Journal of Energy Research and Environmental Technology (JERET)
p-ISSN: 2394-1561; e-ISSN: 2394-157X; Volume 6, Issue 1; January-March, 2019, pp. 46-48

http://www.krishisanskriti.org/Publication.html

A Study Approach for Evaluation of different Size Ratio of Particulate Matter with Variation in Season and Locations of an Urban City

Simpy Singh*, N.C. Gupta and P. Bhattacharya

University School of Environment Management,
Guru Gobind Singh Indraprastha University,
Sec 16 C Dwarka, New Delhi - 110078

Abstract—*The fine size particles were present since ages in the natural atmosphere, however with industrialization and fast paced development, they are now additional in finer range along with its availability to react and form different harmful pollutants. The concern for public health and economic productivity has introduced standard level of PM_{10} and $PM_{2.5}$ concentration under 24 hour and annual observation.*

The present work shows contribution of different particulate matter, PM_{10}, $PM_{2.5}$ and $PM_{1.0}$ having aerodynamic diameter less than 10, 2.5 and 1µm in the air through study of their size concentration ratio factor for two years. The study sites were selected at different locations in capital city with variation in land use pattern and emission intensity. The results obtained were observed with seasonal changes at various sites for ratio of $PM_{2.5}/PM_{10}$, $PM_{1.0}/PM_{10}$ and $PM_{1.0}/PM_{2.5}$. The variation for $PM_{2.5}/PM_{10}$ was observed 0.28-0.63 in summer, 0.40-0.55 in post monsoon and 0.45-0.58 in winter from areas representing urban background, residential, industrial and traffic sites. Further, $PM_{1.0}/PM_{2.5}$ was estimated to identify the contribution of ultra fine to fine particle fraction with value of 0.69, 0.69 and 0.64 at an institutional background location whereas traffic site showed 0.80, 0.82 and 0.58 in summer, post monsoon and winter respectively. The $PM_{1.0}/PM_{10}$ showed value from minimum of 0.11 to maximum 0.37 indicating the low level of factors contributed by ultra fine to the coarse size particle concentration.

The work will be beneficial for understanding the pattern of either similar or dissimilar sources contributing to release of dust or pollutant particles in atmosphere in different seasons and also to assess any dominance character of smaller to coarser size particles.

Keywords: *Urban locations; Size ratio concentration factor; Air quality; Particulate matter.*

Introduction

Aerosols has been inseparable part of various processes occurring during weather changes occurred during dust storm, friction among land and relief features in lower troposphere (Shao and Dong, 2006; Tegen, 2003). The stratosphere and upper layers observes the formation of cloud condensation nuclei and albedo scattering effect under various sizes and nature of particulate matter impacting air quality and global climate change (Ramanathan et al., 2001; Sokolik et al., 2001; Charlson et al., 1992). The growing urban cities and anthropogenic activities have contributed a large share of particulate matter (PM) concentration in the air within a short time of emission during activity (Karagulian et al., 2015).

Thus, the study of particulate matter has taken various dimension in terms of understanding its concentration level, chemical reactivity with other elements, biological interaction with the environments as well combination of these factors to produce smog and other pollution episodes in the city atmosphere.

The PM poses risk to human health because of their potential of deposition and interaction on both respiratory and cardiovascular systems (Pope III and Dockery, 2006; Davidson et al., 2005). The coarse particles, PM_{10} are likely to be deposited in the extra-thoracic and upper bronchial regions, whereas fine and ultrafine particles, $PM_{2.5}$ and $PM_{1.0}$ may travel deeply into the lungs and may be deposited in the lower bronchial and alveolar regions.

