Ambient air quality monitoring in Visakhapatnam bowl area

Ch. Durga Prasad
Department of Environmental Sciences
AU College of Science & Technology, Andhra University
Visakhapatnam, India

B. Prasanna Kumar
Department of Environmental Sciences
AU College of Science & Technology, Andhra University
Visakhapatnam, India

P.V.V Prasada Rao
Department of Environmental Sciences
AU College of Science & Technology, Andhra University
Visakhapatnam, India

***Abstract*—The present scrutiny was carried out to know the significance of air pollutant concentrations in Visakhapatnam bowl area. SPM, RSPM, oxides of nitrogen (NO_X) and sulphur dioxide (SO_2), carbon monoxide (CO) collected in eight sites of Visakhapatnam. The locations of sampling stations are in muvvalavanipalem, kancharapalem, naval armament depot, nathayapalem, malkapuram, scindia, one town and jagadamba. The average and range values have also been calculated. It has been observed that the concentrations of the pollutants are high in winter in contrast to the summer season. In the present study, it was perceived that almost all the sites showed SPM and RSPM levels exceeding the anticipated limits as stipulated by Central Pollution Control Board (CPCB) New Delhi. Apart from this the SO_2, NO_X, and CO levels in bowl area were under permissible limits of CPCB.**

Keywords*— *suspended particulate matter (SPM), respirable suspended particulate matter (RSPM), oxides of nitrogen (NOX) and oxides of sulphur (SO2) and carbon monoxide(CO, air pollution, bowl area

I. INTRODUCTION

Air pollution is one of the leading manmade environmental problems that has gained attention since 1950. Among environmental affairs CPCB has evolved a Comprehensive Environmental Pollution Index (CEPI) for 88 study areas with an objective of identifying polluted areas in order to take concerted action and to centrally monitor them at the national level to improve the current status of their environmental segments such as air and water quality, ecological damage and visual environmental circumstances. As per the study of CPCB, Visakhapatnam area was contemplated as critically polluted area, which lies between the latitude 17°43' N and longitude 83°17' E in North Eastern Coast of Andhra Pradesh with a spoon shaped topography ringed by hill ranges on three sides and sea on the other side. The study area is often called as bowl area for assessment of environmental related issues. Visakhapatnam is one of the identified problematic areas in the country due to its vast industrial activities with accessible harbour facilities and other infrastructure. With the establishment of major industries in the core of Visakhapatnam urban area, air pollution problems has become worst and hence the city occupied place in the map of potentially polluted areas. Major habitations and industries are coexisting in the bowl area and active industrialization followed by consequential population and economic growth surrounding industrial nuclei have often serious concern for the environmental deterioration on surrounding areas. Industrial development in Visakhapatnam is conspicuous to urban cluster. It is located in a topographic bowl formed by two hill ranges with peak heights ranging from 1170 to 1603 ft and the area covered is approximately 50 km2. The main reason for degradation of air quality in the cities is the increasing number of road transport, vehicular traffic and industries. This has lead to increase in the concentration of gaseous and particulates pollutants in the ambient air. The study area has major industrial zones like hindustan petroleum corporation limited, coramandel fertilizers, hindustan zinc, bharat heavy plate & vessels limited, hindustan shipyard within the bowl area, additionally to this the other emitting source of pollution like rail networks, road transport corporation, sea port, natural harbour, airport, lies within the bowl area at the same time the predominant winds are from southwest emissions passing through the bowl area and their fate is subjected to the diurnal variations in the air exchange from the land and sea. This paper is an attempt to investigate the air quality status at selected monitoring sites of Visakhapatnam bowl area.

II. SOURCES OF SPM, RSPM, NO_X, SO_2, CO WITHIN THE BOWL AREA

The major sources of SPM, RSPM, NO_X, SO_2 and CO are vehicular emissions, industrial emissions, open combustions, and port handlings.

A. Objectives

- To determine the concentrations of suspended particulate matter (SPM), respirable suspended particulate matter (RSPM), oxides of nitrogen (NO_X) and oxides of sulphur (SO_2) and carbon monoxide(CO) with in the bowl area during winter and summer seasons.
- To identify the polluted sites in study area.

