International Journal of Civil Engineering and Technology (IJCIET)
Volume 9, Issue 7, July 2018, pp. 363–372, Article ID: IJCIET_09_07_037
Available online at http://www.iaeme.com/ijciet/issues.asp?JType=IJCIET&VType=9&IType=7
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

ANNUAL AUGMENTATION OF RESPIRABLE PARTICULATES (PM_{10}& $PM_{2.5}$) AND GASEOUS POLLUTANTS (SO_2, NO_2& O_3) IN CHENNAI CITY

Prabakaran P
Research Scholar,
Department of Chemistry, Bharath Institute of Higher Education and Research,
Bharath University, Chennai, India

Manikandan A
Associate Professor and Head, PG and Department of Chemistry,
Bharath Institute of Higher Education and Research, Bharath University, Chennai, India

ABSTRACT

This study measured the atmospheric respirable particulate matters (PM_{10}& $PM_{2.5}$) and gaseous pollutants SO_2, NO_2 and O_3 during the period between July 2015 and June 2017 at five zones of Chennai city namely North zone (Madhavaram), South zone (Tambaram), East zone (Triplicane), west zone (Vadapalani) and centre zone (T. Nagar). Annual mean assessment reveals, the mean of PM_{10} and $PM_{2.5}$ were exceeds the maximum permissible limits prescribed in NAAQS (CPCB, 2009). However the annual mean of SO_2, NO_2, and O_3 at all locations remains under the prescribed limit of NAAQS (CPCB, 2009).The seasonal assessment indicates, summer season experienced with high level of respirable particulates (PM_{10}& $PM_{2.5}$). Specifically, except monsoon season, all seasonal mean of PM_{10} and $PM_{2.5}$ had exceeds the maximum permissible limits, but the level of gaseous pollutants (SO_2, NO_2 and O_3) remains under the permissible limit during entire seasons. Cumulative seasonal comparison shows, that the seasons during July'2016 to June'2017 is loaded with higher pollutants than the seasons of July'2015-June'2016. In further the measured data was assessed in terms of annual augmentation of air pollutants, resulted with all location possessing positive percentage of augmentation with PM_{10} and $PM_{2.5}$. Likewise a gaseous pollutant of SO_2 and O_3 expressively shows positive percentage of augmentation. Whereas, NO_2 shows negative augmentation at Vadapalani and all other locations exhibits positive augmentation. This significant positive annual augmentation indicates, the air quality continuously contaminating and level of pollution was increasing day by day.

Key words: Annual augmentation, NO_2, O_3, PM_{10}, $PM_{2.5}$ and SO_2.

Cite this Article: Prabakaran P and Manikandan A, Annual Augmentation of Respirable Particulates (Pm_{10}& $Pm_{2.5}$) and Gaseous Pollutants (So_2, No_2& O_3) In Chennai City, International Journal of Civil Engineering and Technology, 9(7), 2018, pp. 363–372.
http://www.iaeme.com/ijciet/issues.asp?JType=IJCIET&VType=9&IType=7

1. INTRODUCTION

Air pollution is a complex problem in most of the cities in India, powered by multiple sources ranging from vehicle exhaust, suspended dust on the roads, industrial effluent gases, construction rubbles, garbage burning and seasonal sources like agricultural residue burning, dust storms and sea salt. Due to the rapid urbanization, increased industries, population and automobiles, it cause increased air pollution and thus causing environmental problems [1]. The fast economic growth in the course of rapid urbanization is causing serious air pollution problems in many cities throughout India [2]. Air pollution is gradually recorded as a hazard to public health in most developing countries. Measurement of recent air quality levels, scientific approach on outdoor and indoor air pollution and health effects are important to identify the burden, develop and implement interventions and to create awareness in urban areas [3]. Exposure of polluted air to cause severe health effects, especially in urban areas where pollutions levels are often high [4]. Metropolitan air pollution possessing severe environmental issues in many cities around the world that has long-term impact on people health and atmosphere [5].Urban traffic related air pollutants are associated with acute health consequences as well as chronic respiratory and cardiovascular disease [6] and the children suffering serious allergies, asthma and respiratory infections in both developed and developing countries and the higher prevalence of asthma in urban school children exposed to traffic pollution compared to rural children [7]. Chennai air quality is adversely affected by traffic pollution due to unpredictable escalation of private and public vehicles and the uninterrupted growth of industries [8]. Indian government reported as more than 100 numbers of industrial clusters in India have been identified as polluted hotspots including the North Chennai as one among them. Hence the continuous air pollution study is most wanted work to the society [9].

