DOI 10.1515/pesd-2016-0001 PESD, VOL. 10, no. 1, 2016

A STUDY OF MEAN RSPM AND SPM LEVELS AT SELECTED SITES IN ASSAM DURING THE RECENT DECADE

Tongdi Jamir [1]

Key words: pollution, SPM, RSPM, CV

Abstract. Air pollution is an important issue around the world. Evidence of air pollution and its impact has been well established by the scientific communities. The effects of these changes on the smaller towns in Brahmaputra valley of Assam still need to be investigated. This study concludes that Suspended Particulate Matter (SPM) and Respirable Suspended Particulate Matter (RSPM) shows increasing trend in all the seasons except during the monsoon season but significant during the winter season. The study also reveals that RSPM remained above the standards throughout the decade, unlike SPM, which rose above the standards only during the years 2006, 2008 and 2009. It is also observed that during the rainy seasons Coefficient of Variation (CV) is high in maximum numbers of stations. The study concludes that exponential increase in population; vehicular activities, rainfall and wind direction as well as geographical conditions have indirectly influenced the pollutions.

Introduction

In advanced countries, ambient air quality has improved. However, there is evidence that exposure to air pollution even at the Levels still leads to adverse health effects. In developing countries like India, increased loadings of atmospheric pollutants from transportation and industrial emissions has increased due to increasing energy demands. Atmospheric particulate matter is the major air pollutant in India. In many Indian cities, the levels of particulate pollutants in the ambient air have been found to be above the permissible limit.

In the recent decades, a primary concern has been laid on the health impact of the air pollutants. Epidemiological and toxicological studies have well established that the human mortality and morbidity rate have risen. Several studies have investigated on air pollutants across the globe. There is substantial research evidence from around the world that urban air pollution has significant negative

[1] Department of Environmental Studies, D.I.E.T, Mon-798621, Nagaland, India, tongdi.jamir@gmail.com

impacts on public health, resulting in premature death. Sivacoumar et al., 2006, investigate on TSPM and PM_{10} of Chennai city (India); the results indicate that ambient concentrations and occupational exposure levels exceeded the Indian National Standards. Barman (2010) studied ambient air quality of Lucknow city, and reported that mean SPM and RSPM were found to be higher than prescribed limit of NAAQS. It is also found out that metals like Pb, Mn, Cr and Cu showed significant positive correlation with RSPM. Vehicular traffic is the main source of particulate air pollution in Lucknow city (Sharma et al., 2006; Barman et al., 2008). Bhaskar et al., 2010 reported that, there was a continuous decrease of particulate pollutants concentrations within Ahmedabad; however, the concentrations were just above the permissible limits set by the Central Pollution Control Board (CPCB).

Vehicular emission is responsible for higher level of air pollutants like SPM, RSPM, SO_2, NOx, organic and inorganic pollutants including trace metals and their adverse effects on human and environmental health (Kaushik et al., 2006; Maitre et al., 2006; Curtis et al., 2006; Sharma et al., 2006; Jayaraman, 2007). Technological upgradation and scientific know how has reduced the pollution level, however, increase in number of vehicles causes more emission of pollutants and change the composition ratio of the pollutants (Zanini et al., 2006). Vehicular exhaust is one of the most important sources of fine particles (Fang et al., 2005; Barman et al., 2008). There is a strong relationship between higher concentration of SO_2 and NOx and several health effects (Curtis et al., 2006) cardiovascular diseases (Peters et al., 2004; Chen et al., 2005; Dockery et al., 2005) asthma/bronchitis (Ye et al., 2001; Barnett et al., 2005). Cr (VI) is known to have toxic and carcinogenic effects on the bronchial tree (Manalis et al., 2005). The increased level of Cu can lead to respiratory irritance (Manalis et al., 2005). Sebastien Fierens et al., 2007 evaluated the impact of Iron/steel plants and solid waste incinerators and observed that concentration of dioxins correlate positively with their intake of local animal fat. While Yeon-Soon Ahn et al., 2006 found that steel worker cohort exhibits possible cancer mobility in some processing areas. Several studies were conducted to assess the effect of pollution generated by iron and steel factories and risk to the health of workers (Chai et al ., 2004; Hoshuyama Tsutomu et al., 2006; Amal El Safty et al., 2008; Bourgkard et al., 2008).

Evidence for air pollution and its impact has been well established by the scientific communities around the world. The effects of these changes on the smaller city like Guwahati, where studies are meager, still need to be investigated. In addition, most of the ill effects of air pollutants will have an impact on climate. Further, topographical features, along with land use characteristics modify the air pollutants. For e.g. the high Himalayan mountains in the north and the Meghalaya plateau in the south are the important sources for generating and maintaining climate over entire valley. Therefore, it is important to assess air pollution on a smaller scale. For this, the Brahmaputra valley in the state of Assam was selected for this study.

