MONITORING THE INFLUENCE OF OUTDOOR VEHICULAR POLLUTANTS CONCENTRATION ON INDOOR AIR QUALITY OF THE HOUSES LOCATED CLOSE TO URBAN ROADWAY/HIGHWAYS

Dr. Sohail Ayub * and Kashif Baig**

* Associate Professor, Deptt. of Civil Engg., AMU, Aligarh.
**Research Scholar, Deptt. of Civil Engg., AMU, Aligarh

Corresponding Author: Sohail Ayub
Civil Engineering Department AMU Aligarh 2020002 UP India
Mobile No: 0091-9411802300.
Mail: sohailayub@rediffmail.com

ABSTRACT

Present study was undertaken to determine the status of indoor air quality of the houses due to vehicular concentration at different highways/ bypass of Aligarh city. Aligarh is medium sized city located in fertile tract of Ganga-Yamuna doab in north India, in the western part of the Uttar Pradesh. The main concern of the study is to determine the concentration of sulphur dioxide (SO_2), nitrogen dioxide (NO_2), suspended particulate matter at different highways/bypass entering into the Aligarh city with the help of Kimoto air handy sampler HS-7.The concentration of SO_2 and NO_2 are within the permissible limit while the suspended particulate matters are exceeding the permissible limit.

Key words: vehicular pollutants, indoor air quality, houses and urban highways

1.0 INTRODUCTION

Air that a human breathe is a mixture of gases and small solid and liquid particles. On an average a person breathes 22, 000 times a day and take in about 24 kg of air in the process to sustain the requirement of oxygen. Air pollution has three main sources from human activities: stationary, mobile, and indoor. Air pollution occurs when the air contains substances in quantities that could harm the comfort or health of humans and animals, or could damage plants and materials. These substances are called air pollutants and can be either particles, liquids or gaseous in nature [1]. The rapid urbanization in India has resulted tremendous increase in the number of motor vehicles which increasing road congestion and its pollution are now becoming the main source of air pollution in urban India. Vehicular pollution is caused due to tail pipe exhaust emission depending of changes in driving condition, engine condition, and fuel composition in air/fuel ratio. Motor vehicles are the major source of carbon monoxide, nitrogen oxides, lead, suspended particulate matter, sulphur dioxide and volatile organic compounds, with CO_2. Nearly 50% of global CO, hydrocarbon, and NOx emissions from fossil fuel combustion come from gasoline- and diesel-powered engines [9]. It is noticed that air pollution from traffic emission depends on traffic flow, street configuration, and land use activities and the local meteorological characteristics, high govern the ability of the atmosphere to disperse air pollutants. Under idling and deceleration modes, vehicles in this area will emit maximum pollutants. In some reports, truck traffic has been more strongly associated with these adverse outcomes than total vehicular traffic [5,6,7,8]. The air quality can be improved through a combination of technical and non technical measures. India is one of the top ten oil consuming country in the world with the oil consumption of 2,438,000 barrels per day. The transport sector alone consumes more than 50% of the total oil consumption in the country [10].

1.1 EMISSION STANDARDS IN INDIA

Bharat stage emission standards are emission standards instituted by government of India to regulate the output of air pollutants from internal combustion engine equipments, including motor vehicles. The standards and the timeline for implementation are set by the central pollution control board under the ministry of environment & forests. The first emission norms were introduced in India in 1991 for petrol vehicles and in 1992 for diesel vehicles followed by making the catalytic converter mandatory for petrol vehicles and introduction of unleaded petrol in the market. The standards, based on European regulations were first introduced in 2000. All new vehicles manufactured after the implementation of the norms have to be compliant with the regulations.[2] Since October 2010, Bharat stage III norms have been enforced across the country. In 13 major cities, Bharat stage IV emission norms are in place since April 2010. [3], include phasing out of 2 stroke engine for two wheelers, the stoppage of production of Maruti 800 & introduction of electronic controls have been due to the regulations related to vehicular emissions. [4]. While the norms help in bringing down pollution levels, it invariably results in increased vehicle cost due to the improved technology & higher fuel prices.

