Ravinder Singh et al Int. Journal of Engineering Research and Applications www.ijera.com
ISSN : 2248-9622, Vol. 4, Issue 8(Version 4), August 2014, pp.18-26

RESEARCH ARTICLE OPEN ACCESS

Impact of Air Quality on Human Health In The Vicinity of Construction Sites in Delhi-NCR

Ravinder Singh*, Kafeel Ahmad**, D C Jakhwal*** and M Satish Kumar****

* Ravinder Singh, M. Tech. (Environmental Sci. & Engg.) student, Department of Civil Engineering, Jamia Millia Islamia (A Central University), New Delhi-110025, India

** Dr Kafeel Ahmad, Associate Professor, Department of Civil Engineering, Jamia Millia Islamia (A Central University), New Delhi-110025, India

*** D C Jakhwal, Scientist 'B', Central Pollution Control Board, Ministry of Environment & Forests, Government of India, New Delhi-110032, India

**** M Satish Kumar, Sr. Scientific Asstt., Central Pollution Control Board, Ministry of Environment & Forests, Government of India, New Delhi-110032, India

ABSTRACT

Construction sites are important source of air pollution emitting pollutants like PM_{10}, etc. which adversely affect human health especially the respiratory system. The present study aims at monitoring of PM_{10}, health condition of workers, evaluation of API (Air Pollution Index) and development of correlation between API and human health in the vicinity of construction sites. In the present study relevant literature review has also been carried out to study and analyze the impact of air pollution on human health. Reconnaissance survey of 19 selected construction sites in Delhi-NCR has been conducted for the period January 2013 to December 2013 and health related data of people in the vicinity of construction sites has been collected individually through a questionnaire. The air quality data (for pollutant PM_{10}) for the area in which the selected construction sites lie has been obtained from the continuous monitoring stations of Central Pollution Control Board. The monthly average PM_{10} concentration in the ambient air for the study period has been obtained for all the sites. The annual average PM_{10} level of all the sites has been estimated and compared with the prescribed value. Also the air pollution index (API) (for pollutant $PM_{10)}$ has been calculated for each site and compared with the percentage of people suffering with respiratory problems at the respective sites. The results show that the construction sites where the value of API for PM_{10} is higher there the percentage of people suffering with respiratory diseases has also been higher.

Keywords: Air Quality, Air Pollution Index (API), Construction Sites, Human Health, Particulate Matter.

I. INTRODUCTION

Pollution from construction sites is adversely affecting the health, economic well-being and productivity of construction workers and those living in the vicinity of construction sites. Severe chronic diseases are caused by these pollutants to the poor construction laborers and workers who are unaware of the harmful effects of pollutants at the construction sites and continue to work in such unhealthy environments due to poverty and ignorance especially in the developing countries. The poor health condition of the construction workers and of those living in the vicinity of construction sites encouraged the present study. Construction sites are important source of Particulate Matter (PM_{10}) through activities such as vehicle emissions, diesel emission from large construction equipments and generators, blasting of rocks, dust blowing from clearing, excavating, trenching, backfilling, dumping of soil and from truck and equipment traffic. Particulate Matter (PM) is the term used for tiny particles found in the air, including dust, dirt, soot, smoke, and liquid droplets. These particles can remain suspended in the air for long periods of time and the finer one can enter the human respiratory system causing adverse health impacts [1]. Soot or the small particles are released directly from the tailpipe or formed indirectly from the emissions of NOx and Sulfur Oxides.

A systematic review of the association between air pollutants and birth outcomes of small for gestational age (SGA) births found that exposure to coarse PM of $\leq 10\ \mu m$ was associated with SGA births [2]. Research on monetary burden of health impacts of air pollution in Mumbai, India found that Particulate Matter (PM_{10}) and nitrogen dioxide (NO_2) emerged as the critical pollutants for a range of health impacts, including symptoms such as cough, breathlessness, wheezing and cold, and illnesses such as allergic rhinitis and chronic obstructive pulmonary disease (COPD) [3]. A study on Health impacts of particulate pollution in a megacity—Delhi, India found that for the observed PM levels in the city, the health impacts analysis estimates 7,350–16,200 premature deaths and 6.0 million asthma attacks per year [4] . The level of PM_{10} is associated with the rate of death from all causes and from cardiovascular and respiratory illnesses. The estimated increase in the relative rate of death from all causes was 0.51 percent for each increase in the PM_{10} level of 10 µg per cubic meter. The estimated increase in the relative rate of death from cardiovascular and respiratory causes was 0.68 percent for each increase in the PM_{10} level of 10 µg per cubic meter [5]. An urban scale integrated assessment of options to reduce PM_{10} in London concluded that the most cost effective strategies from both perspectives analyzed were those involving the use of alternative fuels, particularly switching diesel vehicles to LPG and/or CNG [6]. An investigation of the contributions of various emission sources to the ambient concentrations of PM_{10} in the Beijing metropolitan region of China found from the modeling results that three major sources (including fugitive industrial emissions, **construction sites**, and road dusts) presented a relatively high contribution to the PM_{10} pollution in Beijing, with the contribution ratios of 28.67%, 42.88%, 42.46% and 35.67% for spring, summer, autumn and winter, respectively [7]. A research on Pedestrians' perception of environmental stimuli through field surveys: Focus on particulate pollution found that the air quality was considered to be poor by 42% of the interviewees at the **construction site**, which was burdened with higher PM counts and sound levels. Through the exposure–response relationships between the various perception votes and PM, it was possible to predict perceived air cleanness using the PM count [8].