1. Study area

Brahmaputra valley is situated on a subtropical region varying from 26^0 N-28^0 N and 89^0 E-96^0 E. The valley covers an area of 5, 80,000 sq. km out of which 70,634 sq. km falls within Assam. The Brahmaputra plain is surrounded by the Arunachal Himalaya in the north, Purvanchal hills in the east and Meghalaya plateau hills in the south while it is open and joined with the Gangetic plain in the west (Fig. 1).

The length of the valley is 720 km and the width varies from 45 to 90 km. The gradient of the plain is extremely low ranging from 28 m at Dhubri in the west to 130 m at Sadiya in the east. In Koppen's climatic classification, Brahmaputra valley shows humid meso thermal Gangetic type of climate (Cwb). Being a monsoon dominated region, rainfall in the basin is highly seasonal. In this valley, six urban areas namely Bongaigaon, Guwahati, Tezpur, Golaghat, Sivasagar and Dibrugarh are considered for studying inter and intra variations in air pollution over the study region.

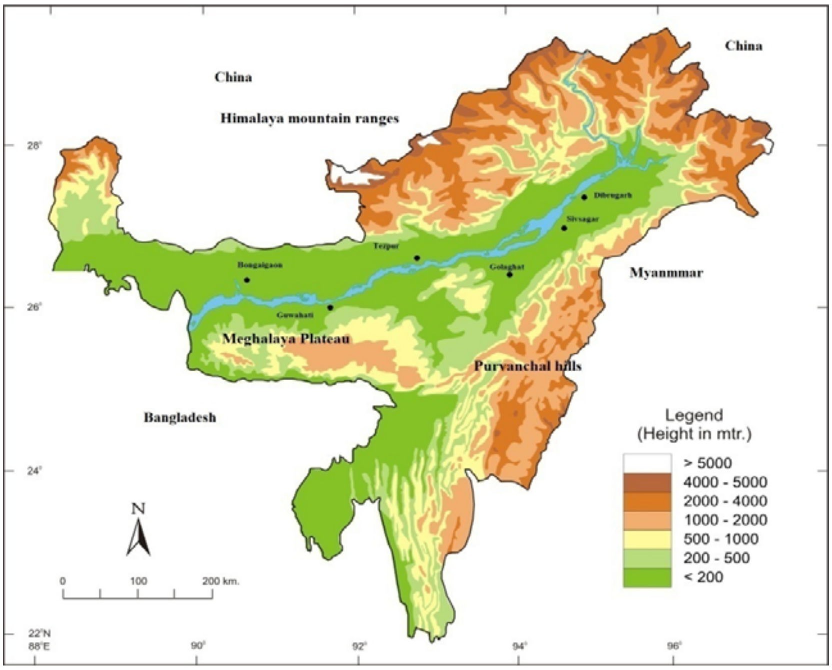

Fig.1- Study Area

Guwahati- lies between 26° 0′N - 26°30′N and 91°15′E and 92°0′E. The city is situated at an elevation of 55.5 m. It is the largest city in Assam and the gate way to North-east India. The city lies between Brahmaputra river and the Shillong plateau. Guwahati is the major commercial, educational and regional hub for transportation of North east India. The city's population in 2001 was 8, 08,021 and in 2012, it is 1.6 million. The most important manufacturing industry in the city is the petroleum refinery. Guwahati Railway Junction is a major station which provides railway services to the entire India. National Highway 31 and 37 and National Waterways No 2 connect with the neighboring states.

Bongaigaon-The town is situated at 26°29′N - 26.48°N and 90.56°E-90°34′E. The town is situated above 54 m and has a population of 2, 14,810. Bongaigaon has a major petrochemical industry, the Indian Oil Corporation Limited, Bongaigaon Refinery and Petrochemicals Limited. This town is also very well connected by road through the National Highway 31 B and 31C.

Golaghat town is located at 26°31′N - 26.52°N and 93.97°E- 93°58E. It has an average elevation of 95 metres. The total Population of the town is 97,782. As per 2001 census, Golaghat had a population of 33,021. The National Highway 39 passes through Golaghat town.

Tezpur town is situated at 26°38′N -26.63°N and 92.8°E-92°48′E. The town is above 48 m and has a population of 100,477. Tezpur is situated on the banks of the Brahmaputra and it is the largest of the north bank towns with a population exceeding 100,000. The economy of Tezpur is dependent on its Tea Gardens and Agriculture, which contribute to the local economy.

Sivasagar- This town is located at 26°59′N-26.98°N and 94°38′E-94.63°E. The average elevation is 95 m above and the population is 53,854. The main feature of the town is the water body. Joysagar, the biggest man-made lake in the country, is spread over 1.29 km^2. The main industries are oil industry and tea industry.

Dibrugarh town is situated between 27°29′N 95°00′E and 27.48°N 95°E. The town is located at an elevation of 108 m. The total population is 1, 86,214. Brahmaputra Cracker, Polymer Limited, Oil and timber are some of the big industries in Dibrugarh. Dibrugarh is the centre of economic activities, known for its oil/natural gas, tea production, tourism, power generation, fertilizer and cottage industry. The N.H. 37 cut across the city and it will soon be connected by the NH-52(B).

