Proceedings of the
International Conference on Mechanical Engineering 2009
(ICME2009) 26- 28 December 2009, Dhaka, Bangladesh

ICME09-RT-45

ESTIMATION OF VEHICLE INDUCED EMISSIONS OF SELECTED URBAN AREAS IN DHAKA CITY

Armana Sabiha Huq

Accident Research Institute, BUET, Dhaka, Bangladesh.

ABSTRACT

This study is devoted to assess vehicle induced pollutants (NO_2, CO_2 and SO_2) in roadside dust and water from fifteen locations in Dhaka City which is carried out by lab experiments. Variation in estimated values of NO_2, CO_2 and SO_2 are presented in bar chart. Maximum value of NO_2 is found to be 0.21 ppm from road side dust at Sayedabad and minimum value is 0.011 ppm from road side water at Nilkhat areas. Maximum value of CO_2 collected from road side water is found to be 29 ppm at Malibag and minimum value is 3 ppm from road side dust at Nilkhat. The maximum and minimum values of SO_2 is found to be 49 ppm from road side dust at Sayedabad and 2.01 ppm from road side water at Mugdapara respectively. Expectedly it is observed that the estimated values of vehicle induced pollutants (NO_2, CO_2 and SO_2) are higher where traffic stream comprises larger sized vehicles i.e. buses, truck etc. Results suggest that in order to tackle vehicle induced pollutants related environmental problems, both vehicle maintenance practice and fuel system should be improved.

Keywords: Air Pollution, Emission, Assessment, Traffic, Roadside, Dhaka City.

1. INTRODUCTION

An increase in the human population is accompanied with a great increase in the need for the transportation of people and goods, traffic volumes have correspondingly increased. While industrial and domestic emissions have fallen, motor vehicle use has increased, and as a result transportation has rapidly become a dominant source of pollution, particularly in urban environment. Thus the assessment of these emissions to pollution level of urban air is of great interest.

Dhaka City is beset with a number of socio-environmental problems. Of them, increasing emission from the motor vehicles is one of the worst problems posing a serious health threat to the city dwellers. In fact, the main contributor of the deteriorating air quality in city is this transport sector followed by uncontrolled and excessive emission from the huge number of motor vehicles. In addition to the excessive carbon, the amount of other harmful elements like the Suspended Particulate Matter (SPM), SO_x, NO_x were found in an intimidating level and the situation is deteriorating day by day. Vehicle pollutants are now regarded as a greater problem than the coal-related emissions whose concentrations are diminishing (Faiz, A. 1994). Concerns about health effects have been much slower in the developing countries than the developed ones (Watkins, H. 1991). Present situation of Dhaka city due to vehicle emissions are as follow:

- The five major primary pollutants of air, including Suspended Particulate Matters (SPM), SOx, NOx, CO, and Hydrocarbons, account for more than 90 percent of air pollution in the Dhaka City.
- At present Dhaka is the most densely populated city with 12 million people. The life of these people is at stake due to this severe air pollution. About 80 percent of the people are suffering from air pollution related diseases whereas this rate is only 18 percent in the rural areas. The lead level in the blood of the city children is found abnormally high.
- The CO base environmental capacity of vehicles is over-saturated.
- Automobile emissions, particularly unburned carbon, smoke, soot, fumes etc constitute particulate in air. Unburned hydrocarbons and their photochemical reactions involving oxides of nitrogen produce smog.
- A major source of emission of nitrogen oxides is also the exhaust from motorized vehicles.
- The most severe harmful effects of exhaust gas emissions are the formation of tropospheric ozone (O3), photochemical smog, acid rain, vegetation injuries, and effects on human health.

Development of efficient Transport-Environment interaction requires rigorous planning, appropriate methodology and finally broader technical backup e.g. software related to Transport-Environment interaction which helps to assess the impact of vehicle emissions from numerous source types. The purpose of this paper is to assess the effect of vehicle emissions on the environment.

The Specific Objective of proposed paper is to estimate the concentration of vehicle emissions (SO_2, NO_2, and CO_2) in roadside Dust and Water at different locations in Dhaka City.

