

Assessment of Gaseous Pollutants and Particulate Matters in Air of Different Industrial Locations of Khulna Division

Md. Khorshed Ali¹, M. Jamaluddin Ahmed²

Abstract— Khulna City is the second port city of Bangladesh. Various Industries are located in Khulna Division. That's why a study plan was undertaken to measure the gaseous pollutants level in the air and also study the atmospheric particulate matters in different industrial locations of Khulna Divisions. Atmospheric pollutants like gaseous (SO₂, NO₂), particulate matters (SPM) were determined in different urban locations of Khulna Division in the month of August, 2008 to February, 2009. Nine different sampling stations of Khulna Division such as British American Tobacco, GLT Plant, Kushtia , Vera Mara Power Station, Kushtia, Akter Agro and Fertilizer In. Ltd , Nitol Cement Factory, Avoy nagor, Jessore , Ahab Jute Mill , Baliadanga , Jessore, BRB Cable In. BSCIC Kushtia , Kiam Metal In. BSCIC Kushtia, Kiam Metal In. BSCIC Kushtia , Khorshed Metals Industries, BSCIC, Shiromoni, Khulna , Nishung Jute Mill, Magura were selected for sample collection. The maximum concentrations of SPM was observed in British American Tobacco, GLT Plant, Kushtia (East Side) the value was 288 μgm^{-3} . The maximum concentrations of SO₂ and NO₂ was observed in Khorshed Metals Industries, BSCIC, Shiromoni, Khulna and the values were 56.8 μgm^{-3} and 63.94 μgm^{-3} respectively. The lowest concentrations of SPM was observed in Residential Area, 1.5 Km southwest from , Vera Mara Power Station, Kushtia and the value was 89.20 μgm^{-3} . The lowest concentrations of SO₂ and NO₂ was observed in Residential Area, 1.5 Km southwest from Vera Mara Power Station, Kushtia and the values were 7.90 μgm^{-3} and 10.10 μgm^{-3} respectively. The values of SPM, SO₂ and NO₂ in air of above locations of Khulna Division are lower than that of TLV value recommended by WHO and DoE. Comparatively the air of Khulna Division is less polluted.

¹ Assistant Professor, Department of Civil Engineering, UITS
E-mail: khorshed.chem@gmail.com

² Professor, Department of Chemistry, University of Chittagong.
E-mail: pmjahmed55@gmail.com

Assessment of Gaseous Pollutants and Particulate Matters in Air of Different Industrial Locations of Khulna Division

Keywords: *Khulna Division; air pollution; particulate matter; gaseous pollutants.*

1. INTRODUCTION

We can not see air, but air is all around us. Surrounding us is a thick layer of air called atmosphere. It is like a blanket around the earth. It extends to several hundred kilometers above the earth. We know that air is necessary for life. Without air, there would be no life on earth.

Air pollution is the introduction of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organisms, or damages the natural environment, into the atmosphere. The atmosphere is a complex, dynamic natural gaseous system that is essential to support life on the planet Earth. Stratospheric ozone depletion due to air pollution has long been recognized as a threat to human health as well as to the earth's ecosystems¹.

Air pollution is a serious problem in many parts of the world. Air is a life sustaining precious natural resource. Fresh air is one of the most indispensable gifts of nature without which mankind cannot survive. But this air becomes polluted by various natural and anthropogenic activities². Air pollution problem is very serious issue because it has effect on human health, climate change, visibility reduction as well as atmospheric chemistry. However, air pollution has received priority among the environmental issues in Asia as well as in other parts of the world. Exposure to air pollution is the main environmental threat to human health in many towns and cities. Air pollution today is virtually slow poisoning humankind all over the world particularly in the urban centers like Dhaka, Bangkok, Katmandu, Delhi, Islamabad, Karachi etc. The reason of such pollution is fall out of consumerist human civilization, which has encouraged rampant industrialization, the swift increase in automobiles and rapid urbanization³.

The meteorological variables (a. wind speed and direction, b. insulation (amount of sunlight), c. mixing depth and d. precipitation) also have impact on the severity of the air pollution problem are given⁴. Atmospheric dilution occurs because of wind circulation or atmospheric turbulence caused by local sunshine. Air pollutant can be removed from the atmosphere by precipitation, different physical and chemical reactions, and also due to the gravitational forces. Aerosol residence times in the atmosphere are 6-12 days from the lower troposphere; 2-4 weeks for the upper troposphere⁵.

Many small industries set up in rural areas are also causing air, water and land pollution. Problem of portable water supply and sanitation is causing health hazards and biological contamination of the environment in both urban and rural areas. Conversion of forest and wetlands into poor quality agricultural land is a major problem in many parts of the country⁶. The air quality standards are different for residential, industrial, commercial, and sensitive areas. In the Tejgaon industrial area the maximum concentration of suspended particles was $1,849\mu\text{gm}^{-3}$ (January 1997) as opposed to the allowable limit of $500\mu\text{gm}^{-3}$. Usually the maximum concentration of air pollution in Dhaka is during the dry months of December to March⁷.

These oxides of nitrogen may remain in the atmosphere for several days and during this time chemical processes may generate nitric acid, nitrates and nitrites as particles. These oxides of nitrogen play a major role in the chemical reactions, which generate photochemical smog⁸. Other impacts from ozone include damaged vegetation and reduced crop yields⁹. An increase of nitrous oxide concentration in atmosphere may also lead to a decrease in the stratospheric ozone concentration which may also affect surface temperature¹⁰.

The major health concerns associated with exposure to high concentrations of Sulfur dioxide (SO_2) include effects on breathing, respiratory illness, alterations in pulmonary defenses, and aggravation of existing cardiovascular disease. SO_2 contributes to respiratory illness, particularly in children and the elderly, and aggravates existing heart and lung diseases. EPA encourages communities to learn about the types of industries in their communities and to work with local industrial facilities to address pollution control equipment failures or process upsets that could result in peak levels of SO_2 ¹¹. Long-term exposure to sulfur dioxide can cause respiratory illness, alter the lung's defense mechanisms, and aggravate existing cardiovascular disease. People with cardiovascular disease or chronic lung disease, as well as children and older adults, may be most susceptible to these effects¹².

Particulate matter has a direct effect on health as a result of respiration, because of the small size of the particles and the effect of heavy metals on biochemical mechanisms, especially because the metals can be bio-accumulated. Fine particles are more easily transported large distances and can stay in the air for a long time, depending on meteorological conditions and the size distribution¹³.