1.1.1 Emission norms for Passenger Cars

Norms	CO(g/km)	HC+ NOx(g/km)
1991Norms	14.3-27.1	2.0(only HC)
1996 Norms	8.68-12.40	3.00-4.36
1998Norms	4.34-6.20	1.50-2.18
India stage 2000 norms	2.72	0.97
Bharat stage-II	2.2	0.5
Bharat Stage-III	2.3	0.35(combined)
Bharat Stage-IV	1.0	0.18(combined)

1.1.2 Emission norms for Heavy Diesel vehicles

Norms	CO(g/kmhr)	HC (g/kmhr)	NOx (g/kmhr)	PM(g/kwhr
1991Norms	14	3.5	18	-
1996 Norms	11.2	2.4	14.4	-
India stage 2000 norms	4.5	1.1	8.0	0.36
Bharat stage-II	4.0	1.1	7.0	0.15
Bharat Stage-III	2.1	1.6	5.0	0.10
Bharat Stage-IV	1.5	0.96	3.5	0.02

1.1.3 Emission Norms for 2/3 wheeler

Norms	CO(g/kmhr)	HC+ NOx)(g/km)
1991Norms	12-30	8.12(only HC)
1996 Norms	4.5	3.6
India stage 2000 norms	2.0	2.0
Bharat stage-II	1.6	1.5
Bharat Stage-III	1.0	1.0

1.2 Vehicular pollution and its influence on indoor air quality

Studies have showed that on an average a person spends approximately 90% of his time indoors, it is easy to understand that the most important environment in relation to our health is the indoor environment [11]. The General mass is not aware that the air inside their home is more polluted than outdoor atmosphere. The worst thing about vehicular pollution is that it cannot be avoided as the vehicular emissions are emitted at the near-ground level where we breathe contributing serious health effects and buildings near emissions take place are also affected. This is particularly true for Indian megacities such as Delhi where world's second highest levels of particulate matter (PM) have been reported [14,15,16]. If the outdoor concentration of air pollutants is already high that could deteriorate the IAQ. Several studies have indicated the associations between traffic-related and the indoor air quality (IAQ) [12,13]. The vehicle population is growing rapidly and due to vehicles exhaust not only urban air quality is getting affected but also indoors.

The concentrations of air toxic pollutants near heavily trafficked roads, as well as the pollutant composition and characteristics, differ from those measured distant from heavily trafficked roads. Homes located very close to large volumes vehicles traffic demonstrate their levels of exposure to air pollutants [17,18]. In both indoor and outdoor air, concentrations of PM10, SO_2 and NO_2 significantly increased with increasing traffic density [19]. It is noticed that air pollution from traffic emission depends on traffic flow, traffic levels, infrastructure design, driving patterns, street configuration, vehicular characteristics, land use activities and the local meteorological characteristics govern the ability of the atmosphere to disperse air pollutants. Several studies have shown the significant difference of PM_{10} and NO_2 levels at the highest and the lowest traffic areas [20, 21, 22, 23, 24]. The effects of air pollution include breathing and respiratory problems, aggravation of existing respiratory and cardiovascular disease, alterations in the body defense systems against foreign materials, damage to lung tissue, carcinogenesis and premature death [25,26]. Elderly adults living within 50 m of a major road or within 100 m of a freeway were found to have significantly increased risk of death due to cardiopulmonary causes in European studies [27,28]. A number of epidemiologic studies have reported associations between residential proximity to busy roads and a variety of adverse respiratory health outcomes in children, including respiratory symptoms, asthma exacerbations, and decrements in lung function [29,30]. Exposure to high levels of nitrogen dioxide can trigger attacks of shortness of breath and wheezing [31].

1.3 Present study and its need

Present study was undertaken to determine the status of indoor air quality due to vehicular concentration at different sites of Aligarh city, Aligarh is medium sized city located in fertile tract of Ganga-Yamuna doab in north India in the western part of the Uttar Pradesh. In India very little quantitative data of air pollution in small cities like Aligarh are available at present moment and whatever data are available is only for 12 metropolitan cities. It was examined that indoor air pollution in developing countries as a major health challenge [32]. The indoor air pollutants are risk factor of a number of diseases and poor health, such as acute respiratory tract infection (ARI), chronic obstructive pulmonary disease (COPD), low birth weight, cataract, blindness especially in developing countries [33]. Women and children spend most of their time indoors, but still more importance is given for monitoring of outdoor air pollutants. The present study though of limited scope of short duration may through some light on the air quality status.

1.4 OBJECTIVE

To determine the concentration of major pollutants nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and suspended particulate matter (SPM) in indoor environment resulting from outside due to traffic. Measure to prevent and/or remediate the problems of indoor pollution have also been suggested.