This study will be beneficial for environmentalist/meteorologist and climatologist to investigate its impact on the climate, namely temperature and rainfall. With this in view, an attempt is being made to investigate the changing patterns of air quality over the major towns of Assam on annual, seasonal and monthly basis.

2. Data and methods

SPM and RSPM monthly mean values were collected from State Pollution Control Board, Assam during the period 2004-2009. The Assam State Pollution Control Board is monitoring the Ambient Air Quality at Bamunimaidam-Guwahati, Santipur- Guwahati, ITI- Guwahati, Barpara-Bongaigaon, Campus-Bongaigaon, Golaghat, Tezpur, Sivsagar and Dibrugarh stations in the state. However, for studying the long range trend of SPM and RSPM, only one station which is located at Bamunimaidam (Guwahati) inside the Board's office premises was analysed. The data for the rest of the stations were used from 2007 to 2009. The frequency of monitoring is twice a week. SPM (1994-2009) and RSPM (2002-2009) monthly mean values were used for this study. Annual and seasonal time series were prepared from the monthly values. Apart from the SPM and RSPM data, meteorological parameters viz., wind direction (number of days wind coming from different directions) and rainfall data were also used for the present study. In addition, population data published by the government of India (Census, 2001 and 2011) and the vehicles population data were used for reference purposes.

The month-wise temperature values pertaining to winter (January-February), pre-monsoon/summer (March–May), monsoon (June–September), post-monsoon (October–December) and annual values were calculated for each station. The seasons were classified according to the criteria given by India Meteorological Department. Linear regression, correlation coefficient, coefficient of variation and student–t test was used. The trends are tested at 95% and 99% level of confidence.

3. Trend in monthly RSPM

From Table 1, it is observed that RSPM is increasing from the months of December-April, however it is not significant. On the other hand, the months from May-November show decreasing trend but it is significant during the months of

Table 1: Trends in Monthly RSPM

M	Slope value	R^2	M	Slope value	R^2
J	y = 23.46x + 104.1	0.523	JY	y = -17.94x + 117.2	0.572*
F	y = 20.18x + 105.7	0.497	A	y = -17.94x + 117.2	0.572*
M	y = 23.81x + 110.5	0.436	S	y = -16.13x + 111.1	0.565*
A	y = 2.939x + 105.1	0.243	O	y = -7.115x + 96.12	0.127
M	y = -1.677x + 102.0	0.021	N	y = -7.602x + 128.9	0.077
J	y = -16.31x + 124.5	0.461	D	y = 10.03x + 136.0	0.48

Note: M- months, Significant value **- 99%;*- 95%.

July, August and September. The highest rate of increase is reported during the month of January and March, while the highest rate of decrease is observed during the months of July and August.

4. Trend in monthly SPM

Monthly concentrations of SPM are depicted in Table 2. It can be seen that high concentrations were recorded mostly in the months of January, February and March while lowest concentrations were recorded from May to November during the study period.

Monthly SPM (Table 2) indicates that the months from December–May show increasing trend and it is significant only during the month of January. It is also observed that there is a decreasing trend from June to November. It is significant during the months of July and August. The highest rate of increase is noticed during the month of March, while the highest rate of decrease is reported during the month of July and August.

Table 2: Trends in Monthly SPM

M	Slope value	R^2	M	Slope value	R^2
J	y = 39.32x + 146.5	0.587 *	JY	y = -24.68x + 175.3	0.549*
F	y = 48.57x + 126.4	0.420	A	y = -24.26x + 175.9	0.579*
M	y = 57.07x + 141.5	0.454	S	y = -17.95x + 159.6	0.301
A	y = 15.41x + 151.3	0.426	O	y = -8.268x + 145.8	0.063
M	y = 3.867x + 152.8	0.090	N	y = -7.670x + 186.8	0.029
J	y = -22.09x + 187.0	0.423	D	y = 14.80x + 212.4	0.24

Note: M- months, Significant value **- 99%;*- 95%.

5. Trend in seasonal RSPM and SPM

Seasonal wise were analysed, and the result reveals that RSPM shows increasing trend in all the seasons except the monsoon season. It is significant during winter and monsoon seasons (Table 3).

Table 3: Trends RSPM and SPM

S	RSPM Slope value	R^2	S	SPM Slope value	R^2
W	y = 22.49x + 106.8	0.567*	W	y = 43.94x + 136.5	0.530*
S	y = 8.360x + 105.9	0.500	S	y = 25.45x + 148.5	0.516
M	y = -16.84x + 116.7	0.561*	M	y = -22.24x + 174.5	0.467
PM	y = 8.767x + 104.3	0.427	PM	y = 14.59x + 158.4	0.490

Note: S-season, W-winter, S-summer, M-monsoon, PM-post monsoon, Significant value **- 99%;*- 95%.

Further, the analysis of SPM indicates that there is an increase during winter, summer and post monsoon seasons, whereas during the monsoon season it shows a decreasing trend. It is observed that only during the winter season it shows significantly.