III. STUDY AREA

Visakhapatnam exhibits distinctly three broad relief features two hill ranges forming northern (Kailasa range), southern (Yarada range) borders and Bay of Bengal. Here the mountain valley effect is preventing the dispersion of air pollutants. The Kailas range (Northern hill range) is about 16km long rises directly from the seashore and gradually lengthen west wards culminating in its central highest part at Thomas Folly (506m). Thereafter, it gradually decreases west ward. The Southern hill range known as Yarada also forms an inaccessible boundary running for about 8km from the shoreline in the East-West direction. The head land projects boldly into the sea and forms a cliff. The height of the range gradually increases eastward attaining its maximum at Yarada Konda (358m). Its height decreases westward and ends abruptly. While the coast line of Visakhapatnam by virtue of its SW-NE direction. The stagnation pockets at the land-sea interface lead to the heapup of air pollutants over the city for short periods. To make the study more precise the present study area is divided into industrial, commercial and residential activity zones. To monitor air quality specifically 8 sites were selected and the sampling was carried out for 8hrs for SPM, RSPM, NO_X, and SO_2 at eight sites out of which 1 sea port, 1 residencial, 1 industrial cum residencial, 1 national hi-way, 1 commercial, 1 national hi-way, 2 commercial cum traffic.

IV. MATERIALS AND METHODOLOGY

SPM and RSPM were collected on Whatman glass fiber filters 8 hourly with a flow rate of 1.2 lpm and estimated by gravimetric method. Sulphur-dioxide was determined by West and Geake colorimetric method while the analysis of nitrogen dioxide was done by modified Jacob-Hochhieiser method and carbon monoxide was determined by Non dispersive Infrared (NDIR) Spectroscopy with a sampling flow rate of 0.5 lpm. Meteorological data such as wind speed, wind direction, temperature relative humidity are recorded with respective instruments anemometer, wind vane, hygrometer. For assessing the air quality status air quality exposure index (AQEI) concept has been used it provides accurate and easily understandable information about the levels of air pollution. The air pollution in the city area has been mainly determined by the presence and levels of suspended particulate matter, respirable suspended particulate matter, sulphur oxides, nitrous oxides and carbon monoxide. The present stations were monitored in summer and winter by placing the hi-volume sampler at a height of 3-5m from the ground, 4m from the trees, and 120m from the automobiles. The study was carried out by hi-volume sampler 460 (NL, BL) by sucking the air on to the filter paper for 8hrs with a flow rate of 1.2 lpm.

V. EXPERIMENTAL PROCEDURE

Gravimetric method for suspended particulate matter (SPM) air is drawn through a size-selective inlet and through a 20.3 X 25.4 cm (8 X 10 in) filter at a flow rate which is typically 1.2 L/min. Particles with aerodynamic diameters less than the cut-point of the inlet are collected by the filter. The mass of these particles is determined by the difference in filter weights prior to and after sampling. The concentration of suspended particulate matter in the designated size range is calculated by dividing the weight gain of the filter by the volume of air sampled.

Gravimetric method for particulate matter (PM10) air is drawn through a size-selective inlet and through a 20.3 X 25.4 cm (8 X 10 in) filter at a flow rate, which is typically 1132 L/min. Particles with aerodynamic diameter less than the cut-point of the inlet are collected, by the filter. The mass of these particles is determined by the difference in filter weights prior to and after sampling. The concentration of PM10 in the designated size range is calculated by dividing the weight gain of the filter by the volume of air sampled.

Modified West & Gaeke method for sulphur dioxide the air is absorbed in a solution of potassium tetrachloromercurate (TCM). A dichlorosulphitomercurate complex, which resists oxidation by the oxygen in the air is formed. This complex is stable to strong oxidants such as ozone and oxides of nitrogen and therefore, the absorbing solution may be stored for some time prior to analysis. The complex is made to react with para-rosaniline and formaldehyde to form the intensely coloured pararosaniline methylsulphonic acid. The absorbance of the solution is measured by means of a suitable spectrophotometer at 560 nm.

Modified Jacobs & Hochheiser method for oxides of nitrogen. Ambient 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.

Non dispersive infrared (NDIR) spectroscopy for carbon monoxide. Atmospheric sample is introduced into a sample conditioning system and then into a non-dispersive infrared spectrometer (NDIR). The spectrometer measures the absorption by CO at 4.7 μm using two parallel infrared beams through a sample cell, a reference cell and a selective detector. The detector signal is led to an amplifier control section and the analyser output measured on a meter and recording system. Some instruments use gas filter correlation to compare the IR absorption spectrum between the measured gas and other gases present in the sample, in a single sample cell. These instruments utilize a highly concentrated sample of CO as a filter for the IR transmitted through the sample cell, to yield a beam that cannot be further attenuated by the CO in the sample and thus acts as a reference beam. The broadband radiation that passes through the sample cell and the CO filter is filtered again by a narrow band pass filter that allows only the CO sensitive portion of the band to pass to the detector. The removal of wavelength sensitive to other gases reduces interferences.