Numerous scientific studies have linked particles pollution exposure to a variety of problem including- increased respiratory symptoms, such as irritation of the airways, coughing or difficult breathing, decrease lung

Assessment of Gaseous Pollutants and Particulate Matters in Air of Different Industrial Locations of Khulna Division

function, aggravated asthma, development of chronic bronchitis, irregular heart beat, non-fatal heart attacks, premature death in people with heart and lung diseases, children and older adults are the most likely to be attacked by particle pollution exposure ¹⁴.

It has been estimated that exposure to fine particulate matter in outdoor air leads to about 100000 deaths (and 725,000 years of life lost) annually in Europe¹⁵.

In addition, if the particle consists of a mixture of purely scattering material such as ammonium sulfate and partially absorbing material such as soot, the cooling versus heating effect depends on the manner in which two substances are mixed through out the particle pollution ^{16, 17}.

The worst pollutant affecting the mega cities as a whole is suspended particulate matter (SPM), particularly amongst mega cities in the continent of Asia. The sources of SPM are varied and can include natural sources such as wind blown dust from desert areas and the generally more toxic SPM from man-made sources such as power generation, motor vehicles (particularly diesel) and industrial processes. The three megacities meet WHO guidelines are those which have undergone large scale control measures to reduce man-made SPM.

Khulna Division, one of the seven Divisions of Bangladesh, is located in the south-west of the country. It has an area of 22,274 sq. km. and a population of 14.47 million. Its headquarters is Khulna city in Khulna District. Khulna is the third largest city in Bangladesh. It is located on the banks of the Rupsha and Bhairab rivers in Khulna District. It is the Divisional headquarters of Khulna Division and a major industrial and commercial center. It has a seaport named Mongla on its outskirts, 38 km from Khulna City. The population of the city, under the jurisdiction of the City Corporation, was 855,650 in 2007. The wider Statistical Metropolitan Area had at the same time an estimated population of 1,388,425.

Like the other big cities of Bangladesh, notably Dhaka and Chittagong, Khulna is undergoing a major transformation, due to its immensely growing population and its status as Bangladesh's third largest city. Because of its strategic location of only 45 km from the port of Mongla, Khulna is considered as being a port city like Chittagong. 25% of all trade handled in Bangladesh passes through Mongla, while the rest goes

through Chittagong. Khulna is also known as the city of Shrimps, because 75% of all shrimps exported from Bangladesh are cultivated in the Khulna zone. In addition to this, a major portion of the Golden Fiber (Jute) is exported through Khulna Zone. Khulna has the largest shipyard of Bangladesh. Khulna Shipyard is operated by Bangladesh Navy. Khulna has some heavy and medium type industries like Khulna Hardboard Mills, Bangladesh Oxygen Company, Khulna Oxygen Company, Platinum Jubilee Jute Mills, Star Jute Mills, and Dada Match Factory. Khulna is famous for its fish and seafood industries. Khulna has a very good transport system with links to all the districts of Bangladesh.¹.

2. EXPERIMENTAL

Sampling impinger for the respective gases was used to sample the atmospheric gaseous contents. High Volume Air Sampler in the selected areas from morning to evening (8 hours) was placed for the purpose. Respirable dust sampler was used for the collection of atmospheric particulate matters. Particulate matters were measured gravimetrically with digital OHAUS modern balance. UV/VIS-spectrophotometric technique was adopted for the determination of SO_x and NO_x content by using Beer's Law.

2.1. Sampling Area:

There are Nine important sampling locations in Khulna Division had been chosen for the collection of the air sample. These are-

- ▶ British American Tobacco, GLT Plant, Kushtia,
- ▶ Nitol Cement Factory, Avoy nagor, Jessore,
- ▶ Vera Mara Power Station, Kushtia,
- ▶ Akter Agro and Fertilizer In. Ltd
- ▶ Kiam Metal In. BSCIC Kushtia,
- ▶ Ahab Jute Mill , Baliadanga, Jessore
- ▶ BRB Cable In. BSCIC Kushtia,
- ▶ Khorshed Metals Industries, BSCIC, Shiromoni, Khulna, and
- ▶ Nishung Jute Mill, Magura

Assessment of Gaseous Pollutants and Particulate Matters in Air of Different Industrial Locations of Khulna Division

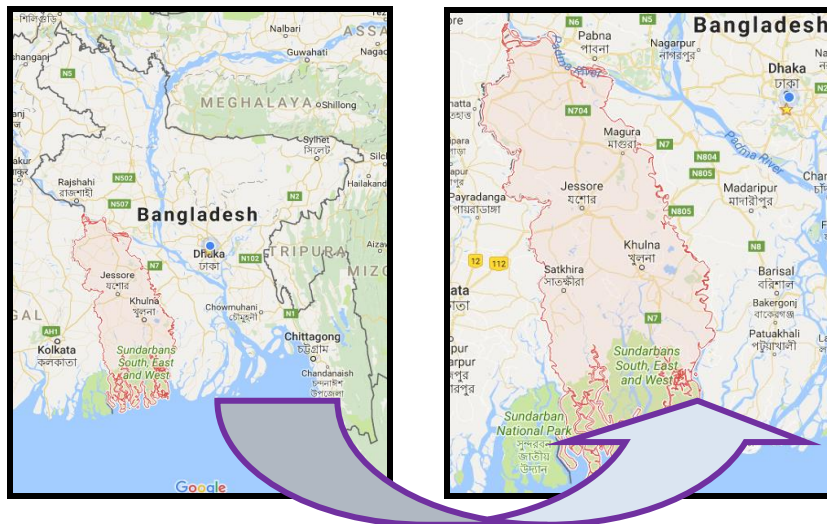


Figure 1. Map of Bangladesh showing the location of Khulna Division.

The all sampling operation was carried out from morning to evening for eight hours. Weather conditions are very sunny in all sampling locations.

A high volume sampler equipped with an impringer was used for the collection of NO_2 samples. The impringer contained 20 mL sodium solution as absorbing solutions. This absorbing solution was prepared before taking into the impringer. When the high volume sampler was started then this absorbing reagent started to absorb the NO_2 samples. After completing the eight hours sampling the solution were taken into the laboratory for the measurement of the concentration of NO_2 in air. The amount of Nitrogen dioxide was then estimated by the color produced when hydrogen peroxide, sulfanilamide and NEDA solution added by spectrophotometrically. The sampling time may vary from a few minutes to 24 hours. For 24 hours sampling absorber should capable of holding 20 mL or more of absorbing reagent. For best time sampling time and rate should be chosen to provide a concentration of approximately 2 to 4 L of sulfur dioxide in 10 mL of absorbing reagent.