2. METHODOLOGY

According to the objective, the measurement procedure for concentration of CO_2, NO_2 and SO2 are described bellow:

2.1 Procedure for Estimation of the Concentration of Carbon Dioxide

Reagent:

- Phenolphalein indicator
- Standard N/44 NaOH

Apparatus:

- Beaker : 2 pc
- Measuring Cylinder : 1 pc
- Dropper : 1 pc
- Stirrer : 1pc
- Burette : 1pc

Procedure:

- 100 ml of sample was taken into a beaker & same quality of distilled water into another beaker. 10 drops of Phenolphalein indicator were added into each beaker, (if a pink color develops, no CO2 is present in the sample), otherwise, we have to go to the next step. CO2 was present in the collected sample.
- N/44 NaOH solution was added from a burette to the sample & it was stirred gently until a slight permanent pink color appears as compared with the distilled water. The ml of NaOH used was recorded.

Calculation:

CO_2 (mg/L) = (Multiplying Factor * ml. of N/44 NaOH added)

Where,

MF = normality of NaOH * equivalent weight of CO2 * 1000/ (ml. of sample taken)

Concentrations of SO2 & NO2 are measured by Hach DR/4000 U Spectrophotometer which are as follows:

2.2 Procedure for Estimation of the Concentration of Nitrite

Diazotization Method (Using Powder Pillows) USEPA Approval, (May 1, 1979): In Hach DR/4000 U Spectrophotometer, the estimated detection limit for programs 2610 and 2620 are 0.0008 and 0.004 mg/L NO_2^- - N, respectively.

Reagent:

- One NitriVer 3 Nitrite Reagent Powder Pillow

Procedure:

- The soft key under HACH PROGRAM was pressed. The stored program number was selected for low rang nitrite by pressing 2610 with the numeric keys.
- The display was shown: HACH PROGRAM: 2610 NITRITE, LR. The wavelength (λ), 507 nm was automatically selected.
- A sample cell with 10ml of sample was filled.
- The contents of one NitriVer 3 Nitrite Reagent Powder Pillow were added. Stopper. The cell was shaken to dissolve. (A pink color was developed which indicated the presence of nitrite)
- The soft key under SHIFT TIMER was pressed.
- When the timer was beeped (after 20 minutes reaction time), a second sample cell with 10 ml of sample (the blank) was filled. Then the blank was placed into the cell holder.
- The soft key under ZERO was pressed. Then the display was shown: 0.0000 MG/L NO2- - N.
- The stopper was removed. The prepared sample was placed into the cell holder. Then the light shield was closed. Finally the result in mg/L nitrite nitrogen (NO2- - N) was displayed.

2.3 Procedure for Estimation of the Concentration of Sulfur Dioxide

Methylene Blue Method USEPA Approval, (May 1, 1979): In Hach DR/4000 U Spectrophotometer, the estimated detection limit for program 3500 is 800µg/L S^{2-}.

Reagent:

- Sulfide 1
- Sulfide 2

Procedure:

- The soft key under HACH PROGRAM was pressed. The stored program number was selected for sulfide (S2-) by pressing 3500 with the numeric keys.
- The wavelength dial was rotated until the small display was shown: 665 nm. Then the display was quickly shown: ZERO SAMPLE. Then: mg/L S2-.
- A clean sample cell was filled with 25 ml of sample.
- A second sample cell was filled with 25ml distilled water.
- 1 ml of Sulfide 1 Reagent was added into each cell. Swirled to mix.
- 1 ml of Sulfide 2 Reagent was added into each cell. Swirled to mix.
- The soft key under SHIFT TIMER was pressed.
- When the timer was beeped (after 5 minutes reaction time), the blank was placed into the cell holder. Then the light shield was closed.
- The soft key under ZERO was pressed. Then the display was shown: 0.0000 MG/L S2-.
- The prepared sample was immediately placed into the cell holder. Then the light shield was closed. Finally the result in mg/L sulfide (S2-) was displayed.
- Estimated amount of sulfide reacted with oxygen to form SO2.

3. EXPERIMENTAL RESULTS AND ANALYSIS

From the experimental lab test, variation in estimated values of NO_2, CO_2 and SO_2 in road side water are presented in Table 1 and Fig 1a to Fig 1c. Besides, Table 2 and Fig 1d to 1f shows variation of the concentration of NO_2, CO_2 and SO_2 in road side dust.

