

Evaluation of Impact of Particulate Matter on Traffic Personnel and at Traffic Junctions

Uma S Kale*, P.H. Sawant

Sardar Patel College of Engineering, Andheri, Mumbai, India

*Corresponding author: Uma S. Kale, Reserach Scholar, Sardar Patel College of Engineering, Andheri, Mumbai, India; E-mail: kaleuma@gmail.com

Abstract

Traffic junctions and congestions are the hotspots of suspended particulate matter. Survey is conducted on the street people those are directly exposed to particulate matter. This study has put more focus on the respiratory disorders caused due to particulate matter. Comprehensive study is conducted on the traffic congestions and traffic personnel. Evaluation of particulate matter (PM_{2.5}) with a diameter of 2.5 micrometers or less is done during the peak hours. A weekly measurement of PM_{2.5} was averaged at the most congested junctions of Mumbai. Time based study is undertaken to correlate the impact of PM_{2.5} and effect of chronic and acute symptoms among traffic personnel's. These effects were monitored through spirometric analysis on exposed and unexposed groups. Further the impacts were categorised into acute and chronic impacts. CALINE 3 is used to predict concentration of pollutants near traffic junctions where vehicles have to wait on queue in idling condition for signals. The traffic personnel's were diagnosed for occupational health effects which comprises of respiratory related diseases. These prospective data supports the development of asthma and respiratory disorders irrespective of the other risks.

Keywords: PM_{2.5}; Traffic congestions; Traffic junctions; Respiratory diseases; Asthma; Traffic personnel; CAL roads

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Introduction

Traffic junctions are provided on roads and at intersections for smooth movement of traffic and to avoid traffic congestions. Traffic signals are provided at the junctions with time duration of 55 sec to 2 min where the vehicles remain in idling condition. The number of vehicles rest at junction for few seconds and emissions are emitted continuously for that particular time. Survey was done at various traffic junctions and was observed that hardly any vehicle is switched off. This idling time increases air pollution levels which cause acute and chronic impact on the exposed people in the vicinity of the traffic junctions. Between 1976 and 1991 vehicle registration of two wheelers, scooter and cars in Maharashtra Metropolitan Region (MMR) increased by factor of 3.25, while truck and bus registration increased by 2.22 times, private vehicle registration increase by 3.45 times mainly as a result of increase in scooter and motor cycle ownership. Private vehicle registration in 2011 is expected to more than double the 1991 levels. Number of private vehicles per 1000 persons is expected to increase from 49 in 1991 to 61.1 by 2011(MMRDA, 1992).



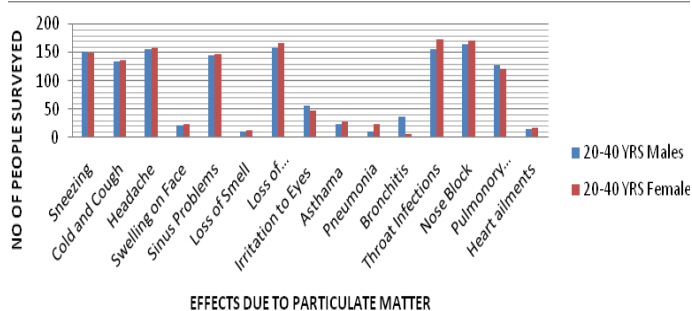
Table 1: Emission Inventory of Air Pollutant in Mumbai city.

Table 1.1 Emission Inventory of Air Pollutant in Mumbai city

Sector	MCGM				MMRDA				
	Pollutants emitted ton/day				Pollutants emitted ton/day				
	SO ₂	NO ₂	SPM	CO	SO ₂	NO ₂	SPM	CO	
Domestic Sector	7.36	3.53	0.45	1.44	12.26	5.88	0.75	2.41	
Industrial & Commercial Sector	Fuel Burning	142.16	41.73	10.81	2.36	257.95	70.15	16.55	4.01
	Process emission	3.20	3.80	27.00	-	9.20	6.00	53.50	-
	Sub - Total	145.36	45.53	37.81	2.36	267.14	76.15	70.05	4.01
Power	12.24	170.64	2.94	2.50	15.94	67.68	3.59	3.22	
Transport	14.78	265.52	48.34	770.51	18.89	211.87	62.33	1005.20	
Total	179.74	485.22	89.54	776.81	314.23	361.58	136.72	1014.84	

(Source: MMRDA, 1992)

It is observed from the data that there is significant correlation between the pollutants released by transport system and the number of vehicles. Rise in population and so on is the rise in number of vehicles every year. This burgeoning number of vehicles is the result of urbanization and growing population which will further host the problems of air pollutants. A public survey was conducted on the public of various age groups for studying the impact due to auto exhausts pollution. People were asked questions through a questionnaire, where the age, sex, occupation and exposure at the junctions were known. Survey was conducted on the street people, vendors, daily hawkers, traffic personals, people who were regularly exposed to traffic congestion and pollution. Total 3125 adult male and females ranging from age group 20 to 40 were surveyed for effects due to particulate matter. It is observed that effects like sneezing, cold and cough, headache, sinus, loss of concentration, throat infections, nose blocks and pulmonary diseases are more commonly found among the people.

**Figure 1:** Survey representing the impact of particulate matter on human body.

An acute and chronic effect of particulate matter is invaded in the society and has become top most issue. Many individuals confuse the difference between an acute disease and a **chronic disease**. An acute disease lasts for just a short time, but can begin rapidly and have intense symptoms. In contrast, a chronic disease produces symptoms for quite some time, lasting for three months or more.