The present scenario in the vicinity of construction sites is very pathetic especially in the developing countries with negligence of pollution control measures, use of obsolete technology and old machines and trucks which have high levels of pollution emissions thereby people near the construction sites are suffering from cardiovascular and respiratory diseases, asthma attacks, acute bronchitis and even premature death. If appropriate measures are not taken to check this present scenario then the loss to humanity in future may be irreparable. The present study aims at finding or verifying the correlation that exists between the quality of air (PM_{10}) and human health.

II. METHODOLOGY

This section describes the methodology adopted in the present study. It includes selection of construction sites in Delhi-NCR, reconnaissance survey, collection of field data, etc. The health related data was collected through questionnaire survey. The air quality data (for pollutant PM_{10}) for the area in which the selected construction sites lie was obtained from the continuous monitoring stations of Central Pollution Control Board. The monthly average PM_{10} concentration in the ambient air for the period January 2013 to December 2013 has been obtained for all the sites for data analysis. From this the annual average PM_{10} level and Air Pollution Index (API) for each site has been estimated so that a comparison is made between the health condition of workers and API at the respective sites and a correlation is developed between API and health condition of people. The details have been given in following sections.

2.1 Site Selection

Nineteen construction sites in Delhi and NCR covering all the major areas have been selected for the study. The sites are Motinagar, Tis Hazari Courts, Nilothi (Janakpuri), Ashok Vihar, Anand Vihar, Dev Nagar, Timarpur, Tilak Bridge, Narela, Inderlok, Vasant Kunj, Sultanpuri, Lajpat Nagar, Vaishali, Rohini, Ansari Nagar, Noida, Delhi University and Mandi House. The location of construction sites in Delhi-NCR is shown in the map in Fig.1. Some of the sites are in congested built-up areas and some are in open areas. For the sites in urban areas the pollution was mainly from construction activities, movement of construction machinery and nearby vehicular traffic.

Fig.1: Map showing construction sites in Delhi-NCR

2.2 Reconnaissance Survey

Field data was collected through Questionnaire Survey conducted between January 2013 to December 2013 on people exposed to air pollution in the vicinity of the selected construction sites. People have been asked questions individually and responses noted down about their health conditions, their perception of the air quality at the construction sites, working hours, living conditions, habits, etc. The site information gathered include name of the project, site address, area of construction site, nature of terrain, nature of soil at the site and type of construction activity being carried out. The information about the construction equipment being used at the selected construction sites was collected through questionnaire survey so that air pollutants emitted from these equipments and machines can be related to the health impacts. It includes site location, name and number of various construction equipments being used and fuel used for operating these equipments. The Questionnaire survey also gathered information about construction materials being used at the sites so that the air pollution caused by the use and handling of these materials can be associated to health impacts. It includes site location; name various materials and mode of their transport.

2.3 Monitoring of PM_{10}

The PM_{10} concentration in the ambient air has been monitored for air quality in the vicinity of construction sites. For this 'continuous air quality monitoring stations' of Central Pollution Control Board located at Pitampura, Sirifort, Janakpuri, Nizamuddin, Shazadabad (Inderlok) and Shahdara in the vicinity of respective construction sites has been used. The PM_{10} concentration data was obtained from January 2013 to December 2013. At these stations sampling for PM_{10} has been done with the help of Respirable Dust Sampler (RDS). This cyclonic fractioning sampler for PM_{10} is a compact unit consisting of protective housing, blower, voltage stabilizer, time totalizer, rotameter and filter holder capable of supporting a 20.3 cm x 25.4 cm glass fibre filter. The procedure or method for measuring PM_{10} concentration in the ambient air is as follows [1]:

(i) The filter paper which is either glass fibre filter paper or EPM 2000 filter paper is put in the air tight desiccators containing silica gel (desiccant) in the control temperature 15 to 27ºC and 0 to 50 percent relative humidity environment for 24h prior to weighing to remove moisture from the filter paper.
(ii) The initial weight of the filter paper is taken on a balance and noted as 'w_1' in g. Then filter paper is put in its filter jacket.
(iii) Remove the filter from its jacket and center it on the support screen with rough side of the filter facing upwards. The filter paper is now ready in the Respirable Dust Sampler (RDS) for the deposition of PM_{10}
(iv) The ambient air is sucked in RDS with the help of suction pump / blower and is rotated through 'Cyclonic Flow Technique'. The 'flow rate' for air being sucked is kept constant at 1.0 m³/min.

with the help of a controller knob in RDS and is checked and noted from the reading in manometer tube fitted in the RDS. The heavy particles i.e. > 10 µm settle down in the cup fitted below the cyclone. The particles of size 0.1 µm to 10 µm get deposited on the filter paper for the sampling period, which is 8 h.

(v) The filter paper is taken out with all precautions so that deposited particles are not disturbed and weighed again; this final weight is noted as ‘w_2’ in g.

(vi) A new filter paper is taken and the steps (i) to (v) are repeated again and again on continuous basis. The sampling is done for each 8 hours period i.e. 6 am to 2 pm, 2 pm to 10 pm and 10 pm to 6 am every day. The average value for each day is calculated and on completion of a month the monthly average value is calculated.

2.4 Calculation for PM_{10} Concentration [1]

(i) Calculate the Volume of air sampled as, **V = Qt**

Where, V = Volume of air sampled, in m³; Q = average flow rate, in m³/min.; t = total sampling time, in min.

(ii) Calculate the PM_{10} in ambient air as, **PM_{10} (as µg/m³) = $(W_2 – W_1) \times 10^6 / V$**

Where, PM10 = mass concentration of particulate matter less than 10 micron diameter, in µg/m³; W_1 = initial weight of filter, in g; W_2 = final weight of filter, in g; V = volume of air sampled, in m³; and 10^6 = conversion of g to µg.

2.5 Evaluation of Air Pollution Index (API) [9]

An ‘Air Pollution Index’ is defined as a scheme that transforms the (weighted) values of individual air pollution related parameters (for e.g. SPM concentration) into single number or set of numbers. As a result, we get an equation which transforms the parameter values – by means of a numerical manipulation – into a more simple and precise form. One of the methods to calculate API is shown by (1):

$$\mathbf{API = 1/n \sum_{i=0}^{n} (PM10\ measured / PM10\ prescribed) \times 100} \quad (1)$$

Where, **n = no. of pollutants**

2.6 Calculation for Air Pollution Index (API)

For Motinagar Construction Site the Estimated Annual Avg. PM_{10} Conc. = 206 µg/m³

The Prescribed Value of Annual Avg. PM_{10} Conc. = 60 µg/m³

Here number of pollutant (PM_{10}), n = 1

API = 1/n $\sum_{i=0}^{n} (PM10\ measured / PM10\ prescribed)$ x 100

So, API = (206/60) x 100 = 343

Similarly, API is calculated for each construction site.

2.7 Rating Scale Indices [9]

A typical rating scale can be as follows:

Index Value	**Remarks**
0 – 25	Clean Air
26 – 50	Light air pollution
51 – 75	Moderate air pollution
76 – 100	Heavy air pollution
> 100	Severe air pollution

III. RESULT AND DISCUSSION

The air quality data of the construction sites in Delhi-NCR has been analyzed for the monthly average variation of PM_{10} concentration for the year 2013. The estimated annual average level of PM_{10} at different sites has been compared with the prescribed annual average. Also the data has been analyzed month wise for all the sites to see which sites have higher values of pollution in a particular month and what has been the trend of variation? The health conditions of workers at the sites have been compared with the level of pollution (PM_{10}) at the respective site and a correlation has been developed.

3.1 PM_{10} Concentration Trend at Motinagar

Fig. 2 shows the trend of PM_{10} concentration variation for different months of the year at Motinagar construction site for the period January to December 2013. The maximum monthly average PM_{10} concentration has been observed to be 316µg/m³ in the month of November.