1.1 Particulate Matters: The road dust, ongoing constructions and industrial activities were contribute to increase the concentration of particulate matter in the developing areas [10]. Particulate matter causes asthma, reduction in visibility and cancer [11]. Particulates can easily penetrate deeply into lungs, they increase the frequency and severity of asthma, aggravate bronchitis and other lungs diseases [12]. Most recent studies focus on finer particulates because of their ability to penetrate deep into the bronchioles and alveoli of the lung, causing direct health hazards like aggravate the existing respiratory and cardiovascular diseases, reduce the body's defence ability against foreign materials, damage to lung tissue, carcinogenesis and premature mortality [13]. Exposure of respirable particulate matters has been increased the number of hospital admissions for a range of cardio-respiratory diagnoses and evets [14].

1.2 Sulphur dioxide (SO_2): Presently SO2 air pollution focused as the main issue in developing countries [15]. The concentration of sulphur dioxide in surroundings is largely affected by anthropogenic interference through burning of the fossil fuel. Brick kilns, located along periphery of cities, play significant role in elevating the SO2 concentration in the ambient air, as they are fed with sulphur rich, inferior quality of coal [16]. Ten minutes exposure of SO2 declines pulmonary function and it cause eye irritation and respiratory inflammation [17]. Combination of particulate matter and sulphur oxides is more harmful than either of them separately [18].

1.3 Nitrogen dioxide (NO_2): Oxides of nitrogen is emitted from a various natural and anthropogenic sources [19]. Highest level of NO_2 was observed at commercial zones during post monsoon season when comparing with all other seasons [20]. Health risk associated with Oxides of nitrogen can cause respiratory disease, asthma, lung irritation and pneumonia [18] and NO_X is easily mixed with blood and then reduces the oxygen level in the blood. It makes the lung tissues inelastic, lung cancer and emphysema [21].

1.4 Ozone (O_3): Ozone is produced in the upper atmosphere by solar reaction. Small concentration of this gas diffuses downward and become the major concern in air pollution. It causes irritation of eyes nose and throat, headache in man [22]. O_3 is a protective shield layer in the stratosphere [23] and harmful to human health at the ground level. An increase in O_3 might responsible to a warming of the Earth's atmosphere [24]. High ozone levels exposure can modify the lung function, airway inflammation and increased airway responsiveness to Broncho constrictors [25].

Due to such a potential negative impact on society, insisted to investigate the concentration of most common air pollutants of PM_{10}, $PM_{2.5}$, SO_2, NO_2 and ground level O_3 in Chennai city. Assessment extended to find out the monthly and annual mean, seasonal variation and the annual augmentation of these pollutants from July 2015 to June 2017. Results from this study may help to society to adopt necessary preventive measure to ensure better environmental condition in the Chennai city, Tamil Nadu.

2. MATERIALS AND METHODS

2.1. Narration of study Area

Chennai is one of the highly populated metropolitan city in India, it has important contribution in the cultural, intellectual and historical growth of India. Nowadays Chennai accomplished with industries like automobile, food, retail and IT sector, etc., and it's geographical specification lies between 12°09', 80° 12NE and 13°09', 80°19'NE [26]. First location Madhavaram is one of the suburbs of northern part of Chennai city and geographically situated at 13.15°N 80.24°E. Second location Tambaram is upcoming big residential locality in Southern part of the metropolitan city of Chennai Southern part of the metropolitan city and located at 12.93°N latitude and 80.11°E longitude. The Third location Triplicane is situated very close to the sea shore of Bay of Bengal with 13.0553°N 80.2807°E. Fourth location Vadapalani is suburban locality of west Chennai at 13.049713°N 80.212555°E. Fifth location of T. Nagar is at 13.03416°N 80.23006°E. Initially T Nagar was a residential locality, but due to industrialization, this locality has turned out to be one the prominent commercial hub.