For the collection of SO_2 samples, the impringer contained 20 mL tetrachloromercurate solution as absorbing solutions. This absorbing solution was prepared before taking into the impringer. When the high volume sampler was started then this absorbing reagent started to absorb

the SO₂ samples. After completing the eight hours sampling the solution were taken into the laboratory for the measurement of the concentration of SO₂ in air. The absorbing reagent containing SO₂ to form a stable dichlorosulfitomercurate solution. The amount of sulfur dioxide was then estimated by the color produced when pararosaniline hydrochloride was added to the solution.

2.2. Procedure for the Determination of SO₂

2.2.1. Sample Collection

The sampling time may vary from a few minutes to 24 hours. For 24 hours sampling absorber should capable of holding 20 mL or more of absorbing reagent. For best time sampling time and rate should be chosen to provide a concentration of approximately 2 to 4 μ L of sulfur dioxide in 10 mL of absorbing reagent.

A high volume sampler equipped with an impringer was used for the collection of SO₂ samples. The impringer contained 20 mL tetrachloromercurate solution as absorbing solutions. This absorbing solution was prepared before taking into the impringer. When the high volume sampler was started then this absorbing reagent started to absorb the SO₂ samples. The all sampling operation was performed for eight hours in different locations in air of Chittagong city. After completing the eight hours sampling the solution are taken into the laboratory for the measurement of the concentration of SO₂ in air. The absorbing reagent containing SO₂ to form a stable dichlorosulfitomercurate solution. The amount of sulfur dioxide was then estimated by the color produced when pararosaniline hydrochloride is added to the solution.

2.2.2. Preparation of Sample (SO₂) for Analysis

Absorbing solution (0.1 M sodium tetrachloromercurate):

27.2g (0.2 mole) mercuric chloride and 11.7 g (0.2 mole) sodium chloride was dissolved in 1 liter of deionized water. (Caution: - Highly poisonous if spilled on skin, flush off with water immediately). This solution may be stored at room temperature for several months.

Assessment of Gaseous Pollutants and Particulate Matters in Air of Different Industrial Locations of Khulna Division

Pararosaniline hydrochloride (0.04%):

0.20g of pararosaniline hydrochloride was dissolved in 100mL of deionized water and filtered the solution after 48 hours. This solution is stable for at least 3 months if stored in the dark and kept cool. Pipetting 20 mL of this into a 100 mL volumetric flask. And 6 mL of concentrated hydrochloric acid was added. It was allowed to stand for 5 minutes, and then dilute to mark with deionized water. This solution should be pale yellow with a greenish color. It may be stored at room temperature in an amber bottle for a week or for about 2 weeks if refrigerated.

Formaldehyde solution (0.2%):

5 mL of 40 percent of formaldehyde solution was diluted to one liter with deionized water.

Sodium sulfite solution:

640 mg of sodium metabisulfite was added in 1 liter of water. This yields a solution of approximately of 0.40 mgL^{-1} as SO_2 . The solution should be standardized by titration with standard 0.01 N iodine with starch as indicator and should be adjusted to 0.0123 N. Then 1 mL is equivalent to $150 \mu\text{L}$ of sulfur dioxide. It should be prepared freshly when needed.

Starch solution:

A thin paste of 1.25 g of soluble starch and 0.006 g mercuric iodide was prepared in cold water and poured into 500 mL of boiling water while stirring, boiling was continuing for several minutes. Finally it was stored into glass stoppered bottle.

2.2.3. General Procedure

The determination of sulfur dioxide in the atmosphere, the measured air sampled is drawn through a solution of sodium tetrachloromercurate. The sulfur dioxide is absorbed by formation of the dichlorosulfitomercurate (II) complex ion $\text{HgCl}_2\text{SO}_3^{2-}$. This complex resists oxidation by oxygen from the air and it reacts with formaldehyde

and pararosaniline in acid solution to form a pararosanilinemethylsulfonic acid, which is highly colored and absorbs at 560 nm. This method is sensitive and relatively free from interference. Metal traces such as iron and manganese interfere and, if they are not removed as particulates by pre-filtration, their interference is eliminated by adding a chelating agent such as EDTA to the collection solution. As little as 0.003ppb sulfur dioxide can be measured in the atmosphere.

The samples should be analyzed as early as practicable since the colored complex loses strength approximately one percent per day. If the samples are to be stored or transported, stoppered glass or polyethylene containers should be used and a correction factor should be applied. Any water lost by evaporation during sampling was replaced by de-ionized water and mixed thoroughly. Sample was prepared as the standard for calibration curve and absorbance was taken.

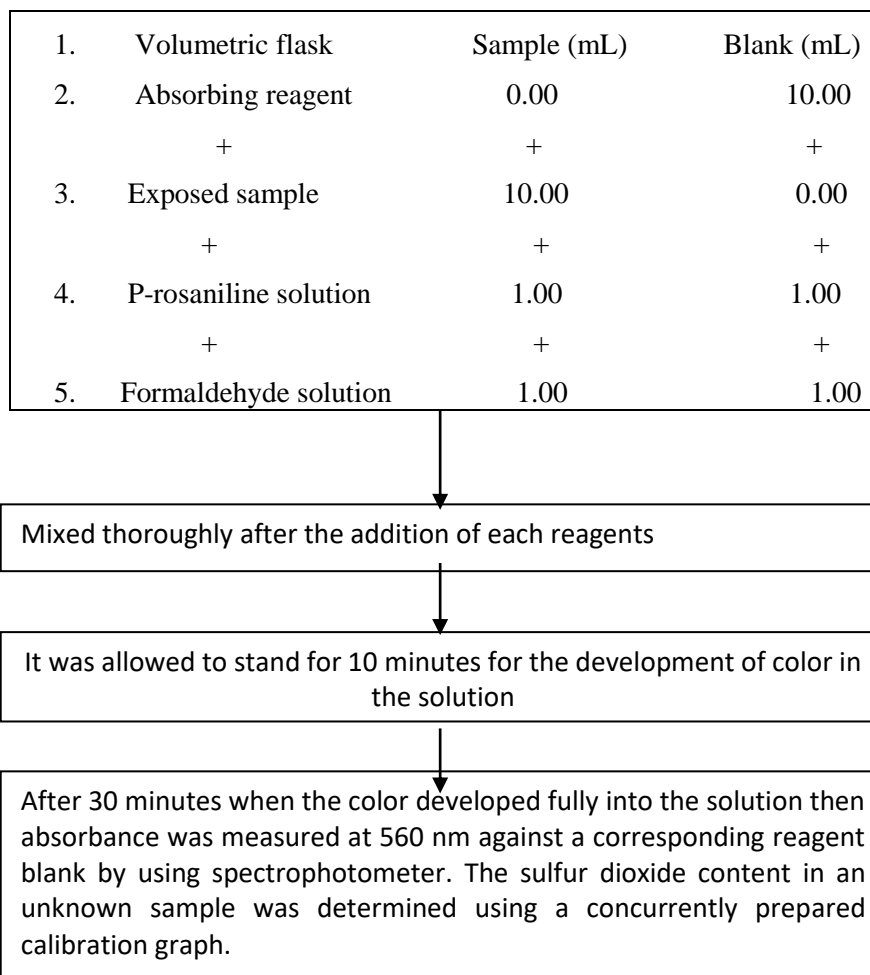
If mercury precipitate was present, it was removed by filtration or centrifugation. To the clear sample adjusted to 10mL with deionized water to compensate for evaporation losses, 1.00mL of p-rosaniline solution and 1.00mL of the formaldehyde solution was added and mixed well. The complete analysis has been given in the following.