Materials and Methodology

The experimental monitoring sites were located were to be representative as micro-habitats in developed urban area. The capital city of India, Delhi has witnessed a major change of land use from 90% of agricultural land in early decade of 1970-1990 to 90% of urban infrastructure in 2000-2010 (Srinivasan, 2001). The sites were selected on basis of land-use pattern such as urban-natural background area (UB) at Dwarka, which is an educational institution with low density of population, urban- residential (UR) at Janakpuri, urban-industrial (UI) at Mayapuri, a site of light goods manufacturing industrial activities, automobile service stations etc and an urban traffic site (UT) at Rajendra place intersection in the city (Kumar et al., 2016; Rathee, 2014). The location map for the urban area with the monitoring sites marked is provided in Figure 1.

The PM concentration was monitored with help of laser based GRIMM Aerosol spectrometer (Model 1.108). The instrument works on dual principle of light scattering and gravimetric filter sampling providing number and mass concentration of the particles suspended in ambient air. The instrument measures concentration values in environmental mode as PM_{10}, $PM_{2.5}$ and $PM_{1.0}$ on real time basis.

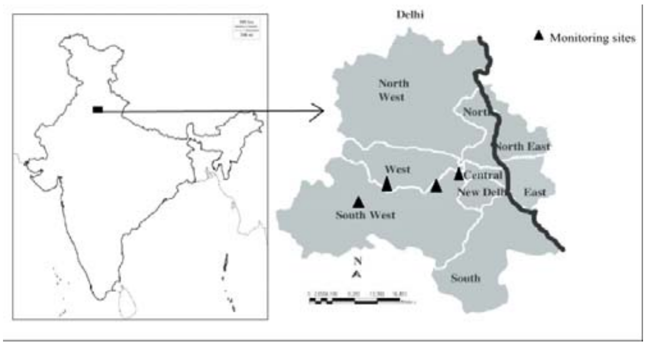

Figure 1. Location map of monitoring sites in the city

Results and discussion

The mass concentration from the monitoring was averaged to get daily as well as weekly to obtain an average value for the seasonal factor from each site. The values were further calculated to express ratio factor from size concentration under coarse, fine and ultra fine division of particles as given in Table 1.

The share of fine sizes to coarse particles ($PM_{2.5}/PM_{10}$) was found maximum at industrial site in summer months followed by winter months at both industrial and traffic sites. The post monsoon observed half share from the fine particles released at institutional and residential sites. Rao et al., 2012 have observed in winter season, the size fraction of $PM_{2.5}$ with PM_{10} was found to range from 0.4-0.9 for various industrial sites in Orissa. The size fraction of $PM_{2.5}/PM_{10}$ in summer season was from 0.1-0.8 and in post monsoon; the ratio varies from 0.4-0.8 of the total concentration load.

The observation of ultrafine particles to coarser sized particles that is, PM_{10} aerodynamic diameter less than 10µm was having minimum percentage of sharing of similar sources of emission. The post monsoon season observed the highest value of 0.38 and minimum of 0.11 at institutional and residential sites respectively. The study of industrial site was also done with view to understand the change in concentration of PM on weekend and weekdays and the result was obtained as average of 0.25-0.31 for pre monsoon and post monsoon observation (Singh et al., 2015).

The low level of contribution can be attributed towards the difference in sources of the release the particular sizes of particles in the air such as high temperature mediated process and reaction in atmosphere and vehicular release for the ultra fine particles, while the crustal and other geo-genic sources are main responsible for the coarser mode of particle fraction.

Further the ultrafine to finer size of particles share the high chances of similar sources of emission from vehicular exhaust, thermal power plant and industrial release etc impacting human health and ecological biodiversity (Singh et al., 2018; Watson et al., 2010). The sharing was high in summer and winter months followed by post monsoon where there is a likely chance of coagulation of ultra fine particles to bigger size particles (Vecchi et al., 2004). The traffic site showed the highest sharing coefficient from 0.58-0.82 likely due to presence of traffic all through the day. George et al., 2016, had observed mass size ratio fraction to be around 0.51 at sites dominated by vehicular emission while 0.34 for the road dust having crustal source of particles.