Often, people are confused as to what constitutes an acute disease. They believe an acute disease is always severe. In reality, an acute disease can be mild, severe, or even fatal. The term acute does not indicate the severity of the disease. Instead,

it indicates how long the disease lasts and how quickly it develops. Examples of acute diseases include colds, **influenza**, and **strep throat**. Air pollution has both acute and chronic effects on human health, affecting a number of different systems and organs. It ranges from minor upper respiratory irritation to chronic respiratory and heart disease, lung cancer, acute respiratory infections in children and chronic bronchitis in adults, aggravating pre-existing heart and lung disease, or asthmatic attacks. In addition, short and long-term exposures have also been linked with premature mortality and reduced life expectancy (Marilena Kampa, et al., 2008). A number of intermediary biomarkers of heart disease have been shown to be associated with exposure to particulate air pollution in human populations, including blood pressure, carotid artery intima-media thickness (Schwartz, 2011). Air pollution has both acute and chronic effects on human health, affecting a number of different systems and organs. It ranges from minor upper respiratory irritation to chronic respiratory and heart disease, lung cancer, acute respiratory infections in children and chronic bronchitis in adults, aggravating pre-existing heart and lung disease, or asthmatic attacks. In addition, short- and long-term exposures have also been linked with premature mortality and reduced life expectancy. These effects of air pollutants on human health and their mechanism of action are briefly discussed. A number of intermediary biomarkers of heart disease have been shown to be associated with exposure to particulate air pollution in human populations, including blood pressure, carotid artery intima-media thickness (a measure of atherosclerosis), heart rate variability (associated with arrhythmia), and Von Willibrand's factor (associated with thrombosis). Less consistent findings have been reported for a number of other intermediaries (Schwartz, 2011). Human exposure to air contaminants may be evaluated by direct or indirect methods. Direct methods are carried out by personal exposure measurement, either with pumped or diffusive sampling or by measurements of biological markers. Indirect methods involve calculation of human exposure, by combination of concentrations at various locations and time spent by people in each specific environment (Cocheo, et al., 2011). The results of the analysis show that controlling air pollution sources in Shanghai will induce significant health benefits. Controlling emissions from industrial sources is found to be more cost-effective to protect human health than controlling power-plant emissions in Shanghai (Jia Li, et al., 2004). The public's total, cardiac and lung, and cancer mortality risks of long-term fine particulate matter (PM) exposure increase steadily with rising pm exposure (Thurston, G.D., 2008). While TSP is a trigger for respiratory diseases, the airways of individuals suffering from respiratory diseases seem to be protected by humidity contained in the air. Dry air aggravates the adverse effect of TSP. (total suspended particles) (Severin, et al., 2009). Populations associated with differential biological capacity to respond to air pollution exposure are fetuses and children, the elderly, and persons with pre-existing diseases. Higher risks have been shown for these groups (Makria, et al., 2008). Particulate matter from the metro has been shown to be relatively toxic (Nieuwenhuijsena, et al., 2007). PM as a pollutant in the atmosphere is a mixture of particles with diverse physical and chemical characteristics, which are largely determined by their sources and meteorology (Katsouyanni, et al., 2011). One approach to understanding the impact of pollution on health would be to assume that everyone is unaware of the amount of pollution in the

air. Therefore, ambient levels of pollution would serve as an unbiased proxy for an individual's exposure to pollution and pollution levels would not be correlated with any types of behaviour (Matthew, et al., 2004). Traffic police exposed to nitric oxides have shown significant increase in tHcy (Homocysteine plasma level) which is further associated with significant reduction in nitrite and nitrate serum levels (Zawilla, et al., 2011). The study was conducted to quantify PM_{10} concentration in occupational environment of traffic police in Pokhara. It is observed that traffic police is exposed to very high level of PM_{10} in their occupational environment (Ashish, et al., 2008). Apparent decrease in fertility and other reproductive outcomes were observed in a study conducted on homogenous population of young to middle aged policeman (Sree Devi, et al., 2006). This study indicates reduction in the lung function efficiency of the traffic policeman exposed to vehicular pollution. Forced Vital Capacity (FVC) was 82% of the expected in traffic policeman than the control group shows 99%. Warning symptoms of asthma were observed in the study (Sopan, et al., 2005). It is observed from the study that environmental lead pollution is associated with an increased blood lead concentration in those who are regularly exposed to vehicle exhaust in high traffics areas. The mean blood levels were significantly high in constable exposed directly to pollution (Farida Agha, et al., 2005). Study was conducted on pulmonary functions and it is observed that the exposed group indicated restrictions to the lung expansion, obstruction and narrowing of the airways in traffic personnel compared to the non exposed general police personnel of same BMI (Parvati Pal, et al., 2010). Traffic police with less than five years of exposure had complained of irritating cough and tightness of chest. As age and exposure increased symptoms like allergies, difficulty in breathing, increasing cough etc were observed 0.9% were observed with severe restrictive ventilator defect (Thippana, et al., 1999). Red blood cells count and average of haemoglobin blood levels of exposed children are significantly low from those of the non exposed children. There is significant difference in prevalence of anaemia (Nikolic, et al., 2008).

Materials and Methods

Descriptions and details of experimental site and analysis

Mumbai a metropolitan of India is selected as experimental site with 20 top listed congested sites. These sites are the locations with traffic junctions spread over the Mumbai city. City is over crowded with population and so as with the number of vehicles rising every year. These sites are estimated with congestion lasting for longer hours as well as pollution. Traffic police are accordingly diagnosed for noise levels at the junctions.