2.2.4. Blank Preparation

In the blank preparation 10 mL of unexposed tetrachloromercurate solution was taken in a volumetric flask, added 1.00 mL of p-rosaniline and 1.00mL of formaldehyde solution. If the collecting reagents remain exposed to the atmosphere during the interval between sampling and analysis, the blank should be exposed in the same manner.

The analysis of sulfur dioxide is outlined in the following Flow chart (Figure-2)¹⁸

Assessment of Gaseous Pollutants and Particulate Matters in Air of Different Industrial Locations of Khulna Division



Calculation:

Figure 2. Flow chart of the steps for the analysis of sulfur dioxide (Blank)¹⁸

The calculation of the volume of air sampled is as follows:

$$V_s = \frac{F_1 + F_2}{2} \times T \times 10^{-6}$$

Where,

V_s = volume of air sampled, (m³)

F_1 = measured flow rate before sampling, (mLmin⁻¹)

F_2 = measured flow rate during sampling, (mLmin^{-1}), and

T = time of sampling, (min.)

Again the calculation of the concentration of sulfur dioxide as follows:

The microliters of sulfur dioxide in the sample by multiplying the absorbance by the slope of the calibration plot. Then the concentration of sulfur dioxide in air is:

$$\text{Mass of sulfur dioxide in } \mu\text{gm}^{-3} = \frac{\mu\text{L of SO}_2 \times 20}{V_s}$$

2.2.5. Calibration Curve

The preparation of calibration curve for the determination of sulfur dioxide is outlined in the following Flow chart (Figure-3)¹⁸.

1	Volumetric flask (10mL)	1 Blank	2	3	4	5
		+	+	+	+	+
2	Sulfite solution	0.00mL	0.5mL	1.0mL	1.5mL	2.0mL
		+	+	+	+	+
3	Absorbing reagent	10.0mL	9.5mL	9.0mL	8.5mL	8.0mL
		+	+	+	+	+
4	P-rosaniline	1.0mL	1.0mL	1.0mL	1.0mL	1.0mL
		+	+	+	+	+
5	Formaldehyde	1.0mL	1.0mL	1.0mL	1.0mL	1.0mL

Mixed thoroughly after the addition of each reagent.

It was allowed to stand for 10 minutes for the development of color in the solution

After 30 minutes when the color developed fully into the solution then absorbance was measured at 560 nm against a corresponding reagent blank by using spectrophotometer.

Assessment of Gaseous Pollutants and Particulate Matters in Air of Different Industrial Locations of Khulna Division

↓

6	Absorbance	0.0	0.033	0.054	0.074	0.094
7	Concentration	0.0	0.530	0.91	1.260	1.700

Figure 3. Flow chart of the calibration curve for the determination of sulfur dioxide¹⁸.

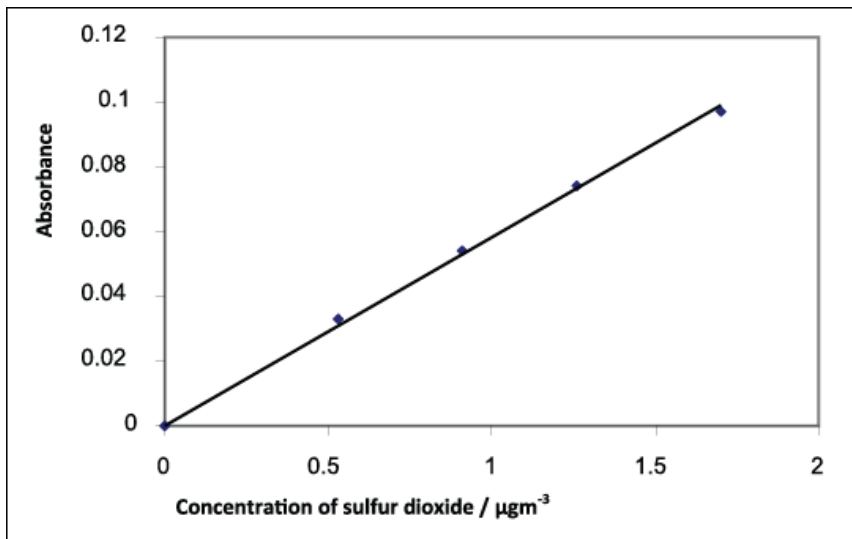


Figure 4. Calibration curve for the determination of sulfur dioxide¹⁸.

2.3. Procedure for Determination of NO₂

2.3.1. Sample collection Sampling:

The sampling train included the absorber, critical flow control device and pump. 50 mL absorbing reagent added to the absorber. Disconnect the funnel, insert calibrated flowmeter, and measure flow before sampling. If flow rate before sampling is less than 85 percent of needle calibration, check for leak or change filters as necessary. At the end of the sampling period for 8 hours the flow rate was measured.

Calibration of flowmeter:

Using a wet test meter and a stopwatch, determine the rates of airflow (mLmin⁻¹) through the flow meter at several ball positions.

Calibration of hypodermic needle:

The calibrated flowmeter was connected, the needle to be calibrated, and the source of vacuum in such a way that the direction of airflow through the needle is the same as in the sampling train.

A high volume sampler equipped with an impringer was used for the collection of NO₂ samples. The impringer contained 20 mL sodium solution as absorbing solutions. This absorbing solution was prepared before taking into the impringer. When the high volume sampler was started then this absorbing reagent started to absorb the NO₂ samples. The all sampling operation was performed for eight hours in different locations in air of Chittagong city. After completing the eight hours sampling the solution are taken into the laboratory for the measurement of the concentration of NO₂ in air. The amount of Nitrogen dioxide was then estimated by the color produced when hydrogen peroxide, sulfanilamide and NEDA solution added by spectrophotometrically.

2.3.2. Preparation of Sample (NO₂) for Analysis

Absorbing reagent:

4.0 g of sodium hydroxide was dissolved in deionized water and dilute to 1000 mL.