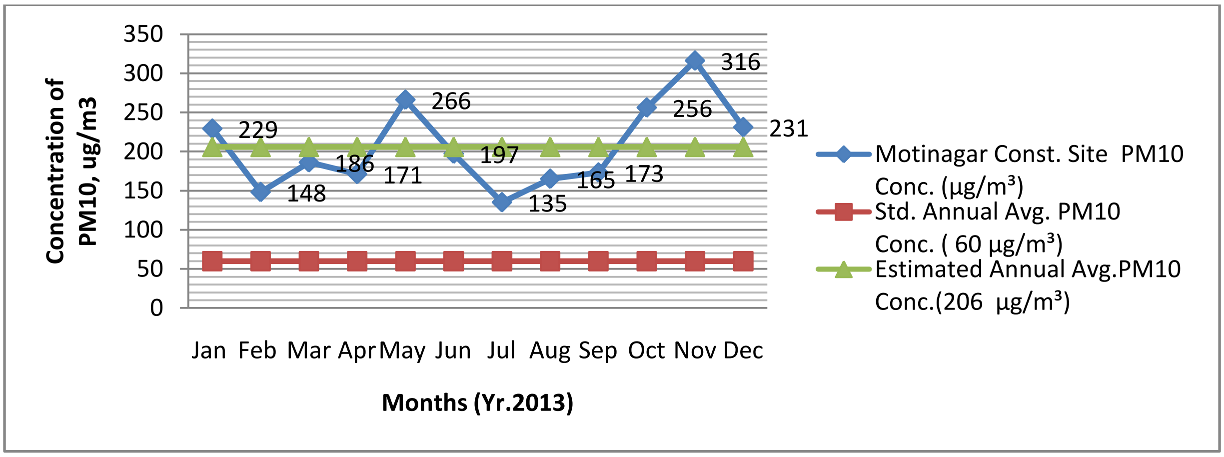

Fig. 2: PM_{10} concentration levels at Motinagar construction site

However, the minimum monthly average PM_{10} concentration has been observed to be 135µg/m³ in the month of July. Both the minimum and maximum values of monthly average PM_{10} concentration are way above the prescribed standard (60µg/m³). The annual average concentration of PM_{10} has been estimated to be 206 µg/m³, which has also violated the prescribed standard by more than three times. The occurrence of higher PM_{10} levels may be due to emissions (from construction vehicles, generators, construction equipments, etc.) as a result of increased construction activities along with weather conditions that entraps pollutants. The maxima in November may be due to cooler temperature that brings down the boundary layer and calm winds that prevents pollutants from drifting. In such a stable atmosphere the thermal turbulence will be least and vertical mixing of pollutants will be restricted thereby increasing the concentration of pollutants near the earth's surface. In contrast the minima in July, in addition to other factors, may be due to the onset of summer monsoon that brings cleaner air and reduces the level of gaseous pollutants by washing down the particulates. The figure shows a second peak (266 µg/m³) in the month of May which may be due to increased construction activity and blowing of dust in dry weather by movement of construction vehicles and equipments in addition to other factors. From a peak in January (229 µg/m³) the PM_{10} concentration drops to a lower value and remains somewhat stable in February, March and April due to increase in day temperature and vertical mixing of pollutants and then again rises to a peak in May (266 µg/m³) after which it falls to a low in July (135µg/m³) and remains somewhat stable till September and then rises to the maximum value of 316µg/m³ in November as shown in the Fig. 2

3.2 PM_{10} Concentration trend at Tis Hazari Courts

The trend of PM_{10} concentration variation for different months of the year at Tis Hazari Courts construction site for the period January to December 2013 is shown in the Fig 3.

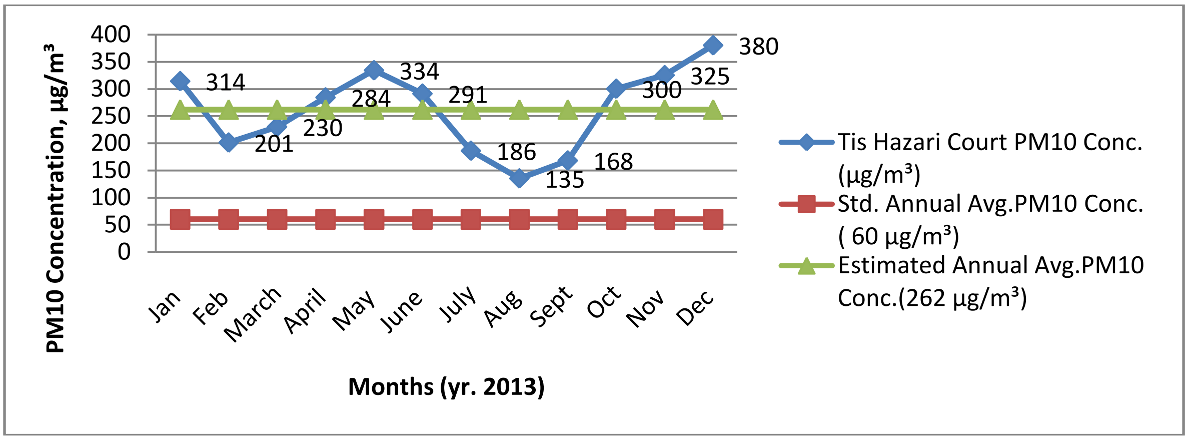

Fig. 3: PM_{10} concentration levels at Tis Hazari Courts construction site

The month of December shows the maximum monthly average PM_{10} concentration as 380 µg/m³ in the year 2013. However the minimum monthly average PM_{10} concentration has been observed to be