Traffic junctions are consider as hot spot of air pollution, as vehicles have to wait in idling mode of operation for signals and so the and congestion period was recorded. Traffic Police (Police constables, police naik, police head constables) having outdoor duties and administrative work along with street vendors were diagnosed for asthma and other respiratory disorders. Spirometric analysis was done for finding asthma in the traffic police.

Selection of the Monitoring Sites

In order to meet the objectives of the project, an area with significant population exposure and the location where

maximum concentration are expected to occur from the existing road are selected as monitoring sites. The traffic junction are preferred monitoring sites as most of the vehicles stops in idle mode at the junction depending upon signal timing, so these are hot spots of air pollution. Sites selected for monitoring are Khada Parsi junction, Nana chowk junction, Haji Ali junction, Nagpada junction, Kemp's corner, Andheri West, Bhandup Station junction, Dadar T T junction, Dharavi junction, Elphinstone Road Junction, Ghatkopar link road, JVPD, Indian Oil junction, Kalamnagar junction, Khetwadi junction, Kotwal Garden, Panjarapol Junction, Santacruz airport road, Parel T T junction, Sion Station junction. Twenty junctions are selected as hotspots of traffic congestions by the traffic control department.

Measurement of $PM_{2.5}$ at the sites and prediction modelling

$PM_{2.5}$ is measured at the junctions with the help of high volume sampler, Model-PEMHVS 310. The annual average of the $PM_{2.5}$ is considered for modelling through CALRoads. The model CALRoads View accounts for the idling emissions. Hence, in his study it was decided to use the model CALRoads View.

Description of CAL Roads View Model

CALRoads View is an advance version built in with CALINE4 and CAL3QHC. The CALRoads View interface has easy-to-use options that compose the CALINE4, and CAL3QHC run-stream file. The graphical output capabilities of CALRoads View can help to create impressive presentations of model results. We can customize the project using display options such as transparent contour shading, annotation tools, change fonts, and specify wind arrows. Descriptions of input parameters required for this model are discussed below.

Site Geometry

CALRoads View software can import the site map in image format, which makes it easy to locate the link over the map. Wind direction is assumed to be spatially constant over the study area under consideration.

Free Flow Link

A free flow link is defined as a straight segment of roadway having a constant traffic volume, travel speed, vehicle emission factor, width and height. Its end point co-ordinates specify location of the link. Link width is defined as a width of the travel roadways plus three meters on each side to account for the dispersion of the plume generation by the wake of moving vehicles.

Queue Link

A queue link is defined as a straight segment of roadways with constant width and emission source strength, on which vehicles are idling for a specified period of time. The location of each link is determined by its beginning point co-ordinates and an arbitrary end point co-ordinate. Width of the link is determined by width of travel roadways only.

Discrete Receptor Location

Receptor location is specified in terms of X, Y, and Z co-ordinate. A receptor should be located outside the mixing zones of free flow link. There is no restriction for receptor height.

Grid Receptor

A grid receptor can be overlay on the site domain with specified distance interval in grid form. It provides the one hour highest concentration over the map/site.

Emission Sources

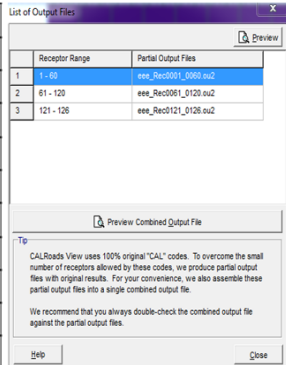
Separate emission estimates can be provided as input data for each free flow and queue link as follows.

a) **Free flow links:** Vehicles are assumed to be travelling without delay along free flow links. An emission factor in ‘grams/vehicle mile’ should be obtained which represents the driving cycle in the link.

b) **Queue link:** Vehicles are assumed to be in idling mode of operation during a specified period of time along a queue link. It assumes that vehicle will be in idling phase of signal timing. An idle emission factor in ‘grams per vehicle - hour’ is given as an input.

Table 2: Inputs Data for Modelling.

Averaging time (min)	60 min
Surface roughness coefficient (cm)	100 cm
Settling velocity (cm/s)	0 cm/sec
Deposition velocity (cm/s)	0 cm/sec
Wind speed (m/s)	2 m/s
Wind direction (degree)	220 – 280 degree
Wind direction increment angle (degree)	10 degree
Stability class	4D (Neutral)
Ambient atmospheric temperature	28°C
Mixing height (m)	1000 meters
Height of receptor (m)	1.8 m



Input Data Requirements

A crucial factor for any air quality model (software) is the input data needed. The accuracy of the model results are highly dependent upon the input data used. Table 2.1 shows the input data requirement for CAL Roads View along with input data for one link of the intersection. Similarly input data for other links and traffic junction were prepared.