Table 1: Vehicle emissions in road side water

Locations	Concentration of Nitrogen-dioxide (NO_2) in ppm	Concentration of Carbon-dioxide (CO_2) in ppm	Concentration of Sulfur-dioxide (SO_2) in ppm
Naya Palton	0.08	15.5	10.15
Segun Bagicha	0.10	18.0	11.00
Bijoy Nagar	0.091	17.0	13.00
Motijheel Ba. Bank	0.12	22.1	12.10
Rajar Bagh	0.015	13.0	3.11
Shahjahanpur	0.106	23.0	10.00
Khilgaon R. Crossing	0.113	20.0	10.03
Mugdapara	0.012	14.1	2.02
Azimpur	0.011	15.0	2.10
Nilkhate	0.011	15.3	1.90
Newmarket	0.05	16.0	50.00
Malibag	0.10	29.0	16.00
Sayadabad	0.09	25.0	15.00
Jatrabari	0.013	12.6	5.03
Bokshi Bazar	0.095	16.9	3.01

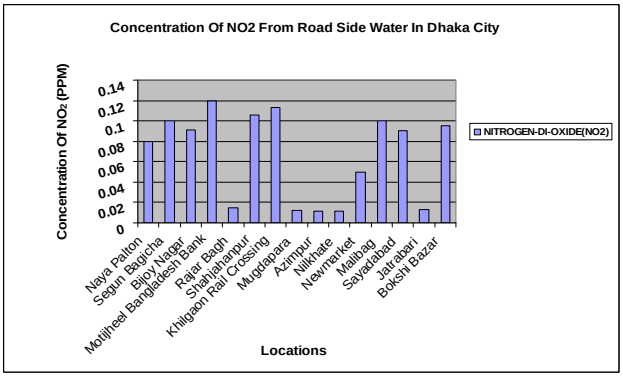

Fig 1a. Concentration of NO2 from Road Side Water at Different Locations in Dhaka City

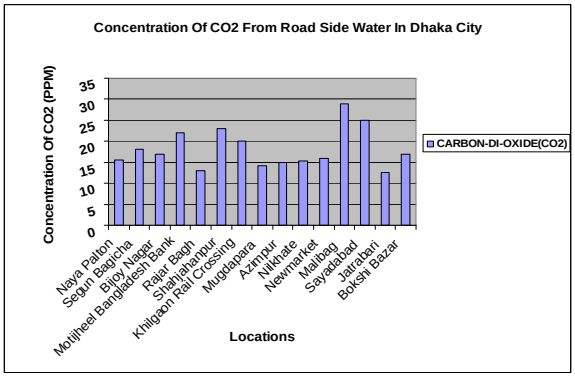

Fig 1b. Concentration of CO2 from Road Side Water at Different Locations in Dhaka City

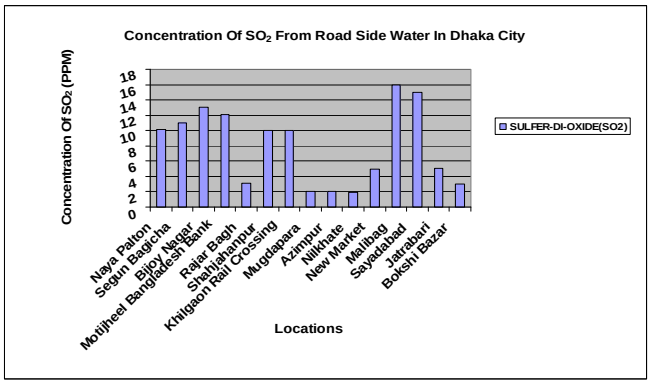

Fig 1c. Concentration of SO_2 from Road Side Water at Different Locations in Dhaka City

From Fig. 1a to 1c, among fifteen observed locations in and around Dhaka City, the concentration of NO_2 found in Road Side Water ranges from 0.011 to 0.12 ppm. The concentration of CO_2 in Road Side Water ranges from 12.6 to 29.0 ppm where as measured concentration of SO_2 varies from 5.03 to 16.0 ppm.

Close observation of Fig. 1a to 1c reveals that road side water collected from Bangladesh Bank areas contains maximum concentration of NO_2 and water collected from Azimpur areas shows minimum concentration of NO_2. From the same Figures it is also observed that maximum and minimum concentrations of

both CO_2 and SO_2 are found in road side water gathered from the Malibug and Jatrabari areas respectively.