2.0 MATERIALS AND METHOD

2.1 Location of Sampling Stations

Present study was undertaken to determine the status of indoor air quality due to vehicular concentration in different highways/ bypass of Aligarh city. It lies between the parallels of 27° 28´ and 28° 10´ north latitude and 77° 29´ and 78° 36´ east longitude. As per provisional reports of census India, population of Aligarh in 2011 is 872,575; of which male and female are 463,123 and 409,452 respectively. The main concern of the study is to determine the concentration of sulphur dioxide (SO_2), nitrogen dioxide (NO_2), suspended particulate matter at different highways/bypass entering into the Aligarh city with the help of Kimoto air handy sampler HS-7. The following strategic locations were selected at highways/bypass which is surrounding the Aligarh city.

Kwarsi Chauraha: This highway located at the outskirt of Aligarh city connecting Atrauli road, Kwarsi bypass road with moderate traffic. Generally traffic increases in the evening.

Eta Road: It is connecting Aligarh city to Eta district, it is surrounded by commercial cum residential area. This road experience light vehicles as well as heavy vehicles like trucks, roadways buses.

Sasni Gate Chauraha: Population density around Sasni gate chauraha is quite high. From Sasni gate chauraha, roads are deflected towards Mathura and Agra. The traffic density is quite high along these route and often experience traffic jam in the evening. This road experience light vehicles as well as heavy vehicles like trucks, roadways buses. It is residential cum commercial area.

Sarsaul Chauraha: From Sarsaul chauraha roads deflect towards Khair bypass, Firdaus nagar bypass (in Aligarh city) and Delhi. This route connects various districts of Uttar Pradesh like Buland shaher, Muzaffar nagar, Meerut as well as districts of Uttarakhand. It experiences very heavy traffic including trucks and roadways buses going/coming towards/from Delhi, Bulandshaher, Meerut and districts of Uttarakhand. This is residential cum commercial area.

3.0 SAMPLING AND ANALYSIS

For present study the samples were collected from residential homes which are located at highways/urban roadways exposed to vehicular emission. 8 sampling locations were selected which were residential houses.

The study was carried out in the last September and beginning of October month and the levels of pollutants like NO_2, SO_2, and SPM were observed. For sampling of NO_2, SO_2 and SPM Handy sampler HS-7 was used for 8-hours from 12:00 NOON to 8 PM. Standard method was followed given by Central Pollution Control Board (CPCB) for sampling and analysis of NO_2, and SO_2. Normally the sampler was kept at the first room of the house from the entrance or at first floor of the house facing towards road.

3.1 Suspended Particulate Matter

Suspended Particulate Matter was collected by means of a Kimoto Air Handy Sampler HS-7. Instrument was calibrated properly and flow rate was adjusted more than 1.2 l/min (usually 1.5 l/min). Whatman 37 mm filter papers were used to collect SPM levels, these filters were weighed before and after exposure to obtain the SPM levels. The difference of the weight of the filter paper divided by the total volume of air sucked gave the concentration of SPM present in the indoor air.

Calculation of Volume of Air Sampled

$V = QT$

V = Volume of air sampled in m**3**

Q = Average flow rate in m**3**/minute

T = Total sampling time in minute

Calculation of PM10 in Ambient Air

$$PM10 = \frac{(W\mathbf{f} - W\mathbf{i}) \times 10\mathbf{6}}{V}$$

PM10 = Mass concentration of particulate matter less than 10 micron diameter in µg/m³

Wi = Initial weight of filter in g.

Wf= Final weight of filter in g.

V = Volume of air sampled in m³

106 = Conversion of g to µg.

3.2 Sulphur dioxide

The sulphur dioxide concentrations were determined at the impingent rate above 1 l/min but not more than 2.2 l/min through wet chemical method classified as " West and Gaeke" method . Sulphur dioxide from air is absorbed in a solution of potassium tetrachloromercurate (TCM). A dichlorosulphitomercurate complex, which resists oxidation by the oxygen in the air, is formed. The complex is made to react with para-rosaniline and formaldehyde to form the intensely colored pararosaniline methylsulphonic acid. The absorbance of the solution is measured by means of a suitable spectrophotometer at 560 nm after allowing 30 minutes for full color development. The concentration of SO_2 was read out from a standard curve prepared by using standard solution of sodium metabisulphite.