135µg/m³ in the month of August. The minimum and maximum values of monthly average PM_{10} concentration have crossed the prescribed standard (60µg/m³). The annual average concentration of PM_{10} has been estimated to be 262 µg/m³, which has also violated the prescribed standard by more than three times. The occurrence of higher PM_{10} levels may be due to emissions from increased construction activities in addition to weather conditions that entrap pollutants. The month of December shows maxima mainly due to cold weather conditions that brings down the boundary layer and calm wind that prevents pollutants from drifting. Under such a stable atmosphere the thermal turbulence will be least and vertical mixing of pollutants will be restricted. In contrast the minima in August, in addition to other factors, may be due to summer monsoon that brings cleaner air and reduces the level of gaseous pollutants by washing down the particulates. Fig. 3 shows a second peak (334 µg/m³) in the month of May which may be due to increased emission and blowing of dust due to movement of construction vehicles and equipments at the construction site under dry conditions.

Similar trends of PM_{10} concentration levels have been observed and analyzed at the other construction sites for the study period.

The PM_{10} levels at different construction sites were considered together month wise for analysis to find the trend in variation of concentration for each month.

3.3 PM_{10} Concentration level in January

January is marked by cold and calm conditions in Delhi. In this month under stable atmosphere the thermal turbulence will be least and vertical mixing of pollutants will be restricted thereby causing higher concentration of

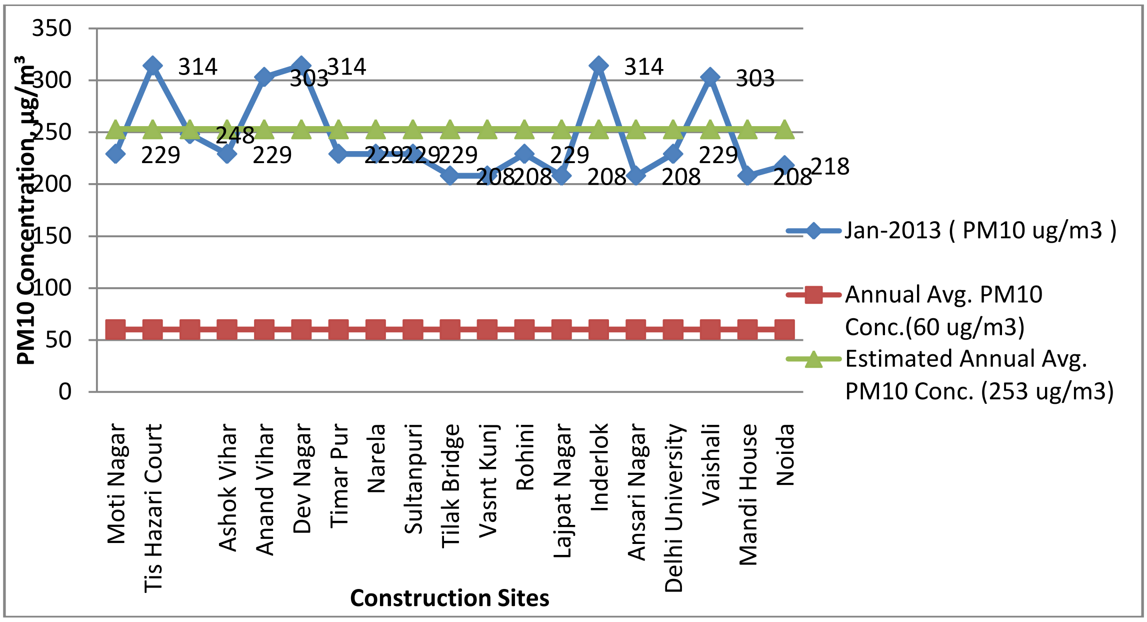

Fig. 4: PM_{10} conc. levels at construction sites in Delhi-NCR in January 2013

pollutants in the air near the earth's surface. Fig. 4 shows the minimum and maximum values in January are 208 µg/m³ and 314 µg/m³ respectively, both the values are way above the prescribed value of 60 µg/m³. In January we find the peak value of PM_{10} at Tis Hazari Courts, Dev Nagar and Inderlok construction sites. All these three sites are in heavy traffic area and are surrounded by tall buildings which contribute in increasing the concentration of pollutants at the construction sites.