2.2. Sampling methods

2.2.1 Determination of Respirable Particulate Matter (PM10 and PM2.5): Cyclonic low technique respirable dust sampler sucked the air stream from the atmosphere with 1.0 m^3 per minute as mean flow rate. Due to centrifugal force, non-respirable particulates fall down in a cup attached at the bottom of a conical hopper. Simultaneously, the size less than 10 µm particulates pass through the central exit at the top of the conical hopper, it was collected on pre weighed EPM 2000 filter paper (GF/A 20.3 cm X 25.4 cm). Microprocessor impact technique sampler was used for sampling of PM2.5 in the ambient air. In this microprocessor impact technique, greater than 2.5µm particulates were dropped on silicon oil immersed polytetrafluoroethylene filter paper placed in the air pathway. Simultaneously less than 2.5µm size particulates were collected on the pre-weighed 47mm PTFE filter. Final concentration of PM10 and PM2.5 are measured from the difference between the weight of filter paper after sampling and before sampling is divided by total volume of sampled air. The final result of $PM_{2.5}$ expressed as µg/m^3.

2.2.2 Sampling and analysis of gaseous pollutants (SO_2, NO_2& O_3)

For SO2, Modified West & Gaeke Method was used to collect sample from ambient air, due to air bubbling technique, SO2 absorbed in the 0.04M tetrachloromercurate solution as in the form of dichlorosulphitomercurate complex with 1L/min flow rate. While addition of 0.6% sulphamic acid, 0.2% formaldehyde and para rosaniline solution, this complex converted to penetratingly coloured pararosanilinemethylsulphonic acid. Specific absorbance of pararosanilinemethylsulphonic acid is measured at 560nm. The Modified Jacobs & Hochheiser method was used for NO_2 sampling, it is absorbed in a sodium hydroxide and sodium arsenite solution. From the collected sample, pipetted portion of aliquot, then added hydrogen peroxide, sulphanilamide, NEDA and after colour development period, measured the absorbance of solution at 540 nm. Ozone has been determined by the chemical method described in CPCB guideline. By this method sample collected in 1% KI in 0.1 m Phosphate Buffer absorbing solution, this phosphate buffer solution contains potassium dihydrogen phosphate (KH_2PO_4), disodium hydrogen phosphate (Na_2HPO_4)), and potassium iodide. After sampling, measured the absorbance at 352 nm (UV: Lambda-25).

3. RESULTS AND DISCUSSION

In the present study, measured the concentration of PM_{10}, $PM_{2.5}$, SO_2, NO_2 and O_3 in terms of microgram per cubic meter, at selected zones, such as north zone (Madhavaram), south zone (Tambaram), east zone (Triplicane), west zone (Kodambakkam) and mid zone (T.Nagar) during the period of July 2015 to June 2017. Monthly variation of monitored pollutant in the study location are graphically represented in Figure 1 to Figure 5.

3.1 Respirable Particulate Matters (PM10 & PM2.5): At outcomes, PM_{10} extended from 53.3 µg/m^3 to 248.6 µg/m^3, 55.3 µg/m^3 to 198.3 µg/m^3, 45.2 µg/m^3 to 186.3 µg/m^3, 70.4 µg/m^3 to 245.3 µg/m^3 and 50.3 µg/m^3 to 278.3 µg/m^3 at L1, L2, L3, L4 and L5 respectively. Likewise, $PM_{2.5}$ prolonged from 27.9 to 175.3µg/m3, 29.6to 168.7µg/m3, 21.6to 159.3 µg/m3, 27.9to 178.3µg/m3 and 28.2 to 191.3µg/m3 at L1, L2, L3, L4 and L5 respectively. The peak level of PM_{10} is 278.3 µg/m3 and $PM_{2.5}$ is 191.3 was found at T. Nagar on June 2017and slightest level of PM_{10} is 45.2 µg/m3 and PM2.5 is 21.6 was observed at Triplicane on December 2016.