The Concentration of SO_2 in µg/m³ in the sample is calculated as follows:

$$C(SO_2\ \mu g/m^3) = \frac{(A - A_o) \times 10^3 \times B}{V}$$

A - Sample absorbance
Ao - Reagent blank absorbance
10^3 - Conversion litres to cubic meters
B - Calibration factor, µg/absorbance
V - Volume of air sampled in liters
Conversion of Micrograms per Cubic Metre to Parts per Million
If desired, the concentration of sulphur dioxide may be calculated as parts per million of sulphur dioxide at reference conditions as follows :
ppm SO_2 = µg SO_2/m^3 x 3.82 x 10-4

3.3 Nitrogen dioxide

NO_2 the nitrogen dioxide concentrations were determined at the impingent rate above 1 l/min but not more than 2.2 l/min through "Modified jacobe and Hoshheiser" method. Nitrogen dioxide (NO_2) is collected by bubbling air through a solution of sodium hydroxide and sodium arsenite. The concentration of nitrite ion (NO_2) produced during sampling is determined colorimetrically by reacting the nitrite ion with phosphoric acid, sulfanilamide, and N (1-naphthyl)- ethylenediamine di-hydrochloride (NEDA) and measuring the absorbance of the highly coloured azo-dye at 540 nm. The concentration of NO_2 was read out from a standard curve prepared by using standard solution of sodium nitrite.
Calculations

Air Volume - Calculate the volume of air samples as follows :

$$V = \frac{F1 + Ff}{2} \times ts \times 10\text{-}6$$

V = Volume of air sample, m^3
F1= Air flow rate before sampling, cm^3/min
Ff= Air flow rate after sampling, cm^3/min
ts= Sampling time, min
10-6 = Conversion of cm^3 to m^3
NO_2 Concentration in Air Sample - Calculate as µg of NO_2 per cubic meter of air as follows :

C (NO_2 µg/m3) = (As – Ab) x CF x Vs/ Va x Vt x 0.82
Where,
C NO_2 = Concentration of Nitrogen dioxide, µg/m3
As = Absorbance of sample
Ab = Absorbance of reagent blank
CF = Calibration factor
Va = Volume of air sampled, m^3
Vs = Volume of sample, ml
Vt = Volume of aliquot taken for analysis, ml
0.82 = Sampling efficiency
The NO_2 concentration may be calculated as ppm using :
ppm NO_2 = (µg NO_2 /m^3) x 5.32 x 10-4

4.0 RESULTS AND DISCUSSIONS

The observation of indoor air quality status in Aligarh due to vehicular traffic outside with respect to sulphur dioxide, nitrogen dioxide, suspended particulate matter concentration measured from September to October 2012 at 8 sites. The indoor air quality status in Aligarh with respect to Sulphur dioxide. Because no standards were available for inside air in India, the findings were compared with available NIOSH (177) and WHO (178,179) standards which is shown in the table No.1.Threshold limit for airborne contaminants by national institute for occupational safety and health and the World Health Organization.

Sulphur dioxide concentration ranges from 1.97 µg/m³ at Eta road to 24.24 µg/m³ at Atrauli road as shown in Figure No.1. The sulphur dioxide concentrations at all the sampling location were found below the NIOSH & WHO standard (8h weighted mean). The sulphur dioxide concentration at Atrauli road & Kwarsi Chauraha were found to high as compared to another sampling points it might be because of the burning of coal at sweet shop outside the sampling room in which the sampling has been carried out.

Nitrogen dioxide concentration at different sampling points were found to be 8.78 µg/m³ to 24.97 µg/m³ as shown in Figure No. 2. Houses located at highways/ roadways experience high traffic containing higher concentration of nitrogen dioxide due to the emission from heavy and light vehicles. The concentration of nitrogen dioxide in the indoor environment is also influenced by ventilation and presence of heating appliances present in the houses. The nitrogen dioxide concentrations at all the sampling location were found below the NIOSH & WHO standard (8h weighted mean).

SPM concentration ranges from 347 µg/m³ to 2173 µg/m³ as shown in Figure No.3. Suspended particulate matter concentrations were found to be much higher than WHO Threshold limit (100 µg/m³- PM10). In india just because of the poor road conditions, houses located roadside have very high concentration of PM in indoors. In the present monitoring, it was found that PM concentration were very high in the houses located at Sasni Gate Chauraha, Agra Road, Sarsaul Chauraha because of the heavy traffic at these locations also experience traffic jam in the peak hour.

5.0 CONCLUSIONS

Based on the present study which was carried out to measure the indoor air quality of the houses located near highways/ roadways in Aligarh, the following conclusions can be made:

1. The SO_2 concentration in the indoor ranges from 1.97 µg/m³ at Eta Road to 24.24 µg/m³ at Atrauli Road is within the permissible limit of NIOSH and WHO standards (5235.2 mg/m³-8 h).
2. Nitrogen dioxide concentration at different sampling points was found to be 8.78 µg/m³ to 24.97 µg/m³ is within the permissible limit of NIOSH and WHO standards (5644.2 mg/m³-8 h).
3. The SPM concentration in the indoor air was found to be very high which ranges from 347 µg/m³ to 2173 µg/m³ in comparison to WHO and NIOSH standards (100 µg/m³- PM10).
4. Because no standards were available for indoor air in India, the findings were compared with available NIOSH (177) and WHO (178,179) standards. All the gases pollutants were found to be within permissible limit but SPM concentration exceed the permissible limit making it an important pollutant for assessing potential impact.