6. Comparison of SPM and RSPM with the NAAQ standard

Yearly RSPM and SPM data are compared with the standards; it reveals that during the study period, RSPM were above the standards during the entire time, while SPM remained above the standards only during the year 2008-2009. This shows that the quality of RSPM were worse than SPM (Fig. 2). The comparison between RSPM and SPM on yearly average basis with ambient air quality standards shows that pollutant of RSPM concentrations has often crossed the permissible limit.

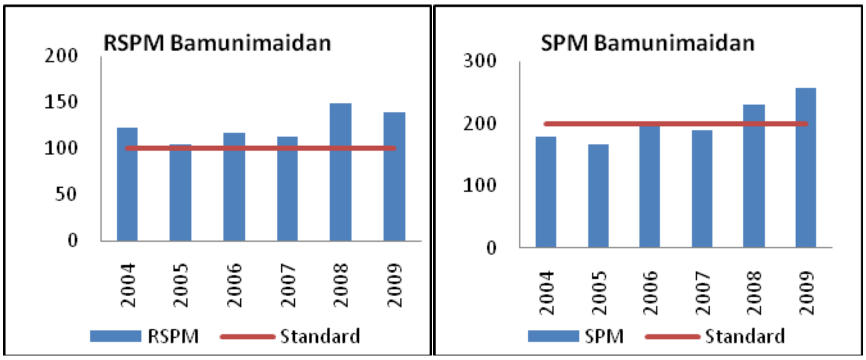

Fig. 2-RSPM and SPM

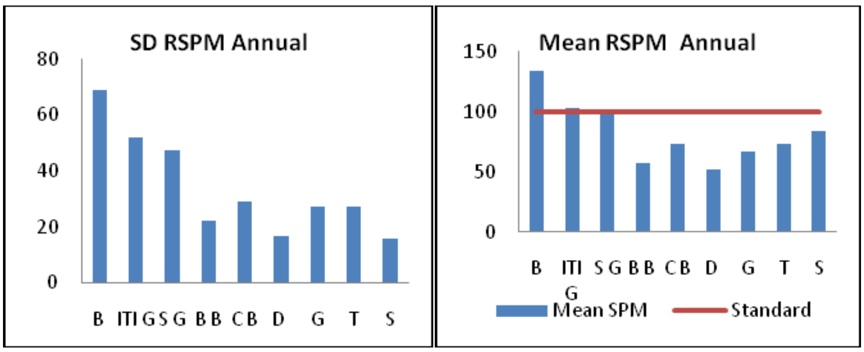

Fig. 3-RSPM Mean and SD

RSPM mean values for all the stations indicate that only Bamunimaidam, ITI and Golaghat were above the standards while Barpara-Bongaigaon, Campus-Bongaigaon, Dibrugarh, Golaghat, Tezpur and Sivsagar showed below the standards (Fig. 3). This indicates that the air quality is good. Further, the SD for all the stations were analysed, the result indicates that the stations Bamunimaidam, ITI and Santipur- Guwahati show higher SD unlike the other stations. SPM standard deviations are highest at Bamunimaidam, ITI and Golaghat due to transportation and industrial activities. Minimum standard deviations are noticed in rest of the towns in Assam because of the nature of the sampling sites, and as such its sources are less when compared with industrial areas.

SPM mean values for all the stations indicate that only Bamunimaidam is above the standards while the rest of the stations are below the standards. This indicates that the air quality is good. Further, the SD for all the stations were assessed, the result indicates that the station Bamunimaidam ITI and Santipur-Guwahati show higher SD unlike the other stations.

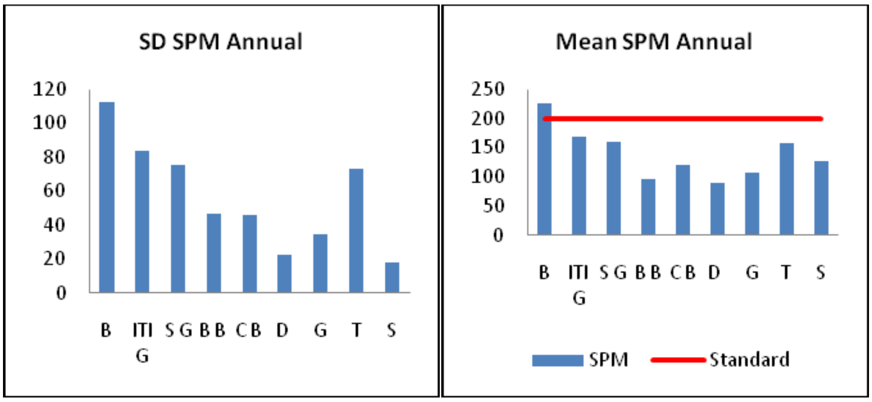

Fig. 4-SPM Mean and SD

The Coefficient of Variation (CV) is defined as the ratio between the standard deviation to mean. This method was used and it is reported in Fig. 5. Fig. 5 (a and b) indicate that for all the stations the CV is not the same during all the seasons. It is observed that during the rainy seasons CV is high which is reported in maximum numbers of stations.