3.2 Gaseous Pollutants (SO2,NO2 & O3): This study evidenced, that the concentration of SO2 ranged 3.1 to 46.4µg/m3, 4.8 to 42.8µg/m3, 5.6 to 59.6 µg/m3, 5.4 to 64.2 µg/m3 and 3.2 to 77.9 µg/m3 at locations L1, L2. L3, L4 and L5 respectively and it is evidenced, that the level of SO_2 at all location are well below the maximum permitted limit given National Ambient Air Quality Standards, however the high level (77.9 µg/m^3) of SO_2 were found in the month of May 2017 at T.Nagar (L5), this is very close to the maximum permissible limit and least values of 3.1 µg/m^3 is found on January 2016 at Madhavaram (L1). The most common air pollutant of NO_2, resulted 99.6 µg/m3 as highest value at L5 in May 2017 and 5.6 µg/m3 as lowest value at L5 in November 2015. The entire assessment of NO_2 varied from 7.6 to 66.7 µg/m^3, 6.0 to 69.3 µg/m^3, 7.3 to 56.6 µg/m^3, 10.9 to 73.0 µg/m^3 and 5.6 to 99.6 µg/m^3, at locations L1, L2. L3, L4 and L5 respectively. The oxidant gas of O_3 observed no significant deviation when comparing with National Ambient Air Quality Standard and ranged from 0.8 to 86.3 µg/m3, 11.5 to 88.5 µg/m3, 10.5 to 80.4 µg/m3, 13.3 to 81.4 µg/m3 and 11.92 to 101.2 at locations L1, L2. L3, L4 and L5 respectively.

3.3 Seasonal Augmentation: Table 1 to 5 illustrate the monitored seasonal mean values at selected five locations. The study duration covered the couple of pre monsoon, monsoon, post monsoon and summer from July 2015 to June 2017. Seasonal data revealed, that the highest seasonal mean of PM_{10} and $PM_{2.5}$ is 185.2 µg/m3 and 140.7 µg/m3 found during summer 2017 at L5. Except monsoon season, all seasonal mean of PM_{10} and $PM_{2.5}$ had exceed the maximum permissible limit. This research not found significant level of gaseous pollutants. Cumulative seasonal augmentation illustrated that, the high level of pollutants during summer season and lowest level were experienced during monsoon season.

3.4 Annual Augmentation

Annual Mean of PM10 and $PM_{2.5}$ at all selected locations were obtained beyond the permissible limit. In contrast the annual mean of SO_2, NO_2 and O_3 were found within the permissible limits. However the annual comparison shows significant increment from July'2016-June'2017 to July'2015-June'2016.

The outcomes of annual augmentation assessment (from Jul'15-Jun'16 to Jul'16-Jun'17) were graphically represented in Figure-6. Annual augmentation of PM_{10} were observed as 12.2% , 5.22%, 5.11%, 1.23%, 4.62% at L1,L2,L3,L4 and L5 respectively. Similarly the augmentation of $PM_{2.5}$ ware observed as 12.63%, 4.0%, 12.25%, 25.48% and 28.32% at L1, L2, L3, L4 and L5 respectively. This data revealed that, the positive percentage of augmentation noticed in particulate pollutants (PM_{10} and PM2.5) from Jul'2015-Jun'2016 to Jul'2016-Jun 2017.Similarly SO_2 and O_2 significantly observed positive percentage of augmentation 5.59%, 7.56%, 19.21%, 29.99%, 37.83% and 7.18%, 12.52%, 9.34%, 3.22%, 4.04% at L1, L2, L3, L4, and L5 respectively. Whereas NO_2 shows 5.84% of negative augmentation at L4 and other sampling location such as L1, L2, L3 and L5 experienced the positive augmentation of 2.31%, 6.89%, 9.90% and 30.08% respectively.