6.0 RECOMMENDATIONS

1. Controlling sources of pollution and ventilating adequately.
2. Improving the conditions of the road by width expansion like 4 lane, 6 lane road, trees and grass should be planted to avoid pollution.
3. Provision of footpath on the roadside.
4. Emissions from the vehicles should be checked frequently.
5. Use of Public transport system.
6. Avoid overloading of the vehicles.
7. Carpooling to school, work and social events.
8. Concerned city development authoritative should not allow the colonies to crop up adjacent to national highways or roads having heavy traffic.
9. Improvement in the fuel quality.

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Table No.1

Pollutant	Time weighted average concentration (8-h workday)	
	ppm	$\mu g\ m^{-3}$
CO	25	28,630
NO_2	3	5644.2
SO_2	2	5235.2
CO_2	1000	1799.6 × 103
NH_3	-	-
H_2S	-	-
PM_{10}	-	100 (70,50,30,20)[a]
PAH	-	0.001
Meteorological Parameters		
RH%	30–80	
Temperature, °C	25.5	
Air movement, ms^{-1}	<0.3	

Figure No. 1

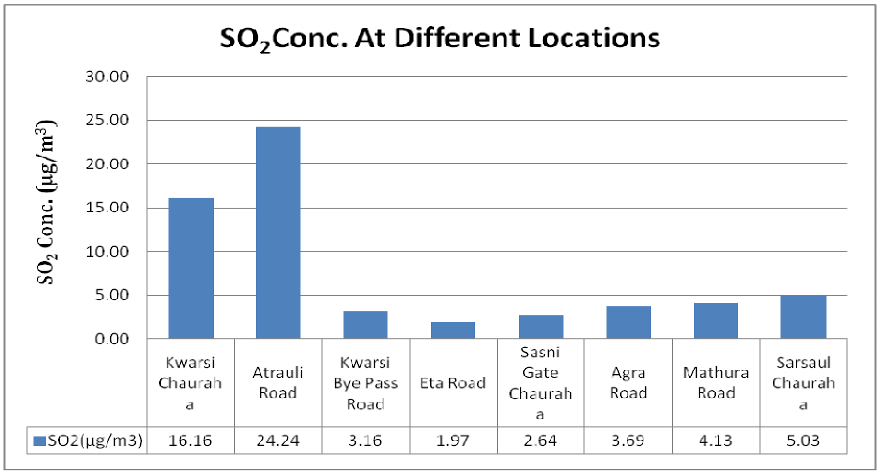

Figure No.2

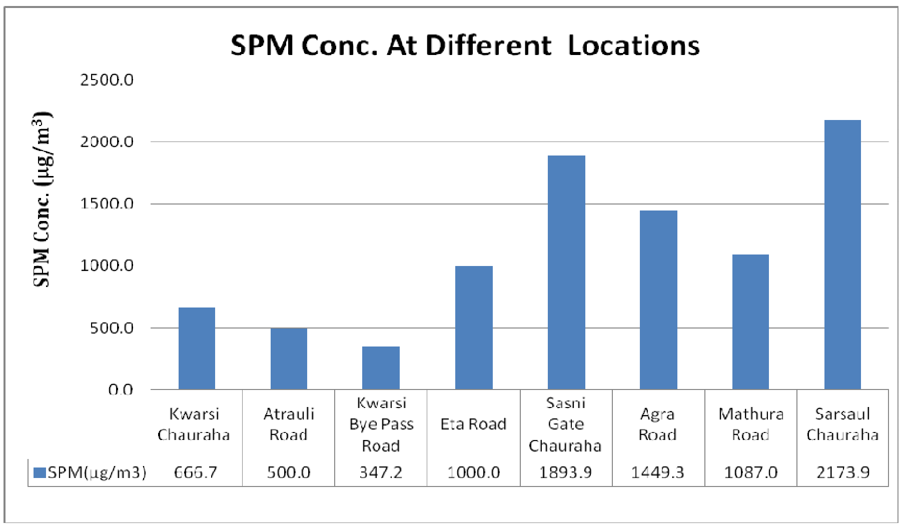

Figure No. 3