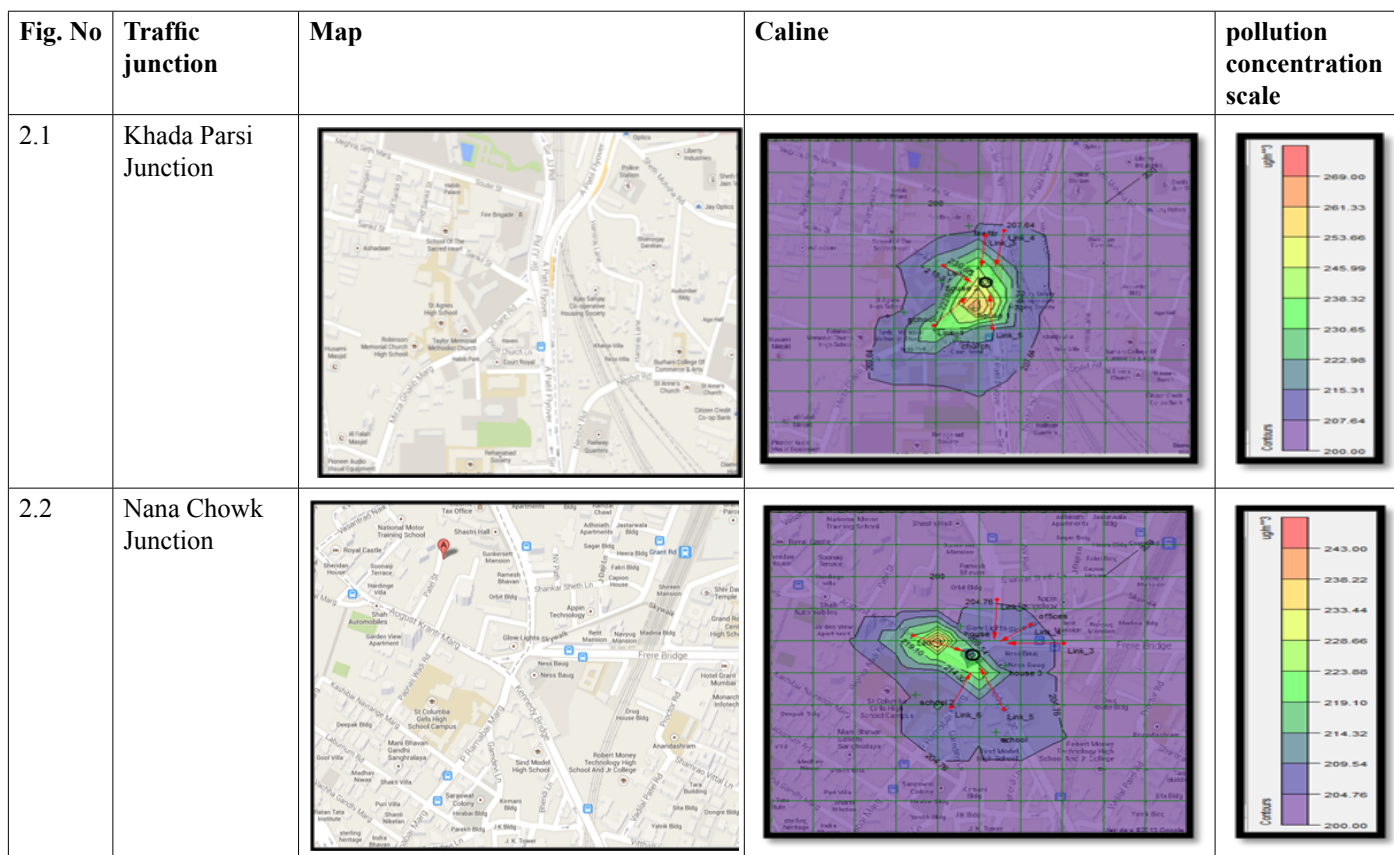
Spirometric analysis of traffic police for diagnosis of asthma


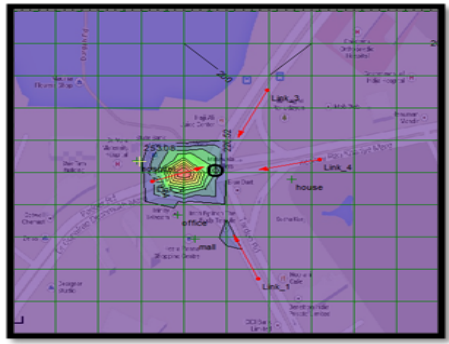
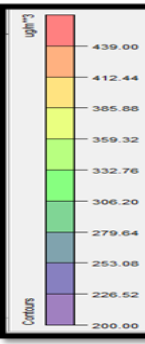

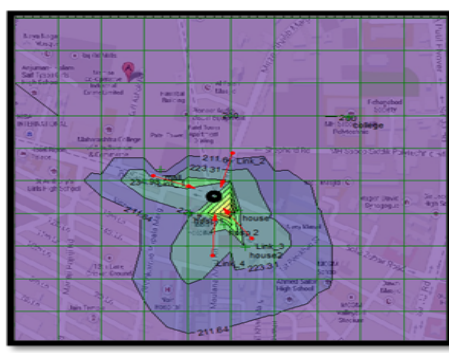
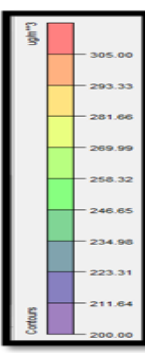

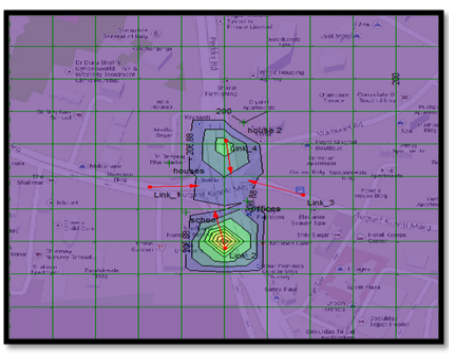
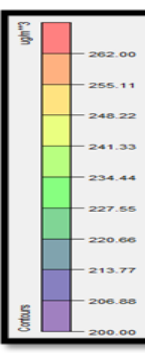
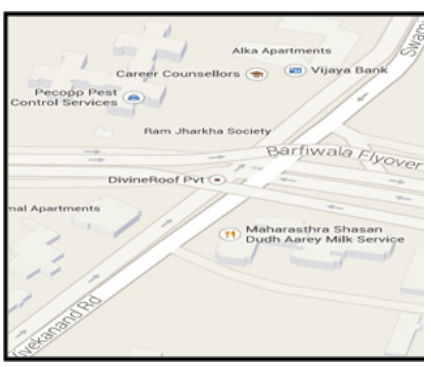
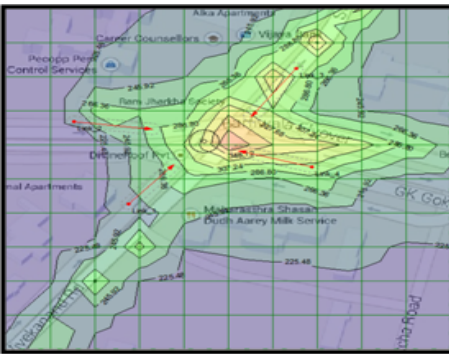