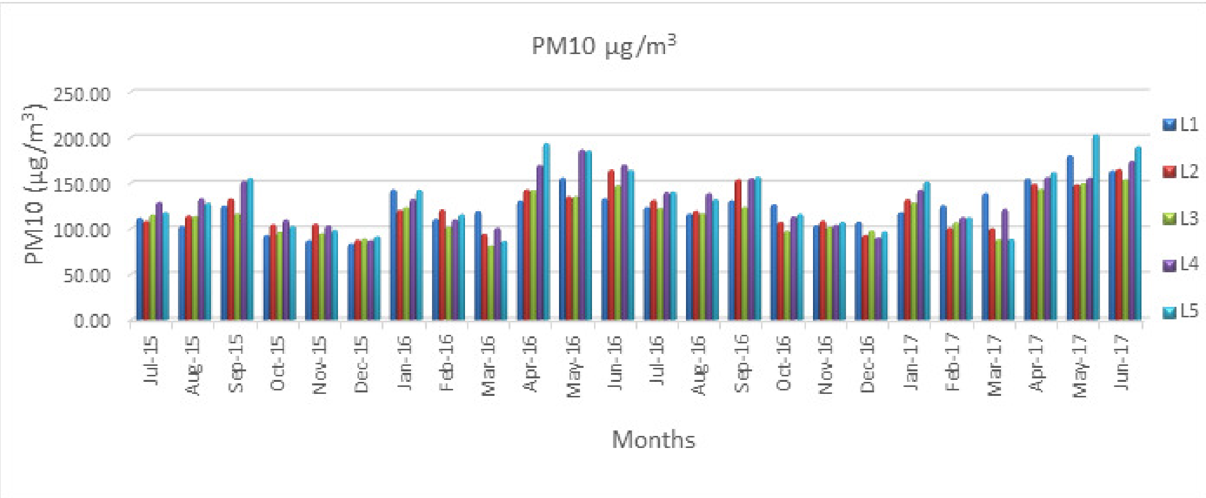

Figure 1 Monthly Variation of PM_{10} µg/m³ at selected location from Jul 2015 to Jun 2017

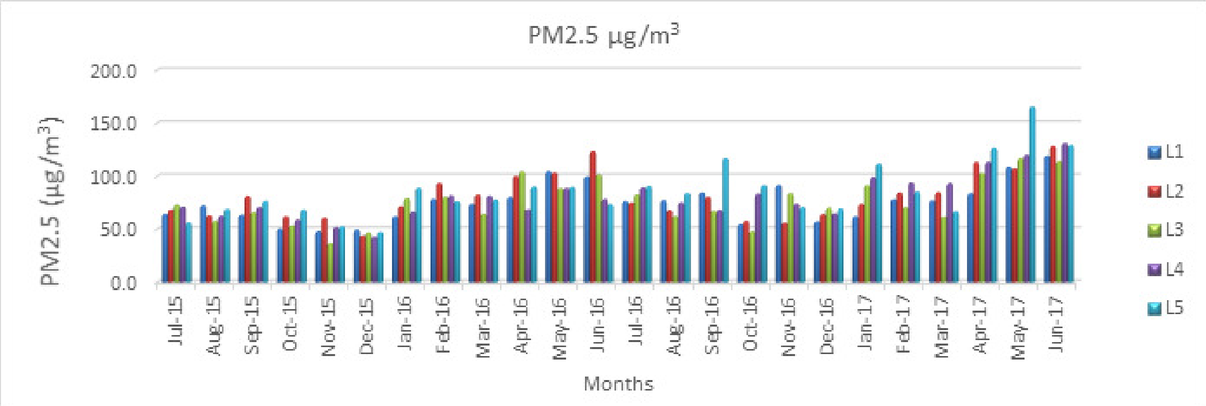

Figure 2 Monthly Variation of $PM_{2.5}$ µg/m^3 at selected location from Jul 2015 to Jun 2017