Sulfanilamide:

20g of sulfanilamide was dissolved in 700 mL of deionized water, and mixing with 50 mL concentrated phosphoric acid (85%) and dilute to 1000 mL. This solution was stable for a month if refrigerated.

N (1-naphthyl) ethylenediamine dihydrochloride::

0.5g of N (1-naphthyl) ethylenediamine dihydrochloride was dissolved in 1000 mL deionized water. This solution is stable for a month if refrigerated and protected from light.

Hydrogen peroxide:

0.2 mL of 30% hydrogen peroxide dilute to 250 mL with deionized water. The solution may be used for a month if protected from light.

Assessment of Gaseous Pollutants and Particulate Matters in Air of Different Industrial Locations of Khulna Division

Standard nitrite solution:

Sufficient desiccated sodium nitrite was dissolved and dilute with deionized water to 1000 mL so that a solution containing 1000 μ g NO₂ per mL is obtained. The amount of sodium nitrite to use was calculated as follows:

$$G = \frac{1.50}{A} \times 100$$

Where,

G = amount in g of sodium nitrite

1.50 = gravimetric factor in converting NO₂ into sodium nitrite and

A = assay, percent.

2.3.3. General Procedure

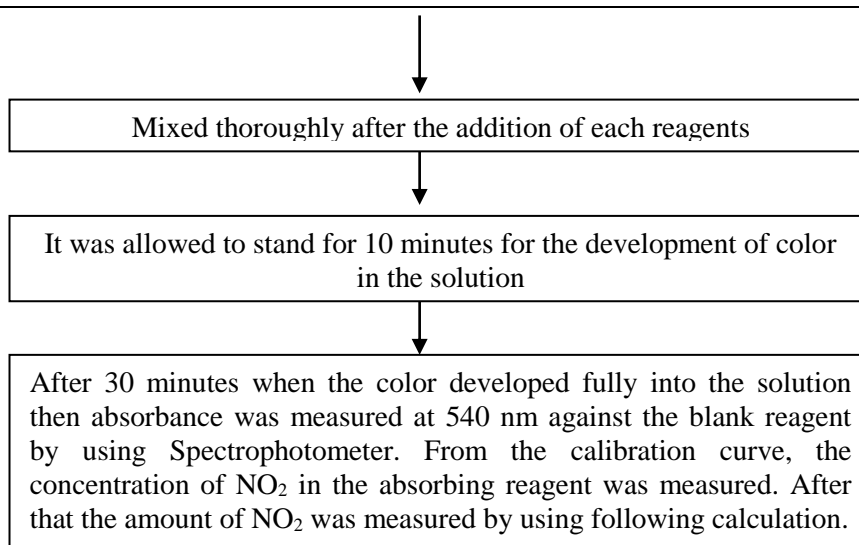
Nitrogen dioxide is collected by bubbling air through a sodium hydroxide solution to form a stable solution of sodium nitrite. The nitrite ion produced during sampling is determined colorimetrically by reacting the exposed absorbing reagent with phosphoric acid, sulfanilamide, and N (1-naphthyl) ethylenediamine dihydrochloride. The method is applicable to collection of 24 hours samples in the field and subsequent analysis in the laboratory. The general procedure for the determination of nitrogen dioxide mention in the following.

2.3.4. Blank Preparation

In the blank preparation 10 mL of unexposed sodium hydroxide solution was taken in a volumetric flask, added 1.00 mL of hydrogen peroxide, 10.00mL of sulfanilamide solution, and 1.40 mL NEDA solution with thorough mixing after the addition of each reagent. After 10 minute color will be developed. If the collecting reagents remain exposed to the atmosphere during the interval between sampling and analysis, the blank should be exposed in the same manner. The procedure for the analysis of nitrogen dioxide mentioned in the following.

The analysis of nitrogen dioxide is outlined in the following Flow chart (Figure-5)¹⁸ :

	Sample (mL)	Blank (mL)
1. Volumetric flask		
2. Absorbing reagent	0.00	10.00
	+	+
3. Exposed sample	10.00	0.00
	+	+
4. Hydrogen peroxide solution	1.00	1.00
	+	+
5. Sulfanilamide solution	10.00	10.00
	+	+
6. NEDA Solution	1.40	1.40



Calculation:

Figure 5. Flow chart of the steps for the analysis of nitrogen dioxide (Blank)¹⁸

Calculation:

The calculation of the volume of air sampled is as follows:

$$F_1 + F_2$$

Assessment of Gaseous Pollutants and Particulate Matters in Air of Different Industrial Locations of Khulna Division

$$V_s = \frac{V_1 F_1 + V_2 F_2}{F_1 + F_2} \times T \times 10^{-6} \quad 2$$

Where,

V_s = volume of air sampled, (m^3)

F_1 = measured initial flow rate before sampling, ($mLmin^{-1}$)

F_2 = measured final flow rate during sampling, ($mLmin^{-1}$), and

T = time of sampling, (min.)

Again the calculation of the concentration of nitrogen dioxide as follows:

The micro liters of nitrogen dioxide in the sample by multiplying the absorbance by the slope of the calibration plot. Then the concentration of nitrogen dioxide in air is:

$$\text{Mass of Nitrogen dioxide in } \mu\text{gm}^{-3} = \frac{\mu\text{L of NO}_2 \text{ mL}^{-1} \times 20}{V_s \times 0.35}$$

Where,

20 = volume of absorbing reagent used in sampling (mL)

V_s = volume of air sampled (m^3)

0.35 = overall average efficiency.

2.3.5. Calibration Curve

The preparation of calibration curve for the determination of nitrogen dioxide mentioned in the following Flow chart (Figure 6):

1	Volumetric flask (25mL)	1	2	3	4	5
		Blank+	+	+	+	+
2	Nitrite solution	0.0mL+	2mL+	4mL+	6mL+	8mL+
3	Absorbing reagent	10.0mL+	8mL+	6mL+	4mL+	2mL+
4	Hydrogen peroxide	1.0mL+	1.0mL+	1.0mL+	1.0mL+	1.0mL+
5	Sulfanilamide	10.0mL+	10.0mL+	10.0mL+	10.0mL+	10.0mL+
6	NEDA	1.4mL	1.4mL	1.4mL	1.4mL	1.4mL

↓

Mixed thoroughly after the addition of each reagent.