The mass ratio of PM was also represented with the help of triangular diagram, where each site was shown in different graphs for the changes observed in season of summer, post monsoon and winter. The $PM_{2.5}/PM_{1.0}$ share a greater similarity of particles released from sources majorly from industrial and traffic in summer and winter months as can be seen from Figure. 2 where they coefficient range from 0.30-0.80. However, institutional areas also showed a high similarity indicating that the only source of these minute particles could be the vehicular movement occurring within the area. The residential site showed fairly half of the identical in similar source emission emphasizing there are more types of activities leading to diverse size range of particles in the air exposed to the people.

Table 1: Mean values of ratio size concentration of particulate matter in different seasons at various sites

PM Size ratio	Seasons	UB	UR	UI	UT
$PM_{2.5}/PM_{10}$	S	0.28	0.33	0.63	0.44
	PM	0.55	0.45	0.40	0.36
	W	0.53	0.45	0.58	0.58
$PM_{1.0}/PM_{10}$	S	0.19	0.17	0.33	0.35
	PM	0.38	0.11	0.20	0.37
	W	0.34	0.22	0.30	0.34
$PM_{1.0}/PM_{2.5}$	S	0.69	0.52	0.52	0.80
	PM	0.69	0.25	0.50	0.82
	W	0.64	0.49	0.51	0.58

Where S - Summer, PM - Post monsoon, W - Winter, UB – Urban institutional , UR – Urban residential, UI – Urban industrial and UT – Urban traffic site.

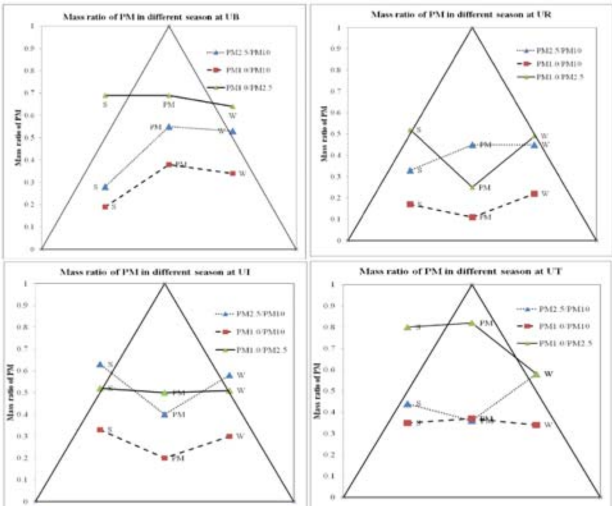

Figure 2. The triangular diagram of PM concentration ratios for four sites with seasonal changes observed for $PM_{2.5}/PM_{10}$, $PM_{1.0}/PM_{10}$ and $PM_{1.0}/PM_{2.5}$.

Conclusion

The $PM_{2.5}/PM_{10}$ ratio indicated that the fine particles make a foremost portion of the coarse particles indicating common source of emission. The scavenging up of particles from the atmosphere during rainfall through wet deposition process gets vanished only after a few days as the industrial emission and flow of vehicles on road network is operated round the year. The work shows the significant change of percentage contribution between the coarse, fine and ultra particles under seasonal changes and the emission activity of an area. The work would be useful for working on the mitigation of pollution release from sources contributing maximum number and finer sizes of particles.

Acknowledgement

The authors are thankful to Dean, University School of Environment Management, Guru Gobind Singh Indraprastha University for supporting the research work. One of the authors Ms. Simpy Singh is thankful to University Grants Commission for providing financial support during the study (Letter No.-UGC – Ref.No.:3209/NET-DEC.2010).

References

[1] Charlson, R. J., Schwartz, S. E., Hales, J. M., Cess, R. D., Coakley, J. J., Hansen, J. E., & Hofmann, D. J. (1992). Climate forcing by anthropogenic aerosols. Science, 255(5043), 423-430.