Fig. 1. Location of ambient air quality sampling sites.

VI. SITE SPECIFIC VARIATION

The minimum value for suspended particulate matter, respirable suspended particulate matter, carbon monoxide is in malkapuram, oxides of nitrogen, sulphur dioxide in nathayapalem that is in summer 142.0, 90.3, 15.4, 1.9 and 227.3 µg/m^3 respectively. The maximum values of suspended particulate matter and respirable suspended particulate matter is in one town, oxides of nitrogen in nathayapalem, sulphur dioxide, carbon monoxide in naval armament depot where the concentrations are 312.3, 249.0, 41.9, 18.4 and 352.6 µg/m^3 respectively in winter.

The minimum value for suspended particulate matter, respirable suspended particulate matter, oxides of nitrogen, sulphur dioxide, carbon monoxide in winter is 146.3, 79.3, 23.5, 3.5, and 235.6 µg/m^3 respectively in nathyapalem. The maximum value for suspended particulate matter, respirable suspended particulate matter is in one town, oxides of nitrogen in malkapuram, and sulphur di oxide, carbon monoxide in naval armament depot in the range of 312.3, 249.0, 41.9, 18.4, 352.6 µg/m^3 in winter.

VII. SEASONAL VARIATION

It was observed that the average concentrations of SPM, RSPM, NO_X, SO_2 and CO are high in winter compared to the summer, the comparative values of summer and winter for all the eight sites are as follows.

TABLE I. CONCENTRATION OF SPM, RSPM, NO_X, SO2 IN WINTER

Site	Winter				
	SPM	RSPM	NO_X	SO_2	CO
MVP	184.6	112.6	44.5	12.6	330.6
KANCHARAPALEM	225.6	158.6	48.1	10.1	346.0
NAD	234.0	164.6	45.6	23.4	364.0
NATHYAPALEM	146.3	79.3	23.5	3.5	235.6
MALKAPURAM	162.6	111.6	43.6	10.1	246.3
SCINDIA	235.3	157.3	36.4	8.7	334.0
I TOWN	337.3	273.3	45.6	18.9	349.6
JAGADAMBA	335.6	180.3	38.0	11.3	362.6

TABLE II. CONCENTRATION OF SPM, RSPM, NO_X, SO_2 IN SUMMER

Site	Summer				
	SPM	RSPM	NO_X	SO_2	CO
MVP	160.3	95.6	35.9	13.0	318.6
KANCHARAPALEM	195.0	133.6	37.1	7.7	334.6
NAD	207.0	142.3	35.7	18.4	352.6
NATHYAPALEM	147.3	108.3	15.4	1.9	228.0
MALKAPURAM	142.0	90.3	41.9	8.0	227.3
SCINDIA	202.3	138.6	31.6	7.6	311.6
I TOWN	312.3	249.0	36.6	17.2	334.0
JAGADAMBA	309.3	157.6	34.1	8.6	339.6

TABLE III. DETAILS OF SAMPLING LOCATIONS

Site No	Sampling station	Details of location
01	MVP	Commercial cum traffic
02	KANCHARAPALEM	National hi-way
03	NAD	Commercial cum traffic
04	NATHYAPALEM	Residential
05	MALKAPURAM	Industrial cum residential
06	SCINDIA	Industrial
07	I TOWN	Sea port
08	JAGADAMBA	Commercial

TABLE IV. AVERAGE CONCENTRATION (MG/M^3) OF SUSPENDED PARTICULATE MATTER (SPM)

Locations	Seasons	
	Winter	Summer
MVP	184.6	160.3
KANCHARAPALEM	225.6	195.0
NAD	234.0	207.0
NATHYAPALEM	146.3	147.3
MALKAPURAM	162.6	142.0
SCINDIA	235.3	202.3
I TOWN	337.3	312.3
JAGADAMBA	335.6	309.3

TABLE V. AVERAGE CONCENTRATION (MG/M^3) OF RESPIRABLE SUSPENDED PARTICULATE MATTER (RSPM)

Locations	Seasons	
	Winter	Summer
MVP	112.6	95.6
KANCHARAPALEM	158.6	133.6
NAD	164.6	142.3
NATHYAPALEM	79.3	108.3
MALKAPURAM	111.6	90.3
SCINDIA	157.3	138.6
I TOWN	273.3	249.0
JAGADAMBA	180.3	157.6

TABLE VI. AVERAGE CONCENTRATION (MG/M^3) OF NITROGEN OXIDE (NOX)