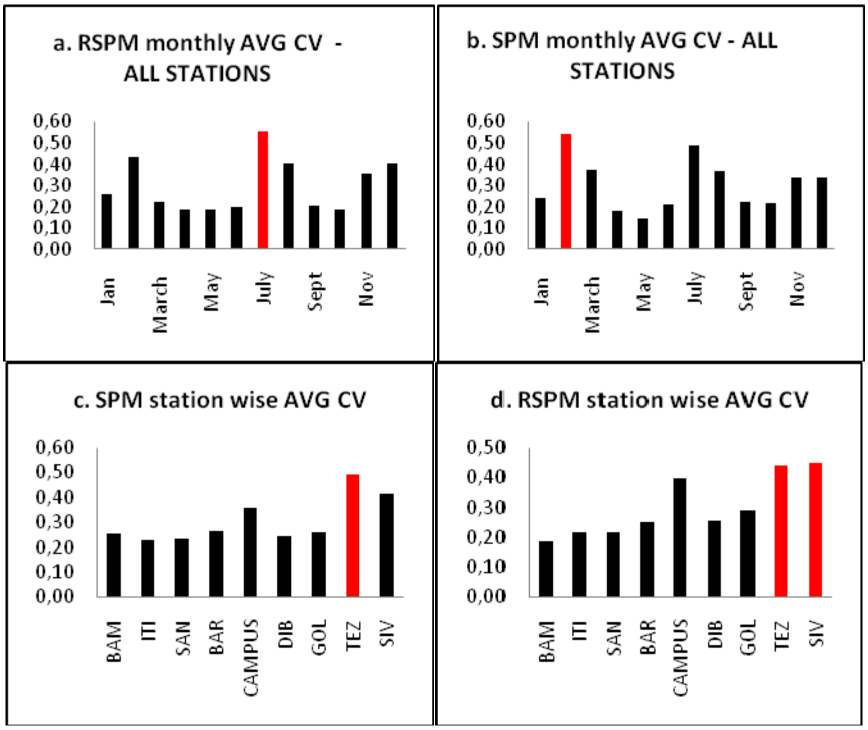

Fig. 5-Coefficient of variation in RSPM and SPM

Further, coefficient of variation for SPM and RSPM for all the stations is shown in Fig. 5 (c and d) which reflects that Tezpur and Sivsagar show higher CV as compared to rest of the stations.

7. Relation with the meteorological parameters

Meteorology plays an important role in distributions of air pollution. Air pollutants are, to a great extend, influenced by seasonal changes as well as meteorological factors like temperature, wind direction, wind speed, precipitation and turbulence. Thus, it is significant to understand the meteorological factors since it plays an important role in controlling the SPM.

In order to find the increase in SPM, the data were subjected to trend. For this, rainfall data was used and is illustrated in Fig. 6.

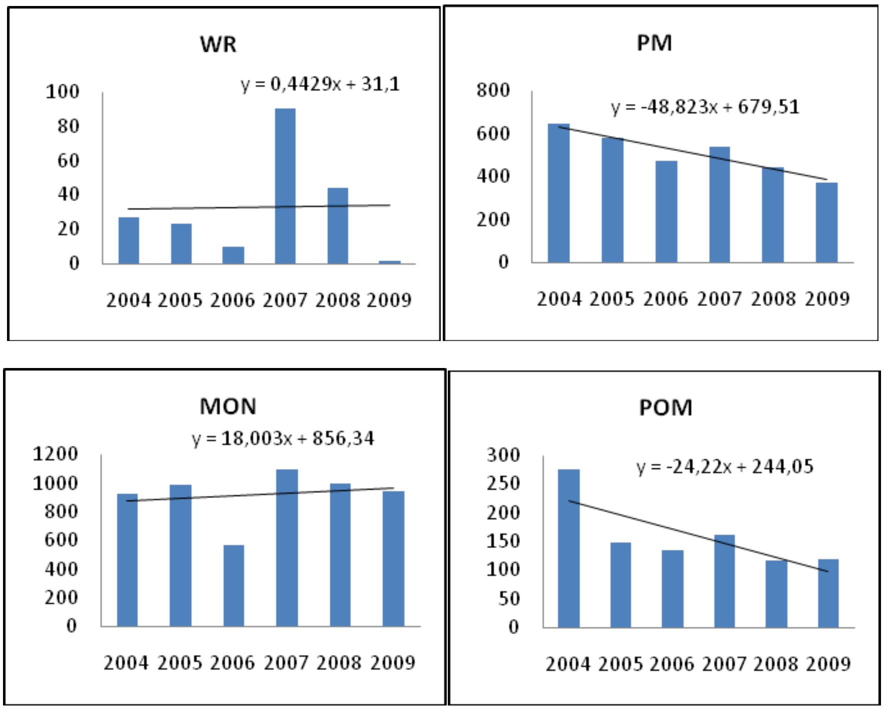

Fig. 6-Rainfall trend in Guwahati

The result indicates that there is an increase in SPM during winter, summer and post monsoon season and decrease during the monsoon season. SPM is higher during the winter as well as summer seasons, and to some certain extend during the post-monsoon season (December). In winter, Brahmaputra valley is characterised by dry and clear sky. Moreover, during the winter season the rain fall is less. As a result, the removal of atmospheric aerosol particles by rainfall is reduced. During the summer season, the climate is very warm even at night. It is observed that SPM shows increasing trend except during the monsoon season. There is a decrease in SPM during monsoon season; this is due to wet weather, as precipitation removes SPM pollutants from the atmosphere. Hence, there is direct relationship between rainfall and SPM. Monsoon seasons are characterized by heavy rain and wind. Thus, the lowest concentrations of particulate matters are seen in the monsoon season.