[2] Davidson, C. I., Phalen, R. F., & Solomon, P. A. (2005). Airborne particulate matter and human health: a review. Aerosol Science and Technology, 39(8), 737-749.

[3] George, K. V., Patil, D. D., Anil, M. N., Kamal, N., Alappat, B. J., & Kumar, P. (2016). Evaluation of coarse and fine particles in diverse Indian environments. Environmental Science and Pollution Research, 24(4), 3363-3374.

[4] Huang, Y., Shen, H., Chen, H., Wang, R., Zhang, Y., Su, S., & Wang, X. (2014). Quantification of global primary emissions of PM2. 5, PM10, and TSP from combustion and industrial process sources. Environmental science & technology, 48(23), 13834-13843.

[5] Karagulian, F., Belis, C. A., Dora, C. F. C., Prüss-Ustün, A. M., Bonjour, S., Adair-Rohani, H., & Amann, M. (2015). Contributions to cities' ambient particulate matter (PM): A systematic review of local source contributions at global level. Atmospheric environment, 120, 475-483.

[6] Kumar, P., & Gupta, N. C. (2016). Commuter exposure to inhalable, thoracic and alveolic particles in various transportation modes in Delhi. Science of the Total Environment, 541, 535-541.

[7] Pope III, C.A., & Dockery, D.W. (2006). Health effects of fine particulate air pollution: lines that connect. Journal of Air and Waste Management, 56(6), 709-742.

[8] Ramanathan, V. C. P. J., Crutzen, P. J., Kiehl, J. T., & Rosenfeld, D. (2001). Aerosols, climate, and the hydrological cycle. science, 294(5549), 2119-2124.

[9] Rao, B. P., Srivastava, A., Yasmin, F., Ray, S., Gupta, N., Chauhan, C., & Wate, S. R. (2012). Particle size distribution of ambient aerosols in an industrial area. Bulletin of Environmental Contamination and Toxicology, 88(5), 717-721.

[10] Rathee, G. (2014). Trends of land-use change in India. In Urbanization in Asia, pp. 215-238, Springer.

[11] Shao, Y., & Dong, C. H. (2006). A review on East Asian dust storm climate, modelling and monitoring. Global and Planetary Change, 52(1-4), 1-22.

[12] Singh, S., Bhattacharya, P., & Gupta, N. C. (2018). Dust particles characterization and innate resistance for *Thevetia peruviana* in different land-use pattern of urban area. International Journal of Environmental Science and Technology, 15(5), 1061-1072.

[13] Singh, S., Gupta, N. C., & Bhattacharya, P. (2015). Study of mass concentration of particulate matter exposure on weekly basis for two seasons at an urban industrial Site in Delhi. Universal Journal of Environmental Research & Technology, 5(4), 179-187.

[14] Sokolik, I. N., Winker, D. M., Bergametti, G., Gillette, D. A., Carmichael, G., Kaufman, Y. J., & Penner, J. E. (2001). Introduction to special section: Outstanding problems in quantifying the radiative impacts of mineral dust. Journal of Geophysical Research: Atmospheres, 106(D16), 18015-18027.

[15] Srinivasan, S. (2001, December). Land Use Change as a Tool: A Framework to Link Transportation and the Environment in New Delhi, India. In The Workshop on Transportation, Land Use and the Environment.

[16] Tegen, I. (2003). Modeling the mineral dust aerosol cycle in the climate system. Quaternary Science Reviews, 22(18-19), 1821-1834.

[17] Vecchi, R., Marcazzan, G., Valli, G., Ceriani, M., & Antoniazzi, C. (2004). The role of atmospheric dispersion in the seasonal variation of PM1 and PM2. 5 concentration and composition in the urban area of Milan (Italy). Atmospheric Environment, 38(27), 4437-4446.

[18] Watson, J. G., Chow, J. C., Chen, L., Wang, X. L., & Diamond Bar, C. A. (2010). Measurement system evaluation for fugitive dust emissions detection and quantification, Desert Research Institute.