3.4 PM_{10} Concentration level in February

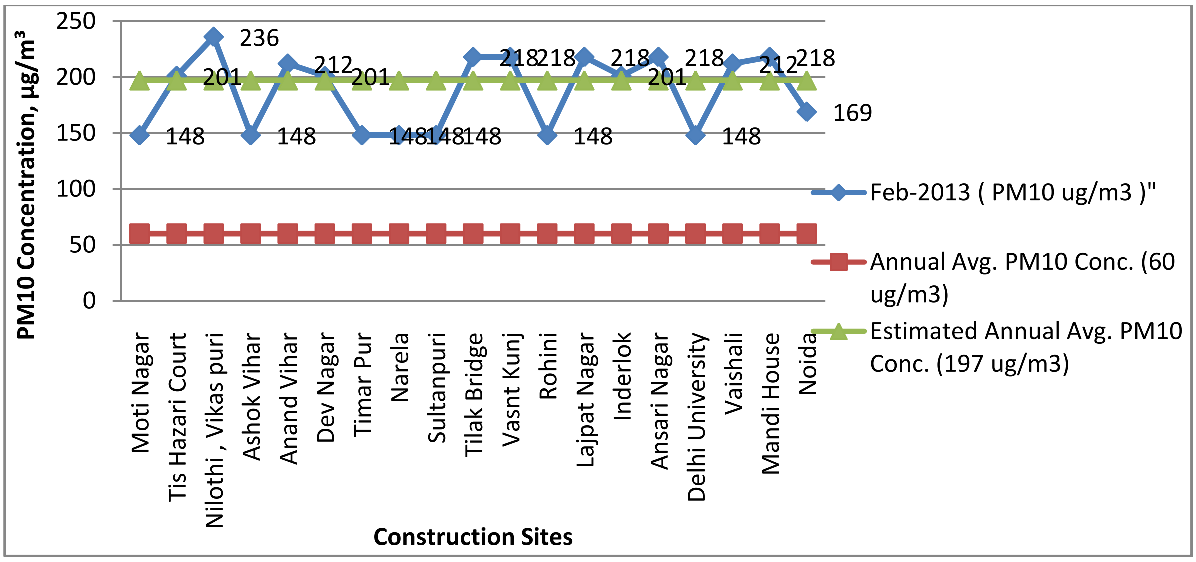

Fig. 5: PM_{10} conc. levels at construction sites in Delhi-NCR in February 2013

The day temperature starts rising in February and the atmospheric conditions are little warmer in Delhi. In this month there is some thermal turbulence and vertical mixing of pollutants thereby causing lesser concentration of pollutants in the air when compared to that in January. Fig. 5 shows the minimum and maximum values in February are 148 µg/m³ and 236 µg/m³ respectively, both the values are way above the prescribed value of 60 µg/m³. The maximum of pollutant concentration in this month is at Nilothi construction site.

Likewise PM_{10} concentration levels at all the other constructions sites in Delhi-NCR has been plotted and analyzed for other months of the year.

3.5 PM_{10} Concentration Level in the Year 2013

Fig. 6 shows the sites such as Tis Hazari Courts, Anand Vihar, Dev Nagar, Inderlok and Vaishali has PM_{10} concentration higher than the estimated annual average PM_{10} concentration of 211 µg/m³ whereas other sites like Noida, Mandi House, Delhi University, Ansari Nagar, etc has PM_{10} concentration lower than the estimated annual average value. The minimum and maximum values in the year 2013 are 167 µg/m³ and 262 µg/m³ respectively; both the values are way above the prescribed annual value of 60 µg/m³. The sites which are in congested areas like Dev Nagar (Karol Bagh) and Inderlok show higher value of PM_{10} levels whereas the sites which are in open areas such as Noida show lower concentration of particulate matter due to easy dispersion. In sites surrounded by tall building the vertical mixing of pollutants is restricted thereby causing larger concentration of pollutants in the air when compared to that in the open areas.