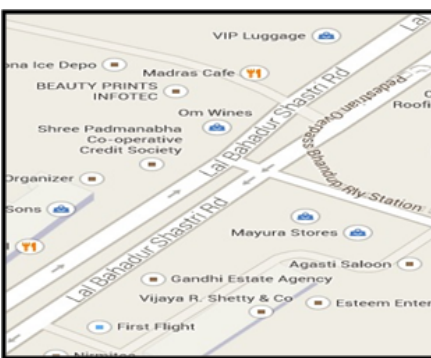
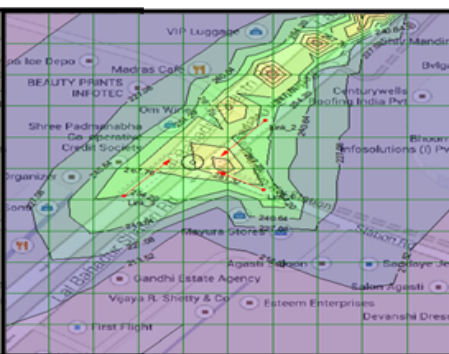

Breath-O-Meter manufactured by Cipla is used to measure the peak expiratory flow rate L / min for diagnosing prevalence of asthma in traffic police. PEFR is checked among all the traffic police and comparison is made among the exposed and unexposed group. Traffic personnel are directly exposed to particulate matter for about 8h of their work profile. Traffic police diagnosed have working experience from less than 5 years to more than 25 years. Traffic police pursuing smoking habit was the criteria used for rejection from the analysis. Readings are analyzed as per chest research foundation, Pune.

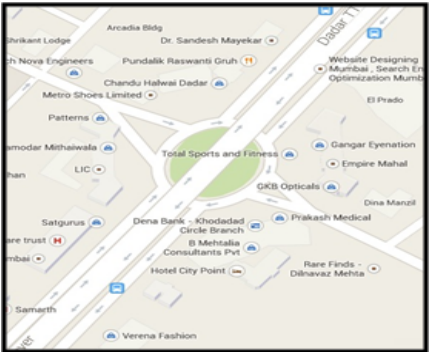
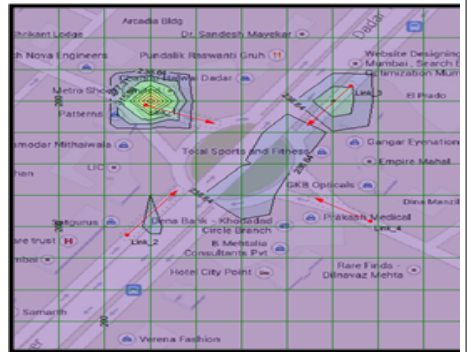
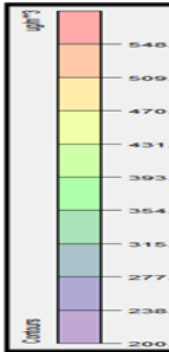
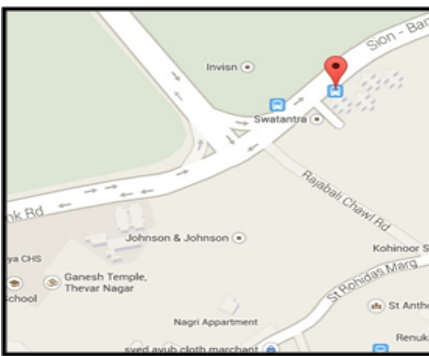
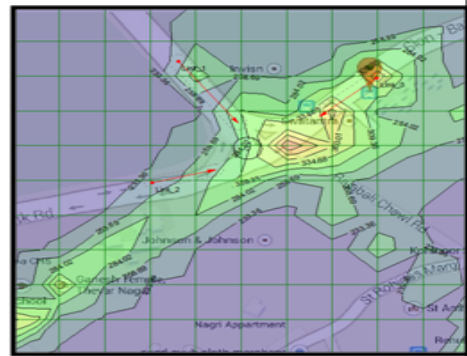
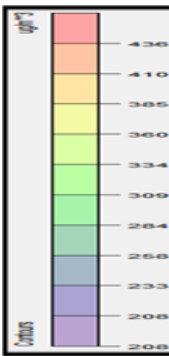
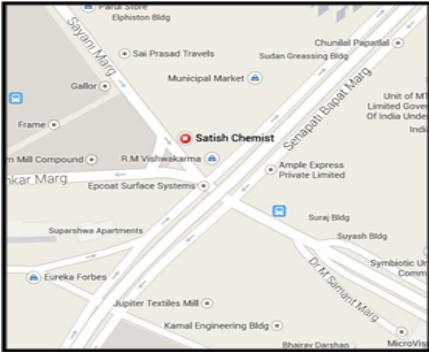
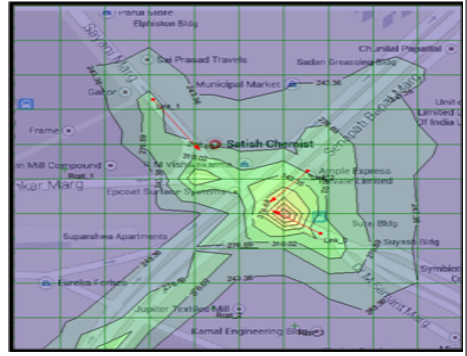
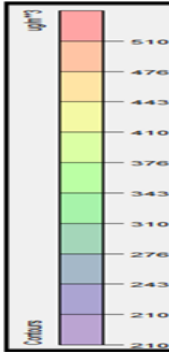