Locations	Seasons	
	Winter	Summer
MVP	44.5	35.9
KANCHARAPALEM	48.1	37.1
NAD	45.6	35.7
NATHYAPALEM	23.5	15.4
MALKAPURAM	43.6	41.9
SCINDIA	36.4	31.6
I TOWN	45.6	36.6
JAGADAMBA	38.0	34.1

TABLE VII. AVERAGE CONCENTRATION (MG/M^3) OF SULPHUR DIOXIDE (SO_2)

Locations	Seasons	
	Winter	Summer
MVP	12.6	13.0
KANCHARAPALEM	10.1	7.7
NAD	23.4	18.4
NATHYAPALEM	3.5	1.9
MALKAPURAM	10.1	8.0

SCINDIA	8.7	7.6
I TOWN	18.9	17.2
JAGADAMBA	11.3	8.6

TABLE VIII. AVERAGE CONCENTRATION (MG/M^3) OF CARBON MONOXIDE (CO)

Locations	Seasons	
	Winter	Summer
MVP	330.6	318.6
KANCHARAPALEM	346.0	334.6
NAD	364.0	352.6
NATHYAPALEM	235.6	228.0
MALKAPURAM	246.3	227.3
SCINDIA	334.0	311.6
I TOWN	349.6	334.0
JAGADAMBA	362.6	339.6

The above tables represent SPM, RSPM, SO_2, NO_X, CO stratums in winter and summer basis, the summer and winter data shows the levels of SPM and RSPM is exceeding the limits almost at all the sites It represents overview of Visakhapatnam air quality status at 1 to 8 locations of the bowl area are in heavily polluted descriptive categories. The AQI study reveals that SPM and RSPM was mainly responsible in all 8 sites in Visakhapatnam bowl area. The monitoring of meteorological parameters such as wind speed direction, relative humidity and temperature has also been integrated with the monitoring of air quality. The overall AQI can give clear view about ambient air and the critical pollutant mainly responsible for the quality of air quality which can be easier for a common man to understand.

VIII. RESULTS

In summer the concentration of spm and rspm are higher in one town area while oxides of nitrogen in malkapuram, sulphur dioxide and carbon monoxide in the naval armament depot. The minimum concentrations are observed in malkapuram and nathyapalem and in the case of winter the maximum concentrations of spm rspm are in one town. While the oxides of nitrogen, sulphur dioxide and carbon monoxide are maximum in kancharapalem and nad respectively. The minimum concentrations are observed in nathayapalem.

IX. DISCUSSION

Suspended Particulate Matter (SPM)

The concentration of the SPM recorded in the study areas ranged between 142.0 to 337.3 µg/m³. It was observed that the average concentration of suspended particulate matter during winter at muvvalavanipalem, kancharapalem, naval armament depot, nathayapalem, malkapuram, scindia, one town, jagadamba sites were 184.6, 225.6, 234.0, 146.3, 162.6, 235.3, 337.3, and 335.6µg/m³ respectively during winter. The average concentration of suspended particulate matter during summer at muvvalavanipalem, kancharapalem, naval armament depot, nathayapalem, malkapuram, scindia, one town, jagadamba sites were 160.3, 195.0, 207.0, 147.3, 142.0, 202.3, 312.3 and 309.3 µg/m³ respectively. Spatial variations of air quality occur in this region as a result of typical topography of air shed, micro meteorological conditions. Due to sea and land breeze phenomenon the air quality in Visakhapatnam city shows wide variation from one area to another.

Respirable Suspended Particulate Matter (RSPM)

The concentration of the RSPM recorded in the study areas ranged between 79.3 to 273.3 µg/m³. It was observed that the average concentration of respirable suspended particulate matter during winter at muvvalavanipalem, kancharapalem, naval armament depot, nathayapalem, malkapuram, scindia, one town, jagadamba sites were 112.6, 158.6, 164.6, 79.3, 111.6, 157.3, 273.3, and 180.3 µg/m³ respectively and the average concentration of respirable suspended particulate matter in summer at muvvalavanipalem, kancharapalem, naval armament depot, nathayapalem, malkapuram, scindia, one town and jagadamba sites were 95.6, 133.6, 142.3, 108.3, 90.3, 138.6, 249.0 and 157.6 µg/m³ respectively.

Nitrogen oxide (NOx)

The concentration of the Nitrogen oxides recorded in the (study) areas ranged between 15.4 to 48.1 µg/m³. It was observed that the average concentration of Nitrogen oxides during winter at muvvalavanipalem, kancharapalem, naval armament depot, nathayapalem, malkapuram, scindia, one town, jagadamba sites were 44.5, 48.1, 45.6, 23.5, 43.6, 36.4, 45.6 and 38.0 µg/m³ respectively and the average concentration of Nitrogen oxides during summer at muvvalavanipalem, kancharapalem, naval armament depot, nathayapalem, malkapuram, scindia, one town and jagadamba sites were 35.9, 37.1, 35.7, 15.4, 41.9, 31.6, 36.6 and 34.1 µg/m³ respectively.