Further to support the increase in SPM, wind data were used which was noted from climatological normal published by IMD (Fig. 7). Fig. 7 indicates that calm days are more as compared to the rest of the wind direction. Further, when the varying seasons are computed, the result indicates that during winter (61%), summer (24%) and post monsoon season (63%), calm days frequencies are high. This might lead to the increase in SPM concentration. Wind affects turbulence and dispersion of pollutants. The greater the wind speed, the greater the turbulence, and hence dispersion of pollutants is high. It was found that precipitation and wind direction cause reduction in SPM level in the environment.

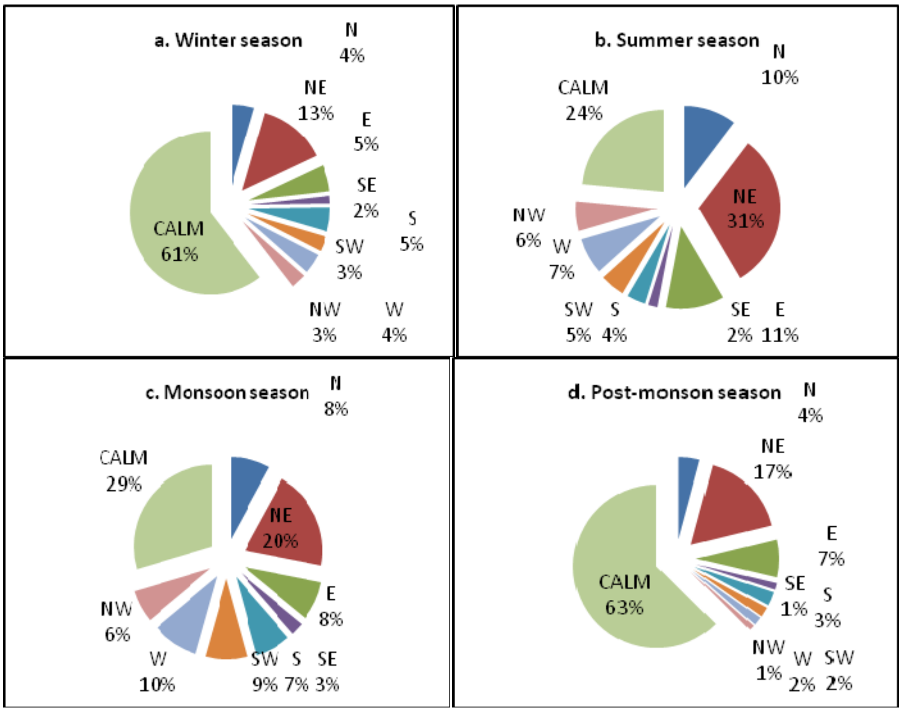

Fig.7- Wind Direction

8. Relation with the socio-economic parameters

Socio-economic parameters indirectly play an important role in influencing SPM. For this, annual population and vehicular data was analysed. The growth in Guwahati population is illustrated in Fig. 8. The result indicates that the population of Guwahati city is rising exponentially at the rate of $y = 4349.e^{0.470x}$. Along with the growth in population, it is observed that there is also an increase in vehicular population (Fig. 9). Since it is difficult to acquire the data, only two years data was used, that is, observed value for the year (2004) and the Projected value for the year (2025). When compared between 2004 and 2025 it shows large variation. All these factors might have led to increase in air pollution.

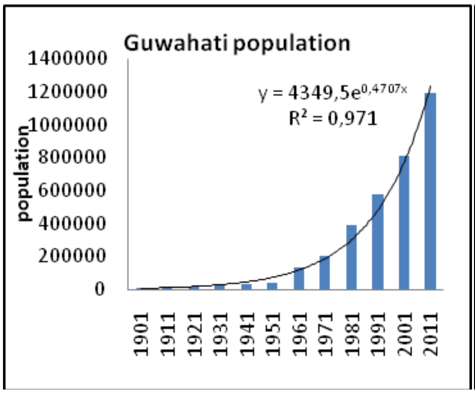

Fig. 8- Human population

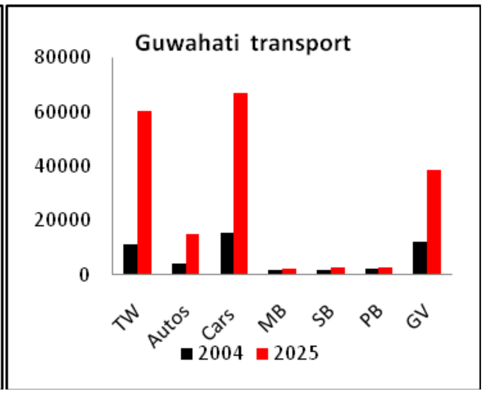

Fig. 9- Vehicle population

Note: Two Wheelers-TW, Mini buses-MB, Standard buses-SB, Private buses – PB; Goods vehicles-GV