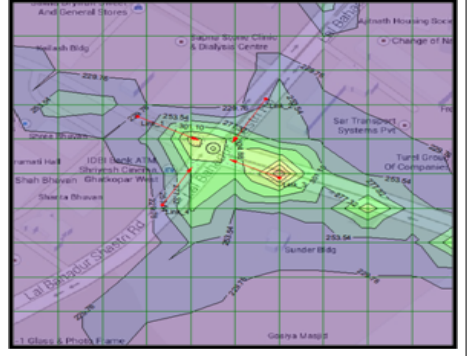
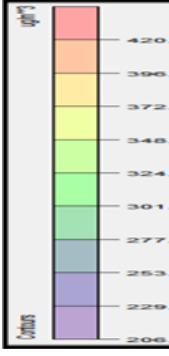
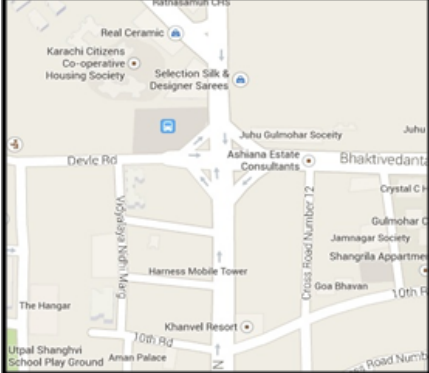
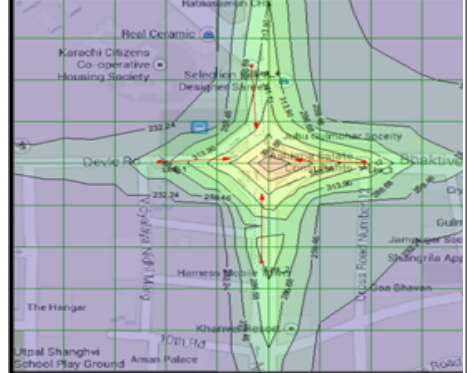
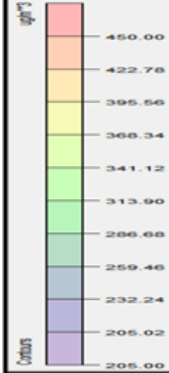
Prediction of Air Quality


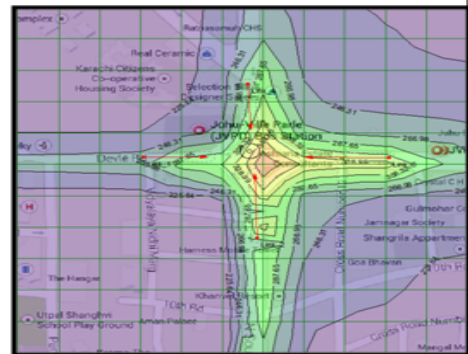
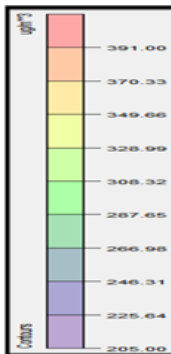
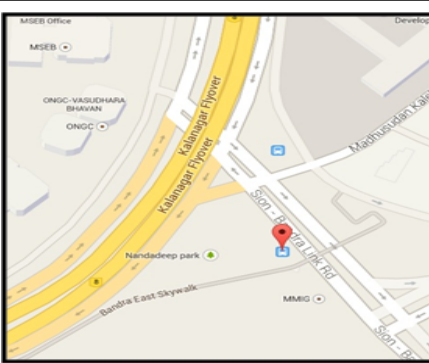
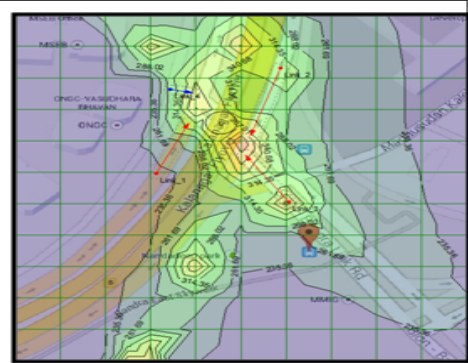
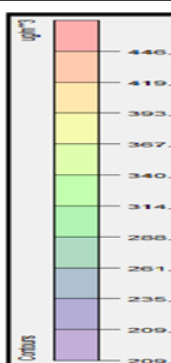