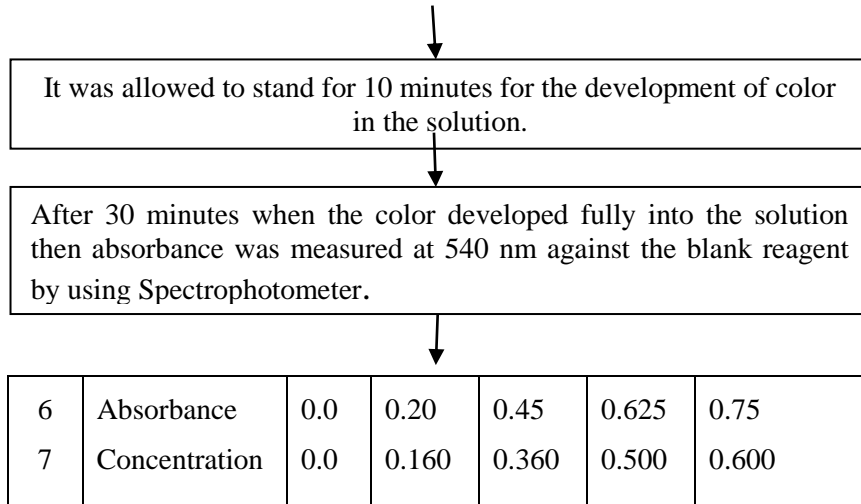


Figure 6. Flow chart of the calibration curve for the determination of nitrogen dioxide¹⁸.

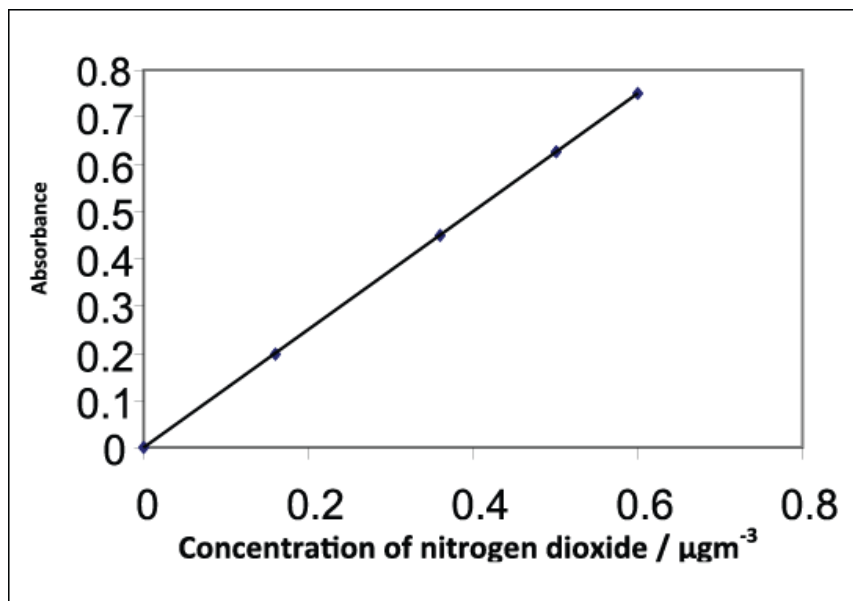


Figure 7. Calibration curve for the determination of nitrogen dioxide¹⁸.

Assessment of Gaseous Pollutants and Particulate Matters in Air of Different Industrial Locations of Khulna Division

2.3.6. Procedure for the Determination of SPM

2.3.6.1. Sample collection

SPM sample was collected in a filter paper by using high volume sampler (Envirotech). A filter paper was set up in the upper portion of the high volume sampler. The high volume air sampler was used to pump the large volume air into the absorber. When high volume air sampler was started then it started to pump air samples and SPM are stored in the filter paper. Before setting the filter paper in the upper portion of the high volume sampler, the initial weight of filter paper was taken by analytical balance. After completing the sampling the final weight of filter paper was taken by using the same balance. The amount SPM was obtained from difference of above two results. SPM was determined by the following calculation.

Calculation

$$\text{SPM in } \mu\text{gm}^{-3} = \frac{(\text{FFW}-\text{IFW}) \times 10^6}{\frac{(\text{IMR} + \text{FMR})}{2}} \times (\text{FTR}-\text{ITR}) \times 60$$

Where,

IFW = Weight of initial filter paper.

FFW= Weight of final filter paper.

IMR = Initial manometer reading.

FMR= Final manometer reading.

ITR = Initial time reading.

FTR = Final time reading.

3. RESULTS

Table. 1. Air Quality Analysis of different Industrial locations in Khulna Division.

(all units are in μgm^{-3})

Date	Sampling Location	SPM	SO₂	NO₂
27.08.08	British American Tobacco, GLT Plant, Kushtia (West Side)	267	31.44	44.44
27.08.08	British American Tobacco, GLT Plant, Kushtia (East Side)	288	27.14	39.23
28.08.08	British American Tobacco, GLT	334	23.33	40.22

UTS Journal of Science & Engineering Volume: 6, Issue: 1

	Plant, Kushtia (North Side)			
28.08.08	British American Tobacco, GLT Plant, Kushtia (South Side)	273	33.17	43.22
16.02.09	British American Tobacco, GLT Plant, Kushtia (West Side)	233	25.17	31.29
16.02.09	British American Tobacco, GLT Plant, Kushtia (East Side)	247	17.07	22.17
17.02.09	British American Tobacco, GLT Plant, Kushtia (North Side)	229	20.19	29.29
17.02.09	British American Tobacco, GLT Plant, Kushtia (South Side)	240	23.22	33.29
Average		263.875	25.092	35.394
04.09.08	Residential Area, 1.5 Km southwest from , Vera Mara Power Station, Kushtia	96.15	8.2	10.6
05.09.08	Residential Area, 1.5 Km southwest from , Vera Mara Power Station, Kushtia	89.2	7.9	10.1
06.09.08	Ferrighat Near Residential Area, 1.5 Km southwest from, Vera Mara Power Station, Kushtia	100.15	8.9	12.7
Average		95.167	8.333	11.133
12.12.08	Ahab Jute Mill, Baliadanga, Jessore	180.76	15.88	27.71
06.12.08	Akter Agro and Fertilizer In. Ltd	150.76	29.79	32.35
06.12.08	Nitol Cement Factory, Avoy nagor, Jessore	255.34	23.85	29.68
12.01.09	BRB Cable In. BSCIC Kushtia	116.19	32.64	41.45
12.01.09	Kiam Metal In. BSCIC Kushtia	125.19	48.58	53.19
13.01.09	Khorshed Metals Industries, BSCIC, Shiromoni, Khulna	175.19	56.8	63.94
24.01.09	Nishung Jute Mill, Magura	200.4	17.91	29.32

Assessment of Gaseous Pollutants and Particulate Matters in Air of Different Industrial Locations of Khulna Division

4. DISCUSSIONS

The average concentrations of NO₂ were found 44.44, 39.23, 40.22, 43.22, 12.70, 10.60, 10.10, 11.80, 32.35, 29.68, 27.71, 41.45, 53.19, 63.94, 29.32, 31.29, 22.17, 29.29 and 33.29 µgm⁻³ respectively in the air of different locations of Khulna Division. In these average values the maximum value 63.94 µgm⁻³ (Table 1 and Fig 9) was found at Khorshed Metals Industries, BSCIC, Shiromoni, Khulna . The lowest value was 10.10 µgm⁻³ found at Residential Area, 1.5 Km Southwest from, Vera Mara Power Station, Kushtia.