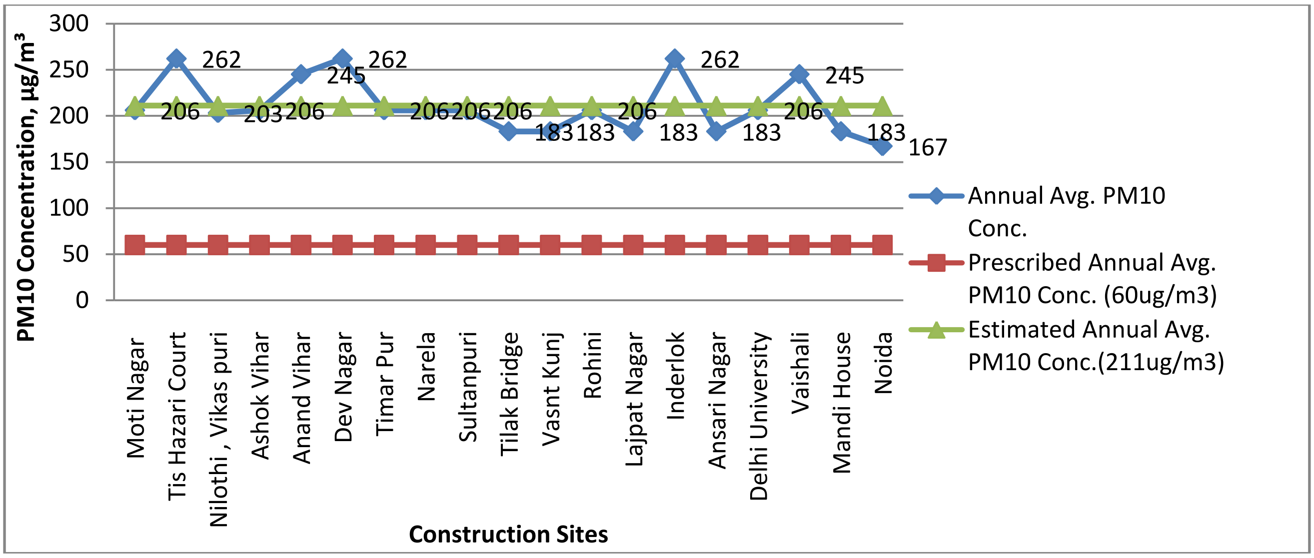

Fig. 6: Annual PM_{10} conc. levels at construction sites in Delhi-NCR in 2013

3.6 Air Pollution Index (API) for PM_{10} and Health Conditions of Workers at Construction Sites

The comparison of Air Pollution Index (API) and percentage of workers suffering with respiratory diseases is shown in Fig. 7 for the respective sites in Delhi-NCR. For Motinagar site the API is 343 (i.e. severe air pollution) whereas the corresponding percentage of workers suffering with respiratory diseases is 80 percent. The higher incidence of respiratory diseases is mainly due to the poor health condition of workers, unhygienic conditions at the site, less use of safety / precautionary measures by the workers against air pollution, longer exposure time to the pollutants as the workers stayed at the site after work, etc.

Similarly for Tis Hazari Courts the API is 436 (i.e. severe air pollution) and the corresponding percentage of workers suffering with respiratory diseases is 25 percent. At this site workers used safety measures like air-filter mask, sprinkling of water to control dust, they are mainly non-smokers, etc. and in addition to this the health condition of workers is good.

The API at Nilothi construction site is 338 (i.e. severe air pollution) and the corresponding percentage of workers suffering with respiratory diseases is 65 percent. Here the existing health condition of workers is poor along with unhygienic conditions at the site, less use of safety / precautionary measures by the workers against air pollution, workers worked in long shifts thereby time period of exposure has been more, etc.

Likewise, all other sites selected for the present study has been analyzed for API and health condition of people.