Guwahati is the largest metropolitan city in the state of Assam, as well as in the Northeast Region. The city population is rising exponentially as indicated in the figure. As such, various sources namely domestic, commercial and industrial produce air pollution. There are thousands of vehicles plying on the road every day. In addition to this, the city area in 1971 was 43.82 sq km, but it has now increased to 340 sq km in the recent years. The population density of Guwahati was 2,558 in 1981, which has increased to 3,741 in 2001. Major industries of the state are located in the city, which adds to contaminate the already polluted air. This is further aggravated by the bad urban planning structure.

9. Relation with the topography

The topography of Guwahati is covered by number of mountains and hills. Its topographic characteristics are the northward extension of the Meghalaya plateau mostly in the form of hills and inselbergs. The highest elevation is 426 m above the mean sea level. The flatness of the area is much broken in its southern part near the Meghalaya plateau. The hill ranges of Guwahati are aligned in north-east to south-west direction and the plain areas are surrounded by these hills.

Topography plays an important role in air quality studies and strongly influences the local meteorology. Thus, winds are responsible for the dispersion of pollutants. However, hill and mountains restrict the transport of pollution away from the urban area (Fig. 10).

As far as the topography of Guwahati is concerned, the city is bounded by the hills and mountain on north and south except the western part. Due to its leeward location, it experiences more calm days. Apart from that, the wind coming from NE direction is also dry. The central part of the city and building structures can be seen as an obstructing parameter that restricts the transport and dispersion of pollutants. The city is not properly planned as it is narrow and has congested streets. So, the pollutants dispersions are weak, thereby leading to increase in pollutions. Thus, topography also plays an important role.

Fig. 10- Guwahati landscape
Source: http://northeasttourismindia.com/hospitable-hotels-at-guwahati/

Conclusions

The study also concludes that SPM and RSPM show increasing trend in all the seasons except the monsoon season. However, RSPM and SPM show significant trend during the winter season. The result also reveals that RSPM were above the standards throughout the entire time, whereas SPM rose above the standards only during the year 2006, 2008 and 2009. Further, during the rainy seasons CV is high in maximum numbers of stations. All these changes are due to exponential increased in population and vehicular activities. Moreover, due to its geographical conditions, dispersion of the air pollutants within the city is retarded. As the city is blocked on three sides by the hills and the hillocks, free movement of air is hampered, thereby the pollution level is comparatively higher. The removal of atmospheric aerosol particles by rainfall is reduced in winter thereby SPM is high while there is a decrease in SPM during monsoon season due to high precipitation. It is also observed that during winter (61%) and post monsoon season (63%) calm days frequencies are high leading to the increase in SPM concentration. All these factors might have led to the increase in SPM concentrations.

Bibliography

Amal, E.S., Khalid, E.M., Sawsan, H., Neveen, A.M. (2008), Zinc Toxicity among Galvanization Workers in the Iron and Steel Industry. Annals of the New York Academy of Sciences, Vol. 1140, **256 – 262 pages**.

Bourgkard., Wild, E.P., Courcot B., Diss, M., Ettlinger, J., Goutet, P., Hémon, D., Marquis, N., Mur, J.M., Rigal, C., Rohn-Janssens, M.P., Moulin, J.J. (2008), *Lung Cancer Mortality and Iron Oxide Exposure in a French Steel-Producing Factory.* Occupational and Environmental Medicine, Vol. 66, 175-181 pages.

Barman, S.C., Singh, R., Negi, M.P.S., Bhargava, S.K. (2008), *Fine particles (PM2.5) in residential areas of Lucknow city and factors influencing the concentration*. Clean Soil Air Water, Vol. 36, 111-117 pages.

Barman, S.C., Kumar, N., Singh, R., Kisku, G.C., Khan, A.H., Kidwai, M.M., Murthy, R.C., Negi, M.P.S., Pandey, P., Verma, A.K., Jain, G., Bhargava, S.K. (2010), *Assessment of urban air pollution and it's probable health impact*. Journal of Environmental Biology, Vol. 31, 6, 913-920 pages.

Barnett, A.G., Williams, G.M., Schwartz, J., Nekker, A.H., Best, T.L. Petriescgevsjt, A.L. (2005), *Air pollution and child respiratory health: A case crossover study in Australia and New Zealand*. American Journal of Respiratory and Critical Care Medicine, Vol. 171, 1272-1278 pages.

Curtis, L., Rea, W., Smith-Willis, P., Fenyves, E., Pan, Y. (2006), *Adverse health effects of outdoor air pollutants*, Environment International, Vol. 32, 815-830 pages.