Sulphur dioxide (SO_2)

The concentration of the Sulphur di oxide recorded in the study areas ranged between 1.9 to 23.4 µg/m³. It was observed that the average concentration of Sulphur di oxide during winter at muvvalavanipalem, kancharapalem, naval armament depot, nathayapalem, malkapuram, scindia, one town, jagadamba sites were 12.6, 10.1, 23.4, 3.5, 10.1, 8.7, 18.9, and 11.3 µg/m³ respectively and the average concentration of Sulphur di oxide during summer at muvvalavanipalem, kancharapalem, naval armament depot, nathayapalem, malkapuram, scindia, one town and jagadamba sites were 13.0, 7.7, 18.4, 1.9, 8.0, 7.6, 17.2 and 8.6 µg/m³ respectively.

Carbon monoxide (CO)

The concentration of the Carbon monoxide recorded in the study areas ranged between 227.3 to 364.0 µg/m³. It was observed that the average concentration of Carbon monoxide during winter at muvvalavanipalem, kancharapalem, naval armament depot, nathayapalem, malkapuram, scindia, one town, jagadamba sites were 330.6, 346.0, 364.0, 235.6, 246.3, 334.0, 349.6, and 362.6 µg/m³ respectively and the average concentration of Carbon monoxide during summer at muvvalavanipalem, kancharapalem, naval armament depot, nathayapalem, malkapuram, scindia, one town and jagadamba sites were 318.6, 334.6, 352.6, 228.0, 227.3, 311.6, 334.0, and 339.6, µg/m³ respectively.

CONCLUSION

The average concentrations of SPM, RSPM in one town, jagabamba, navel armond depot, scindia are beyond the national ambient air quality standards (NAAQS) set by the CPCB, New Delhi. The rspm values have almost exceeded the standards except in muvvalavanipalem and malkapuram. Whereas the NO_X, SO_2, CO were within the limits in all the sites.

REFERENCES

[1] Ravindra, Studies on suspended particulate matter in an Industrial area. Indian J. Env. Protection. 11(5), P. 358-359 (1991).J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68-73.

[2] Ambient air quality status and trends in Delhi (1989-1993). National Ambient Air Quality Monitoring Series (NAAQMS) no 9. New Delhi, India: Central Pollution Control Board, 1996.

[3] P. Balashanmugam1, Dr. M. Ramajayam 2Dr. V. Nehrukumar3 Dr. S. Palanivel raja4 and A. R. Ramanathan5, Air quality modeling for predicting traffic pollution in a south indian town. International Journal of Current Research. 4(9), P. 158-161(2012).

[4] Miranda, J., Andrade, E. and Ledesma, R., A receptor model for atmospheric aerosols from a southwestern site in Mexico city. Atmos. Environ. 30, P. 3471_3479 (1996).

[5] M. K. GHOSE*, S. R. MAJEE and P. K. SINHA, Monitoring and assessment of impact on air environment caused by coke plant operations in india. Intern. J. Environ. Studies.56, P. 475-482(1999).

[6] A. S. Shannigrahia,*, Ramesh C. Sharmaa and T. Fukushimab,y, Air pollution control by optimal green belt development around the victoria memorial monument, kolkata (india)". Taylor & Francis Ltd.

[7] Air Quality Status for Ten Cities of India; Report No. 10 (for 1999 and 2000); National Environmental Engineering Research Institute: Nagpur, India, 2001.

[8] Chak K. Chana,_, Xiaohong Yaoa,b, Air pollution in mega cities in China. Atmospheric Environment. 42, P.1–42 2008.

[9] Rajesh Kumar a , Manoj Sharma a , Ashok Srivastva a , Jarnail S. Thakur a , Surinder K. Jindal a & Harjinder K. Parwana b, Association of Outdoor Air Pollution with Chronic Respiratory Morbidity in an Industrial Town in Northern India. Archives of environmental health: An international journal. 59(9), P. 471-477(2004).

[10] Zemp E, Elsasser S, Schindler C, et al, Long term ambient air pollution and respiratory symptoms in adults (SAPSLDIA study). Am J Respir Crit Care Med journal, 159(12) 57-66, 1999.

[11] J. Panday, M. Agarawal, Evaluation of air pollution phytotoxicity in a seasonally dry tropical urban environment using three woody perennials. JSTOR, 126, P.53-61, 1994.