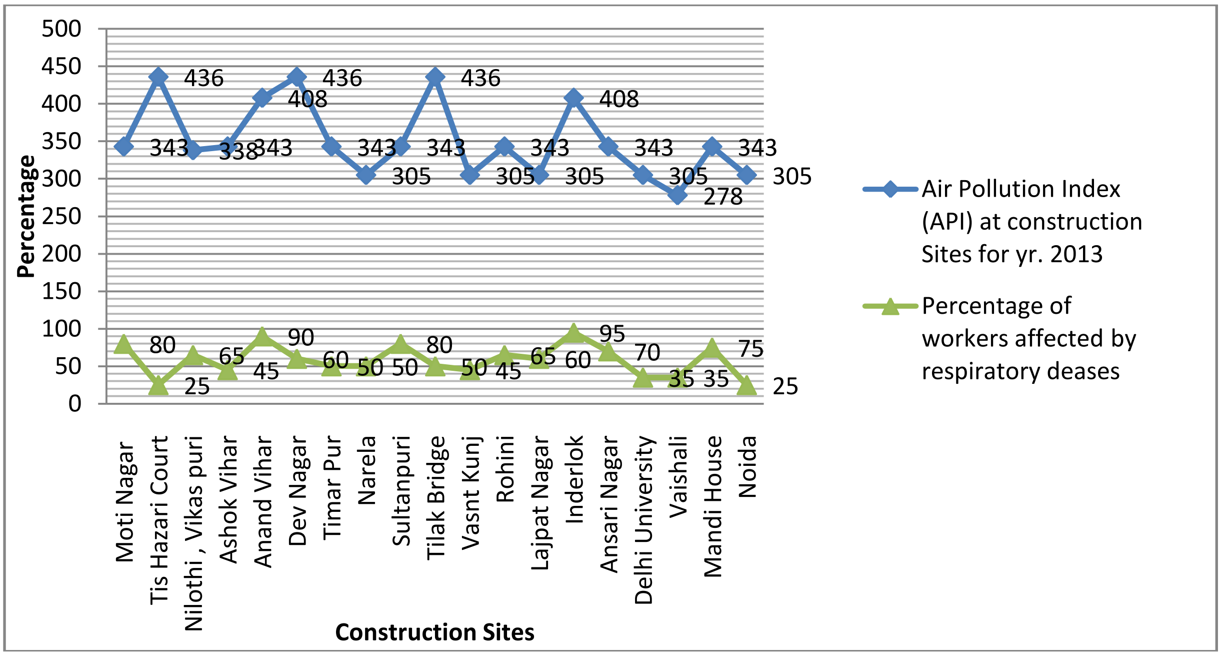

Fig. 7: Air Pollution Index (API) and percentage of workers with respiratory diseases

IV. CONCLUSIONS

The construction sites in Delhi-NCR in general shows two peak PM_{10} concentration values one in the month of May and other in the month of November / December and also two lows one in the month of February and other in the month of July / August throughout the monitoring period (January to December 2013). Both the maximum and minimum values of monthly average PM_{10} concentration showed non compliance with the prescribed standard ($60 \mu g/m^3$). The estimated annual average concentration of PM_{10} for construction sites has also violated the prescribed standard by more than three times. The occurrence of higher PM_{10} levels may be due to increased emissions as a result of increased construction activities along with weather conditions that entraps pollutants. In contrast the minima in July, in addition to other factors, may be due to the onset of summer monsoon that brings cleaner air and reduces the concentration of gaseous pollutants by washing down the particulates. The Air pollution Index (API) for PM_{10} shows a reciprocal relationship with the health condition of the workers. On comparison, for Air Pollution Index (API), the corresponding percentage of workers suffering with respiratory diseases on an average is 58 percent. The higher incidence of respiratory diseases is mainly due to the poor health condition of workers, unhygienic conditions at the site, less use of safety / precautionary measures by the workers against air pollution, longer exposure time to the pollutants as the workers worked in long shifts and stayed at the site after work, etc. At sites where the estimated percentage of workers with respiratory diseases is less than 45 percent, there some precautionary measures like sprinkling water on the dry ground to check the blowing of dust due to movement of construction vehicles and wind, use of air-filter face mask by the workers, workers are mainly non-smokers, construction vehicles and equipments has been new and in good condition, etc. and in addition to this the health condition of workers has been good. The results of this study may also be used for recommending ‘air quality management strategies for the construction sites’.

V. ACKNOWLEDGEMENTS

The authors would like to express gratitude to Central Pollution Control Board, Govt. of India, New Delhi, India, for providing necessary data base from the continuous air quality monitoring stations.

REFERENCES

[1] IS 5182 (Part 23): 2006, *Indian Standard, Methods for Measurement of Air Pollution, Part 23 Respirable Suspended Particulate Matter (PM_{10}), Cyclonic Flow Technique*.

[2] Shah Prakesh S. and Balkhair Taiba, *Air pollution and birth outcomes: a systematic review*, *Environment International, 37(2),* 2011, 498-516.

[3] Patankar A.M. and Trivedi P.L., *Monetary burden of health impacts of air pollution in Mumbai, India: implications for public health policy*, *Public Health, 125(3),* 2011, 157-164.

[4] Guttikunda Sarath K. and Goel Rahul, *Health impacts of particulate pollution in a megacity—Delhi, India, Environmental Development, in press, corrected proof*, 2012, available online.

[5] Samet Jonathan M., Dominici Francesca, Curriero Frank C., *Coursac Ivan and Zeger Scott L., Fine particulate air pollution and mortality in 20 U.S. cities*, 1987–1994, *The New England Journal of Medicine, 343,* 2000,1742-1749.

[6] Mediavilla-Sahagún Antonio and ApSimon Helen M., *Urban scale integrated assessment of options to reduce PM_{10} in London towards attainment of air quality objectives*, *Atmospheric Environment, 37(33),* 2003, 4651-4665.

[7] Cheng Shuiyuan, Chen Dongsheng, Li Jianbing, Wang Haiyan and Guo Xiurui, *The assessment of emission-source contributions to air quality by using a coupled MM5-ARPS-CMAQ modeling system: a case study in the Beijing metropolitan region, China*, *Environmental Modeling & Software, 22(11)*, 2007,1601-1616.

[8] Nikolopoulou Marialena, Kleissl Jan, Linden P.F. and Lykoudis Spyros, *Pedestrians' perception of environmental stimuli through field surveys: focus on particulate pollution*, *Science of the Total Environment, 409(13)*, 2011, 2493-2502.

[9] M N Rao and H V N Rao, *Air Pollution Indices, Air Pollution (New Delhi: Tata McGraw-Hill Education Private Limited*, 2009) 269-275.