In both cases the concentration of SO₂ and NO₂ were found lower with comparing the annual standard value of recommended by Department of Environment (DoE) , Bangladesh and WHO Guideline values in 24 hours average time Table 2. The concentration of the gaseous pollutants NO₂ at different locations of Khulna Division has been shown in the Table 1. The average variation of concentrations of NO₂ at different locations of Khulna Division also shown in Table 1 and Figure 9. The average concentrations of SO₂ were found 31.44, 27.14, 23.33, 33.17, 8.90, 8.20, 7.90, 11.8, 29.79, 23.85, 15.88, 32.64, 48.58, 56.8, 17.91, 25.17, 17.07, 20.19 and 23.22 µgm⁻³ in the above locations are shown in Table 1. The maximum concentrations of SO₂ was observed in Khorshed Metals Industries, BSCIC, Shiromoni, Khulna and the values were 56.8 µgm⁻³. The lowest concentrations of SO₂ was observed in Residential Area, 1.5 Km Southwest from, Vera Mara Power Station, Kushtia and the values were 7.90 µgm⁻³ respectively. In both cases the concentrations were found much lower with comparing the annual DoE standard value (100 µgm⁻³) for Bangladesh and WHO Guideline values in 24 hours average time. The concentration of the gaseous pollutants SO₂ at different locations of Khulna Division has been shown in the Table 1. The average variation of concentrations of SO₂ at different locations in Khulna Division also shown in Figure 10.

The suspended Particulate Matters (SPM) were measured in different industrial locations in ambient air of Khulna Division. The concentrations of SPM were found 267,288, 334,273, 95.05, 96.15, 89.20, 100.15, 150.76, 255.34, 180.76, 116.19, 125.19, 175.19, 200.4, 233, 247, 229 and 240 µgm⁻³ for all sampling locations in Khulna Division as shown in Table 1 and Figure 8, which was lower than the daily average given by WHO.

The maximum concentration of SPM was observed in British American Tobacco, GLT Plant, Kushtia (East Side) the value was $288\mu\text{g}\text{m}^{-3}$. The lowest concentrations of SPM were observed in Residential Area, 1.5 Km Southwest from Vera Mara Power Station, Kushtia and the value was $89.20\mu\text{g}\text{m}^{-3}$. The concentration of SPM in maximum sampling station in Khulna Division is lower than the DoE value. The concentration of SPM in Khulna Division air has shown in Table 1. The Average variation of SPM concentrations has been shown in Figure 8

Table. 2. The Comparison of gaseous pollutants with standard data set. (all units are in $\mu\text{g}\text{m}^{-3}$).

Pollutants	Period	WHO ($\mu\text{g}\text{m}^{-3}$)	DoE ($\mu\text{g}\text{m}^{-3}$)	Current Research ($\mu\text{g}\text{m}^{-3}$)								
				British American Tobacco, GLT Plant, Kushtia	Vera Mara Power Station, Kushtia	Akter Agro and Fertilizer In. Ltd	Nitol Cement Factory, Avoy nagor, Jessore	Ahab Jute Mill, Baliadanga, Jessore	BRB Cable In. BSCIC Kushtia	Kiam Metal In. BSCIC Kushtia	Khorshed Metals Industries, BSCIC, Shiromoni, Khulna	Nishung Jute Mill, Magura
SO ₂	8 hrs	125	150	25.092	8.333	29.79	23.85	15.88	32.64	48.58	56.8	17.91
NO ₂	8 hrs	120	100	35.394	11.133	32.35	29.68	27.71	41.45	53.19	63.94	29.32
SPM	8 hrs	500	200	263.875	95.167	150.76	150.76	180.76	116.19	125.19	175.19	200.4

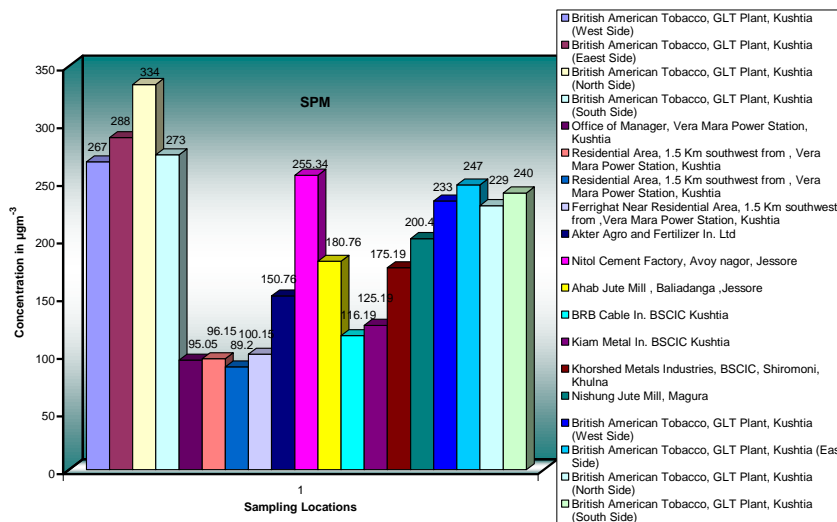


Figure 8. Variation of average concentration ($\mu\text{g}\text{m}^{-3}$) of SPM at the different locations of Khulna Division.

Assessment of Gaseous Pollutants and Particulate Matters in Air of Different Industrial Locations of Khulna Division

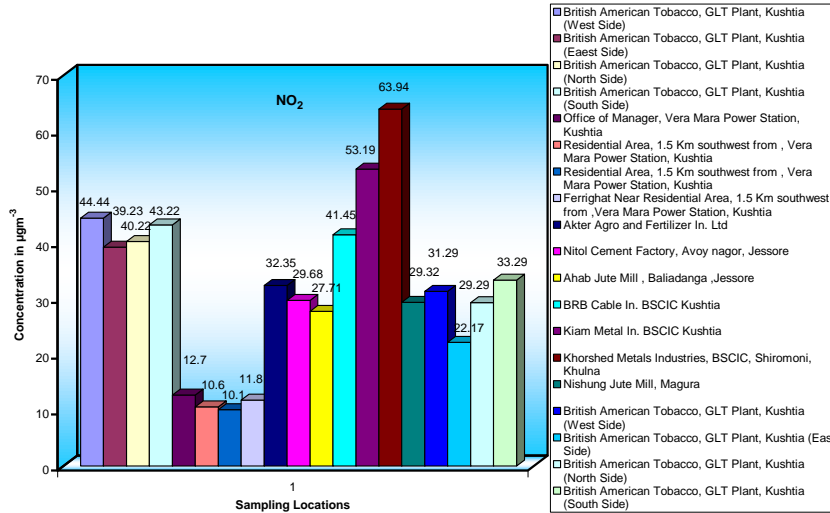


Figure 9. The variation of average concentrations (μgm^{-3}) of NO_2 in air of Khulna Division.