Chen, L.H., Knutsen, S.F., Shavlik, D., Beeson, W.L., Peterson, F., Ghamsary, M. (2005), *The association between fatal coronary heart disease and ambient particulate air pollution: Are females at greater risk?* Environmental Health Perspectives, Vol. 113, 723-1729 pages.

Chai**, Z.F., Qian, Q.F., Feng, X.Q., Zhang, P.Q., Liu, N.Q., Feng, W.Y., Kuang, M.X., Wang H.Y., Zhang Y.Z.** (2004), *Study of Occupational Health Impact of Atmospheric Pollution on Exposed Workers at An Iron and Steel Complex by using Neutron Activation Analysis of Scalp Hair*. Journal of Radio analytical and Nuclear Chemistry, Vol. 259, 153-156 pages.

Dockery, D.W., Luttnabb-Gibson, H., Rich, D.Q., Link, M.L., Mittleman, M.A., Gold D.R. (2005), *Association of air pollution with increased incidence of ventricular tachyarrythmias recorded by impanted cardioverter defibrillators*, Environmental Health Perspectives, Vol. 113, 670-674 pages.

Fang, G.C., Wu, Y.S., Huang, S.H., Rau, J.Y. (2005), *Review of atmospheric metallic elements in Asia during 2000-2004*. Atmospheric Environment, Vol. 39, 3003-3013 pages.

Hoshuyama, T., Pan, G., Tanaka, C., Feng, Y., Yu, L., Liu, T., Liu, L., Hanaoka, T., Takahashi, K.A. (2006), *Retrospective Cohort Study among Iron-Steel Workers in Anshan, China: Exposure Assessment*. JUOEH Occupational Environmental Health Journal, Vol. 28, 253-263 pages.

Jayaraman, G.N. (2007), *Air quality and respiratory health in Delhi*. Environmental Monitoring and Assessment, DOI 10.1007/s 10661-007-9651-0.

Kaushik, C.P., Ravindra, K., Yadav, K. (2006), *Assessment of ambient air quality in urban centres of Haryana (India) in relation to different anthropogenic activities and health risk*.Environmental Monitoring and Assessment, Vol. 122, 27-40 pages.

Maitre, A., Bonneterre, V., Huillard, L., Sabatier, P., Gaudemaris, R. (2006), *Impact of urban atmospheric pollution on coronary disease*, European Heart Journal, Vol. 27, 2275-2284 pages.

Manalis, N., Grivas, G., Protonotarios, V., Moutsatsou, A., Samara, S., Chaloulakou A. (2005), *Toxic metal content of particulate matter (PM10), within the Greater Area of Athens*. Chemosphere, Vol. 60, 557-566 pages.

Peters, A., Von Klot, S., Heier, M., Trentinaglia, I., Horman, A. Wichmann E. E. (2004), *Exposure to traffic and the onset of myocardial infarction*, New England Journal of Medicine, Vol. 351, 1721-1730 pages.

Sharma, K., Singh, R., Barman, S.C., Mishra, D., Kumar, R., Negi, M.P.S., Mandal, S.K., Kisku, G.C., Khan, A.H., Kidwai, M.M., Bhargava, S.K.(2006), *Comparison of trace metals concentration in PM_{10} of different location of Lucknow city*, Bulletin of Environmental Contamination and Toxicology, Vol. 77, 419-426 pages.

Sebastien F. (2007), *Impact of Iron and Steel Industry and Waste Incinerators on Human Exposure to Dioxins, PCBs, and Heavy Metals: Results of a Cross-Sectional Study in Belgium*. Journal of Toxicology and Environmental Health, Part A, Vol. 70, 222- 226 pages.

Sivacoumar, R., Jayabalou, S., Swarnalatha., Balakrishnan, K. (2006), *Particulate Matter from Stone Crushing Industry: Size Distribution and Health Effects*. Journal of Environmental Engineering, Vol. 132, 405-415 pages.

Vijay Bhaskar, B., Mehta Vikram, M. (2010), *Atmospheric Particulate Pollutants and their Relationship with Meteorology in Ahmedabad*, Aerosol and Air Quality Research, Vol. 10, 301–315 pages.

Ye F., Piver, W.T., Ando, M., Portier, C.J. (2001), *Effects of temperature and air pollutants on cardiovascular and respiratory diseases for males and females older than 65 years of age in Tokyo, July and August 1980-1995*, Environmental Health Perspectives, Vol. 109, 355-359 pages.

Yeon-Soon, A., Robert, M.P., Leslie, S., Seong-Kyu, K., Jae-Kil, J. (**2006),** *Cancer Morbidity in Iron and Steel Workers in Korea*. American Journal of Industrial Medicine, Vol. 49, **647 – 657 pages.**

Zanini, G., Berico, M., Monforti, F., Vitali, L., Zambonelli, S., Chiavarini, S., Georgiadis, T., Nardino, M. (2006), *Concentration measurement in a road tunnel as a method to assess "real-world" vehicles exhaust emissions*. Atmospheric Environment, Vol. 40, 1242-1254 pages.