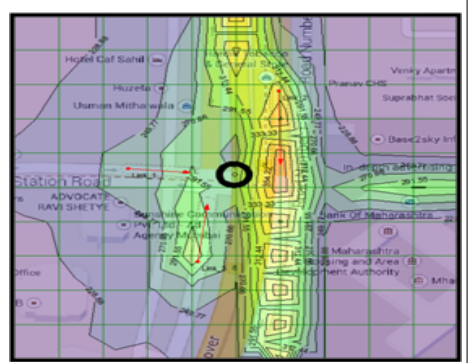
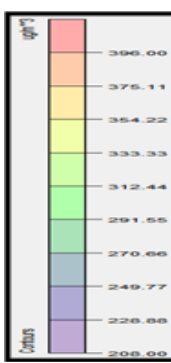
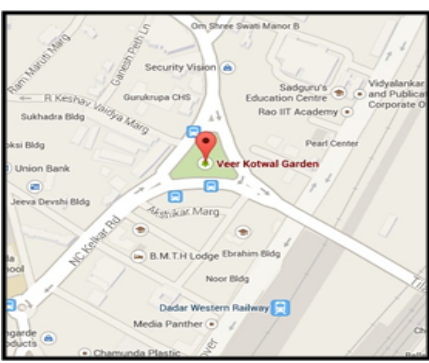
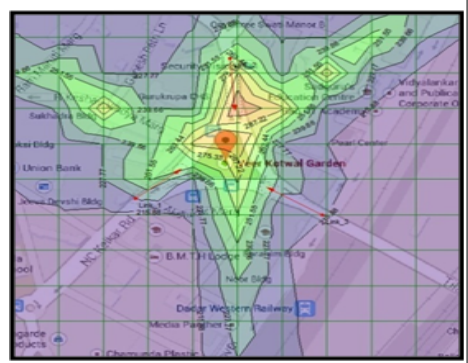
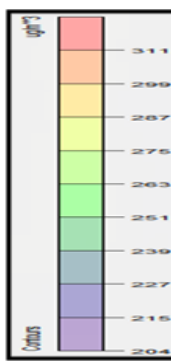
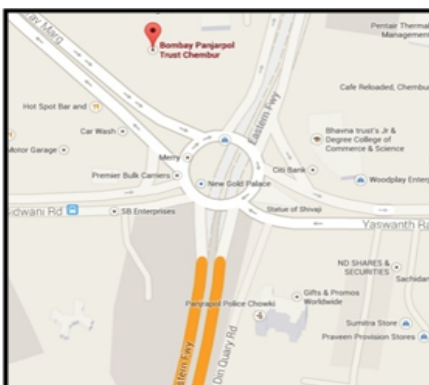
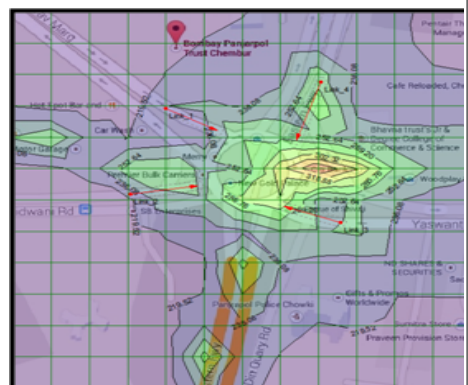
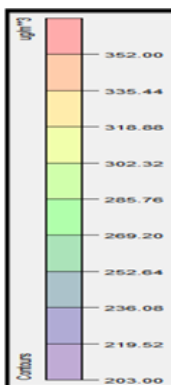
Forecasted traffic volume and emission standards are used as an input for the prediction of air quality. During the model performance we found that the maximum concentration is found at an angle of 220°. As the study is concentrated on the peak hour traffic pollution, the atmospheric stability class was considered as neutral.

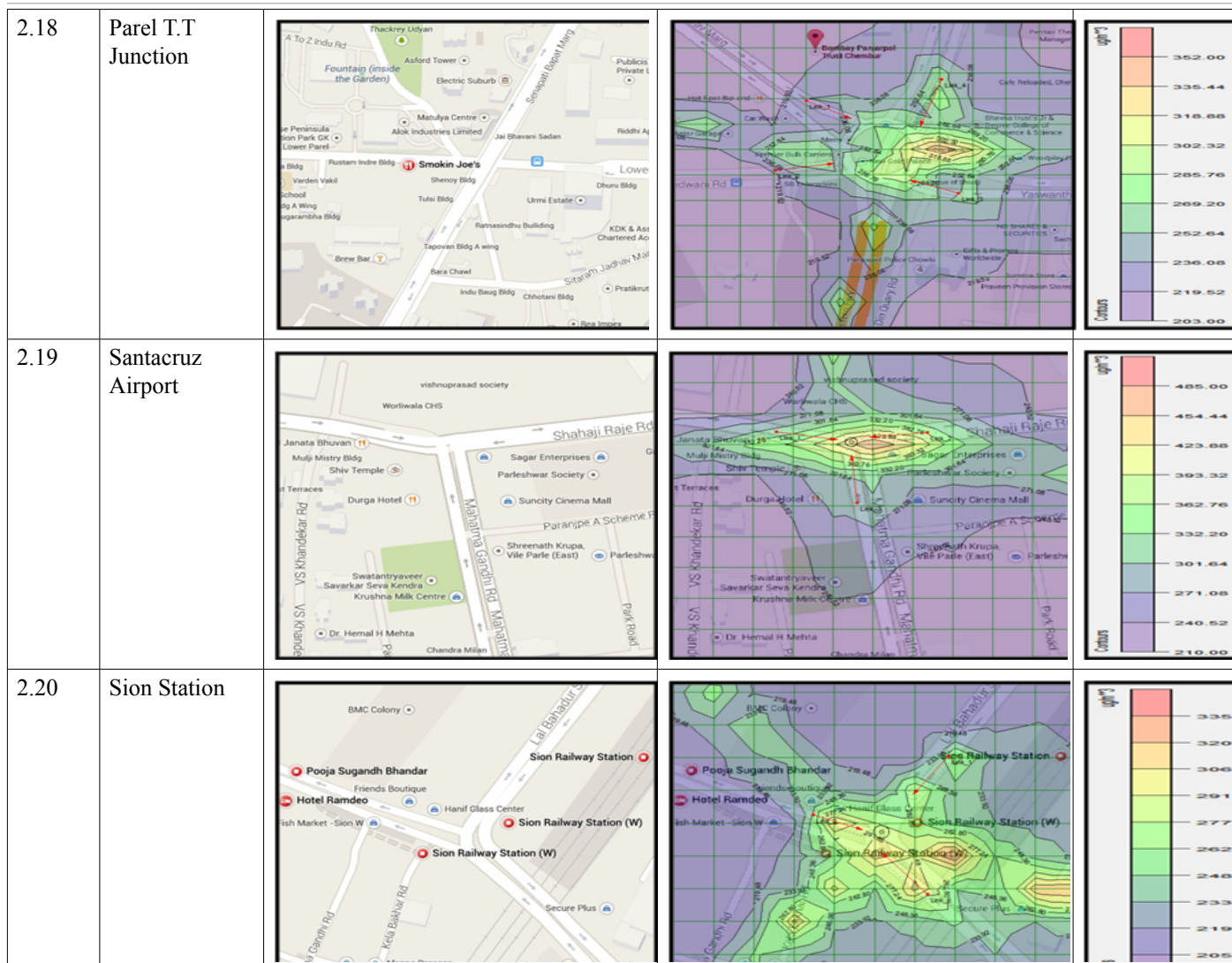
Hence the following sites were selected after through consideration of the above factors in the figure 2.1 to 2.20.