In this study the previous mentioned analysis is also made for road side dust collected from different selected locations of Dhaka City. The results on variation in estimated values of NO_2, CO_2 and SO_2 in road side dust are presented in Table 2 and Fig 1d to Fig 1f. From close observation of Table 2, it is evident that the concentrations of NO_2, CO_2 and SO_2 range from 0.109 - 0.21 ppm, 3.0 – 6.2 ppm and 19.4 – 49.0 ppm respectively for different locations of study area.

Table 2: Emissions of vehicles from road side dust in dhaka city

Locations	Concentration of Nitrogen-dioxide (NO_2) in ppm	Concentration of Carbon-dioxide (CO_2) in ppm	Concentration of Sulfur-dioxide (SO_2) in ppm
Naya Palton	0.11	3.8	29.0
Segun Bagicha	0.12	4.1	32.5
Bijoy Nagar	0.13	4.2	36.0
Motijheel B. Bank	0.16	5.0	42.0
Rajar Bagh	0.13	4.0	20.2
Shahjahanpur	0.15	4.0	31.0
Khilgaon R. Crossing	0.20	4.5	45.0
Mugdapara	0.20	4.1	46.1
Azimpur	0.11	3.1	21.0
Nilkhate	0.109	3.0	19.4
Newmarket	0.15	3.4	21.3
Malibag	0.15	5.0	30.2
Sayadabad	0.21	6.0	49.0
Jatrabari	0.20	6.2	48.3
Bokshi Bazar	0.19	3.8	41.1

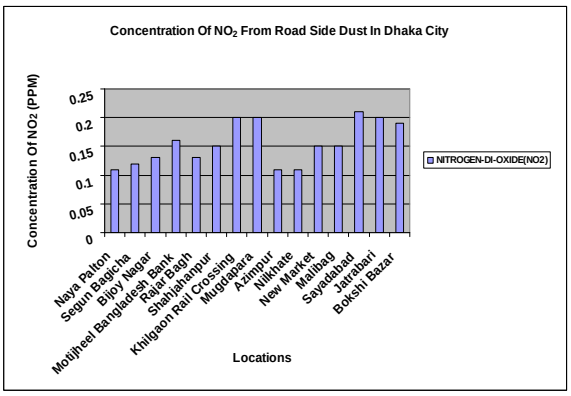

Fig 1d. Concentration of NO_2 from Road Side Dust at Different Locations in Dhaka City

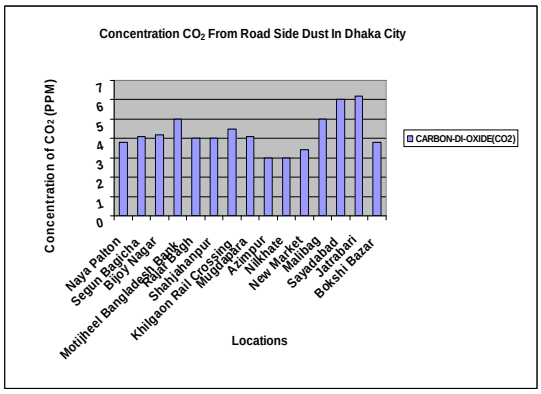

Fig 1e. Concentration of CO_2 from Road Side Dust at Different Locations in Dhaka City

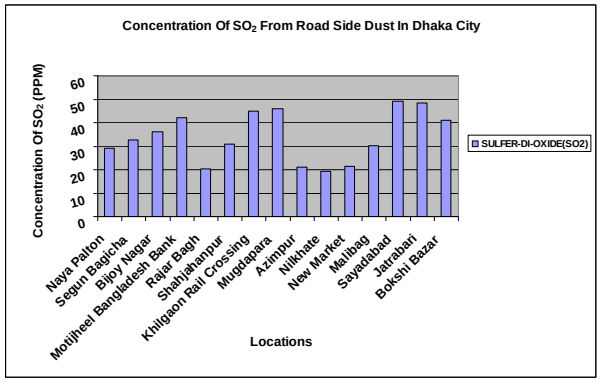

Fig 1f. Concentration of SO_2 from Road Side Dust at Different Locations in Dhaka City

Fig. 1d to Fig. 1f shows that the maximum and minimum concentrations of NO2 and SO2 in road side dust are observed at Saydabad and Nilkhet areas respectively. Whereas, the maximum and minimum concentration of CO_2 are found in Jatrabari and Nilkhet areas respectively.

