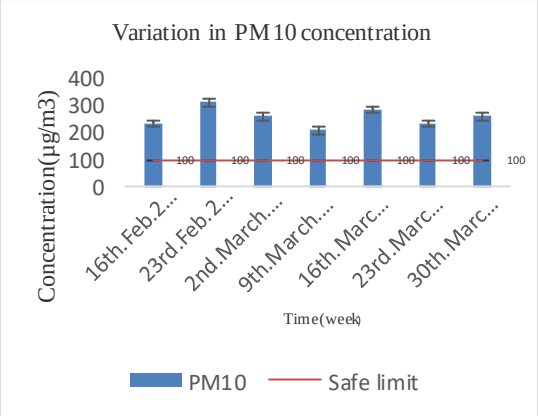

Figure No. 2 Weekly variation in [PM_{10}]

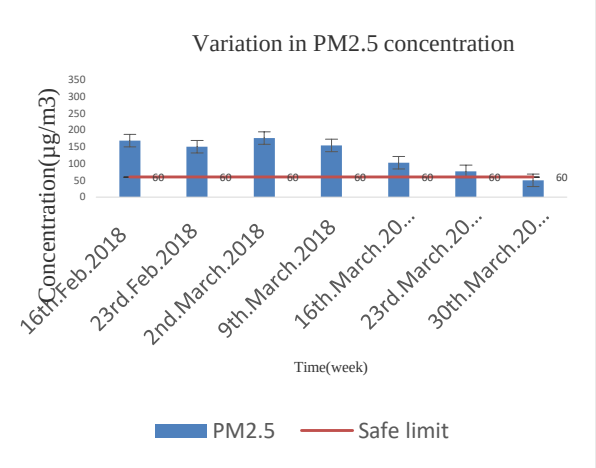

Figure No. 3: Weekly variation in [$PM_{2.5}$]

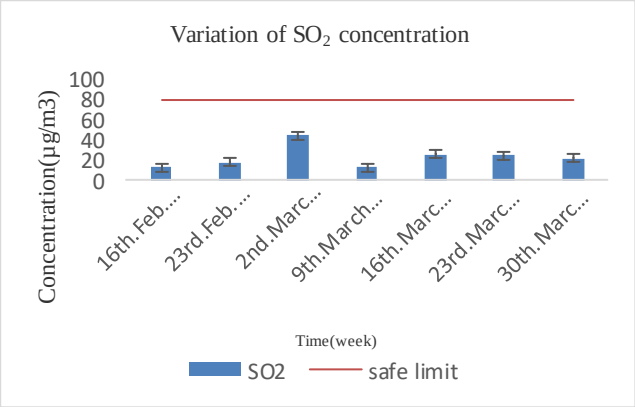

Figure No.4: Weekly variation of [SO_2]

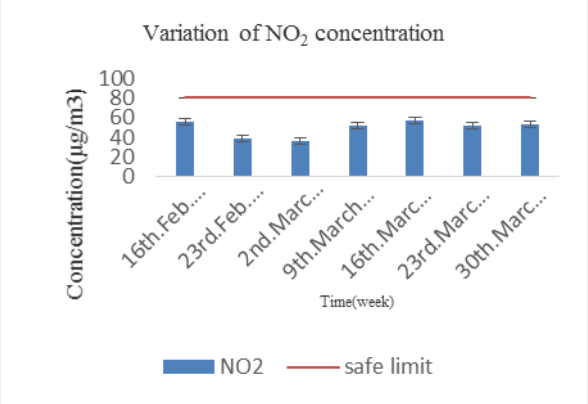

Figure No.5: Weekly variation of [NO_2]

Student Health Status

The spirometer results showed 2% students having severe obstruction (FEV1/FVC, <=30 %< 50%), 20% students having moderate obstruction (FEV1/FVC, <=50 %< 80) and 78% students with mild obstruction (FEV1/FVC, >80%) shown in Table No. 1. The main reason for this obstruction is long term exposure to high concentration of coarse and fine particulate matter. 42% students are smokers which could be second reason of obstruction apart from particulate matter. Recently many epidemiologic studies have demonstrated that high concentration of particulate matter is associated with increasing of respiratory abnormalities in urban children and adolescents. Students spend five days per week for attending classes and other different activities therefore they are more frequently exposed to indoor and outdoor air pollution of that particular environment leading to respiratory problems. Delhi

University is located in polluted urban environment (New Delhi) where air quality has drastically deteriorated and the students are becoming victims. Linares reported frequent respiratory abnormalities in school closer to the most polluted environment and found the pollution concentration level were more often correlated with obstructive-type than restrictive-type change in pulmonary function (Linares *et al*., 2010). Mathew in his research work found PM_{10} is primary responsible for respiratory symptoms in school environment rather compare to SO_2 and NO_2 (Mathew *et al.*, 2015). Delhi University is located in New Delhi which is already tagged as the most polluted city in the World and students are more exposed to such bad air quality leading to respiratory dysfunction.

Table No.1: Health Status: Pulmonary Function Test Results

	Sample size	**50 Students**		
	Age range	**20-30 Years**		
Magnitude of obstruction	**Mild**	**Moderate**	**Severe**	**Very severe**
% Magnitude of obstruction	>=8%	<=50%<80%	<=30%< 50%	< 30%
Students exposed	39	10	1	0

CONCLUSION

The paper aimed to assess the air pollution level and how it affects human respiratory health within the University of Delhi. Location of any university is a crucial factor in the air quality level inside it. Traffic density associated with the University of Delhi can be the main source of air pollution in its atmosphere. Among the measured pollutants during this study, PM concentration was much higher than the permissible limits in India. Regarding the health of the students, 2% of students sample showed severe obstruction due to prolonged exposure to high concentration of coarse and fine particulate matter. The present study revealed that there is a necessity to focus on air quality management in universities to safeguard the health of academicians and the environment.

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