2.3	Haji Ali Junction			
2.4	Nagpada Junction			
2.5	Kemps Corner			
2.6	Andheri station			
2.7	Bhandup Station			

2.8	Dadar T.T. Junction			
2.9	Dharavi Junction			
2.10	Elphiston Road Junction			
2.11	Ghatkopar Link Road			
2.12	Indian Oil			

2.13	JVPD			
2.14	Kalangar (Bandra)			
2.15	Kherwadi			
2.16	Kotwal Garden			
2.17	Panjarpol Junction			



Figures 2.1 to 2.20: Hence the following sites were selected after through consideration of the above factors in the figure.

Results of Asthma Diagnosis Using Spirometric Analysis:

Table 3: Data showing asthma in exposed and unexposed traffic police.

Experience years	Total No of Tested	Asthma Diagnosed	Asthma Absent	%
	23	2	21	8.69
05 - 10	33	5	28	15.15
10 - 15	26	5	21	19.23
15 - 20	31	6	25	19.35
20 - 25	16	6	10	37.5
25 <	7	2	5	28.57
TOTAL	136	26	110	21.41

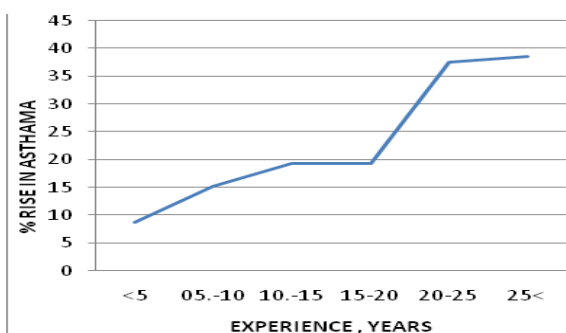


Figure 3: Rise in asthma in the traffic police.

Results and Discussions

The growing number of asthma outbreak is a serious problem associated as occupational hazard towards the traffic police. Efforts have to be made to reduce the exposure levels at the source itself. Traffic junctions are identified as the most polluted spots where maximum concentration will occur as the vehicles have to idle for signals at the junctions. The model CALRoads View is capable of calculating the length of vehicles queue due to signals and it considers the emission during idling mode of operation. Hence the develop model is more appropriate for predicting concentration near traffic junctions. This is clear from the comparison of model predicted values with the monitored concentration values, as the model performance is satisfactory. From the monitored data, RSPM, which represent contribution from all sources, identified as major pollutant, which is far above the standards drawn by CPCB. The sensitivity analysis of model shows that the model output is very dependent on the parameters like signal timing, wind speed and direction, emission factor and stability class. So, one has to be very careful in application of these parameters to the model.

Construction of the flyover will definitely improve the air quality, as it is very clear from the predicted concentration of CO and PM at all the junctions. From the sensitivity analysis of model, it is clear that, if, the signal timing is reduced the concentration of pollutant will also reduce. For the longer time signalized junction the time display panel can be fixed, so one can shut down the engine for a while, which may reduce the pollution near junction. During study it has been found that, the small change in traffic volume keeps the same concentration of pollutant. So, the model needs to improve in this regards to get the accurate results for every small change in traffic volume. This study provides the clear idea about, how the development of good infrastructure will help in building of good environmental conditions”

Suggestions to Improve the Air Quality

The results of this study can be effectively used for development of management strategies to reduce air pollution levels due to vehicular movement. Improvement in air quality can be ascertained by reducing emission standards of vehicles, by reducing vehicular population and construction of bridge. Following are some suggestions to improve the air quality. Fixing of emission standards of vehicles to maintain desired level of air quality. Duties of the traffic police can be shifted to various locations to avoid direct indirect exposure. Construction of flyover can avoid the idling of vehicles near the signalized intersections. Providing the green belt along the roadways to counteract the CO emission. Regulatory authority should be very strict in implementing the new standard of emissions (EURO 3 and 4), which will certainly improve the air quality. The percentage of public transport system (buses) is less than 5% in all the traffic junctions. Provision of efficient and fast mass transport system, creating public awareness on vehicle emissions and its impact on human health to induce more public transport or sharing of private vehicles can reduce the vehicular population and the pollution level to a great extent.

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