Therefore, from the above analysis it is observed that the maximum value of NO_2 is 0.21 ppm from road side Dust at Sayedabad and minimum value is 0.011 ppm from road side water at Nilkhat. Maximum value of CO_2 is 29 ppm from road side Water at Malibag and minimum value is 3 ppm from road side Dust at Nilkhat. Maximum value of SO_2 is 49 ppm from road side Dust at Sayedabad and minimum value is 2.01 ppm from road side water at Mugdapara.

4. CONCLUSIONS

This paper was motivated by poor environmental pollution situation prevailing in Dhaka City. Although there exist plethora of opinions regarding improvement of the situation, only few studies had been done on this issue. Due to the lack of scientific and engineering basis, most of the measures undertaken in order to assess the situation failed to produce desired result. In fact, to improve the situation a comprehensive planning is required incorporating various planning options and analyzing their impacts. In this research work attempt had been made to investigate on vehicle induced pollutants (NO_2, CO_2 and SO_2) from dust and water collected from different locations of Dhaka City. Details of analyses results are presented in the earlier section. On the basis of the analyses, summary of important findings and recommendations for future probable research study are presented in the following section.

4.1 Findings of the Paper

From investigation on vehicle induced pollutants like NO_2, CO_2 and SO_2 collected from fifteen different locations of Dhaka City reveals that:

- Maximum value of NO2 is 0.21 ppm in road side dust at Sayedabad and minimum value is 0.011 ppm from road side water at Nilkhat.
- Maximum value of CO2 is 29 ppm in road side water at Malibag and minimum value is 3 ppm from road side Dust at Nilkhat.
- Maximum value of SO2 is 49 ppm in road side dust at Sayedabad and minimum value is 2.01 ppm from road side water at Mugdapara.

The above finding suggests that the estimated values of vehicle induced pollutants (NO2, CO2 and SO2) are higher where traffic stream comprises larger sized vehicles i.e. buses, truck etc. Which definitely implies that to tackle vehicle induced pollutants related environmental problems, besides congest management both vehicle maintenance practice and fuel system should be improved.

5. RECOMMENDATIONS

In Bangladesh air pollution monitoring is a very recent phenomenon. Therefore, extensive study on this topic is essential. This is a multi-disciplinary topic. Therefore, people of different disciplines like Engineers, Chemists, Doctors, Geologists, Botanists, etc. should be engaged to this particular study. Undoubtedly, this study has many limitations in terms of data collections, coverage and assumptions. Consequently, in order to acquire better assessment of the impact of vehicle emissions, the study should consider the following suggestions:

- The further study should be like that estimation of the distance of how far a sophisticated building (Hospital, residential are, schools etc) should be installed from roadside to reduce the severity of affected people from air pollution.
- For analyzing the impacts of vehicle emissions a comprehensive planning is essential to incorporate various planning options.
- Reliable and sophisticated equipments should be procured to collect various pollutant concentrations from vehicle emission. Moreover, data should be collected instantaneously.
- Along with vehicle emission estimation, more comprehensive studies should be carried out to find out the effects of changes in the air pollution.
- It is recommended that for mitigation of vehicular emission problems the 3Es approach should be persuaded. Besides Engineering study, both Educational and Enforcement measures ought to be taken to build general awareness among the public as well as to warn the polluters.

6. REFERENCES

1. Faize, A., Walsh, M.P. and Weaver, C.S. (1996), "Air Pollution from Motor Vehicle", The World Bank (WB), Washington, D.C.
2. Watkins, H. (1991), "Air Pollution from Road Vehicle", TRRL, State of the Art Review, U.K.
3. EPA publication, http://www.epa.vic.gov.au.
4. Huq, A.S. (2006), "Assessment of Vehicle Induced Pollution by Indirect Measurement in Dhaka City", B.Sc. Engineering Thesis, Department of Civil Engineering, BUET, Dhaka.
5. Raw, S. (1994), "Environmental Pollution Engineering", Wiley Western Limited.

7. MAILING ADDRESS

Armana Sabiha Huq
Junior Research Fellow/Lecturer,
Accident Research Institute, BUET
Dhaka, Bangladesh.