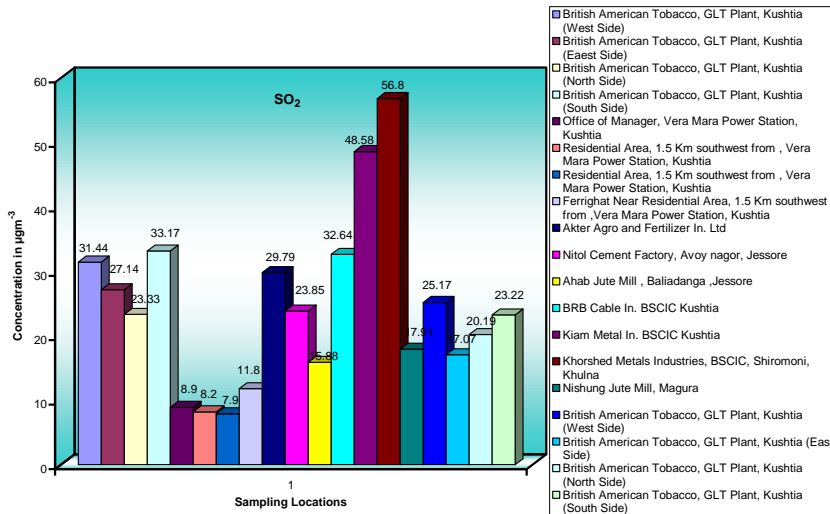


Figure 10. The variation of average concentrations (μgm^{-3}) of SO_2 in air of Khulna Division.

5. CONCLUSIONS

Industrial smoke, motor vehicles, especially two-stroke engine vehicles are an increasingly important source of air pollution emissions in Khulna Division. Further understanding of the sources of air pollution, the

contribution of various industries to air pollution emissions, and the characteristics of industrial emission control measures are necessary to design a cost effective action plan. It is recommended that government will undertake actual measurement of emission factors, complete the emission inventory, and conduct an investigation on emission control measures. Everyone contributes to National and Global emissions of pollutant gases, but it is not only governments that can take action to reduce the environmental damage caused. The cumulative energy reductions by individuals would reduce the need for energy consumption, conserve stocks of raw materials such as coal, oil and gas, and bring about a reduction in pollutant gas emissions.

The values of SPM, SO₂ and NO₂ in air of the discussed locations of Khulna Division are lower than that of TLV value recommended by WHO and DoE. Comparatively the air of Khulna Division is less polluted. Therefore, it is suggested that though the air of Khulna Division is less polluted, Government of Bangladesh should take proper steps to control the air pollution of Khulna Division. In general, there is only a limited understanding of air quality of air in Khulna Division. Therefore Government has recognized that there is a real need to improve air quality management capacity of Khulna Division.

6. RECOMMENDATIONS

Some recommendations are given for controlling the severe air pollution situation in air of Khulna Division:

- ☞ All types of Industries should be situated far away from public places in Khulna Division.
- ☞ All types of 20 years old diesel vehicles should be banned in Khulna Division by 2017. CNG filling station should be increased.
- ☞ Only covered van type trucks may be allowed to run.
- ☞ Strict enforcement of the laws regarding controlling of environment is necessary for Industrial pollution.
- ☞ Air quality monitoring network should be increased.
- ☞ Public awareness should be increased.
- ☞ Open burning system should be stopped.

Assessment of Gaseous Pollutants and Particulate Matters in Air of Different Industrial Locations of Khulna Division

7. REFERENCES:

1. Jimmy Wales, Wikipedia, **2009**, 08/17/2012.
http://www.en.wikipedia.org/wiki/Air_pollution
2. G. Rahman , M. K. Mojumder and B. Rana, Bangladesh State of Environment Report **2000**, p.101.
3. E. Nahid, “A project report on investigation of the concentration of Airborne particulate matter in Dhaka City Air”
4. H. E. Hesketh; “Understanding and Controlling Air Pollution” (Ann. Arbon. Science Publishers Inc), **1972**
5. H. C. Perkins; Air Pollution (Me, Graw Hill Book Co.), **1974**. p.5.
6. Md. Masud Karim, Traffic pollution in Bangladesh & Metropolitan Dhaka a Preliminary Investigation
7. Sifatul Quader Chowdhury “Bibiligraphy United Nations Environment Programme, State of the Environment of Bangladesh, **2001**”.
8. A. K. De. “Environmental Chemistry”, New age international (P) limited, New Delhi, Fifth Edition, **2000**.
9. Sue Hare, Laura Cresswell, Rebeca Twig, & Joe Buchdahal, “Atmosphere, Climate & Environmental Information Programme” UK, **1999**.
10. H.Y. Ming, Environmental Toxicology, Second Edition, CRC Press LLC, USA, 2005, pp. 36-41.
11. <http://www.epa.gov/air/urbanair/SO2>.
12. <http://www.epa.gov/air/urban/SO2/chfl.html>.
13. M. M. Karim and H. Matsui; “A Mathematical Model of Wind Flow, Vehicle Wake and Pollutant Concentration in Urban Road Microenvironments”, Part I– Model Description, Transportation Research, Part D: *Transport and Environment*, Elsevier Science Ltd. **1998**, 3(2), 81.
14. B. Brunkreef and S.T. Holgate; *Air Pollution and Health*, *Lancet* October **2002**, 360, 934.
15. WHO Regional Office for Europe "Health Aspects of Air Pollution" **2003**.
16. J.T. Kiehl and B.P. Briegleb; The Relative Roles of Sulfate Aerosols and Greenhouse Gases in Climate Forcing. *Science*, **1993**, 260, 311.
17. J.T. Kiehl; Sensitivity of a GCM Climate Simulation to Differences in Continental versus Maritime Cloud Drop Size. *J. Geophys.* **1994**.
18. M. Jamaluddin Ahmed and Md. Khorshed Ali; *Int. J. Res. Chem. Environ.*,2(2), **2012**, 178-187.