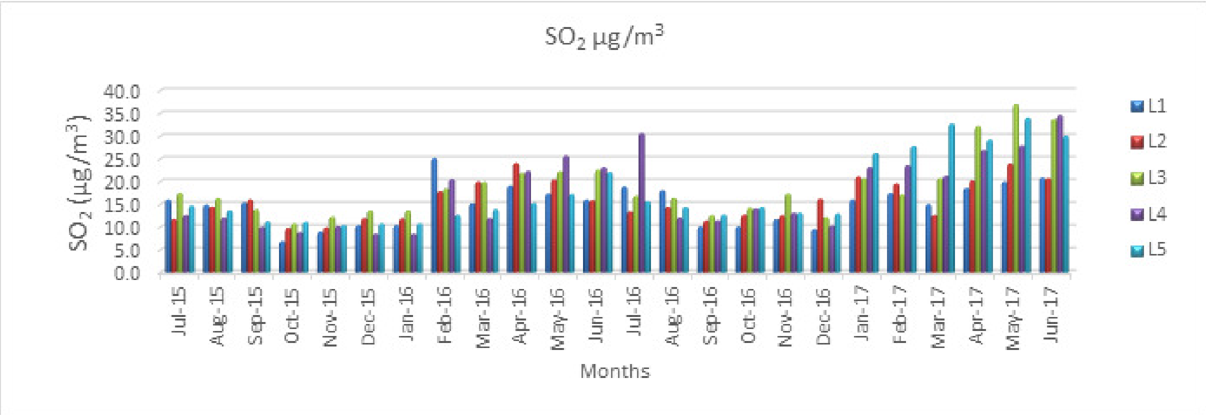

Figure 3 Monthly Variation of SO_2 µg/m^3 at selected location from Jul 2015 to Jun 2017

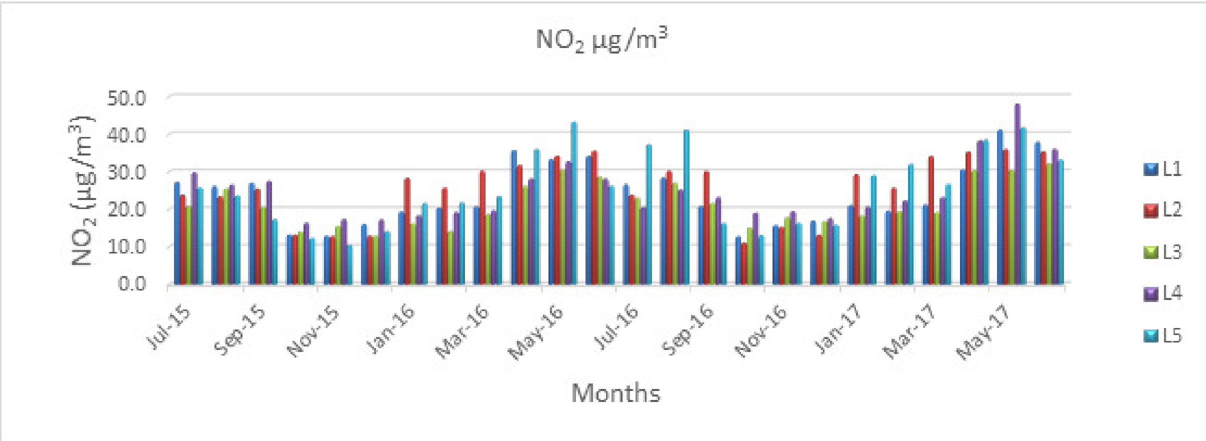

Figure 4 Monthly Variation of NO_2 µg/m^3 at selected location from Jul 2015 to Jun 2017

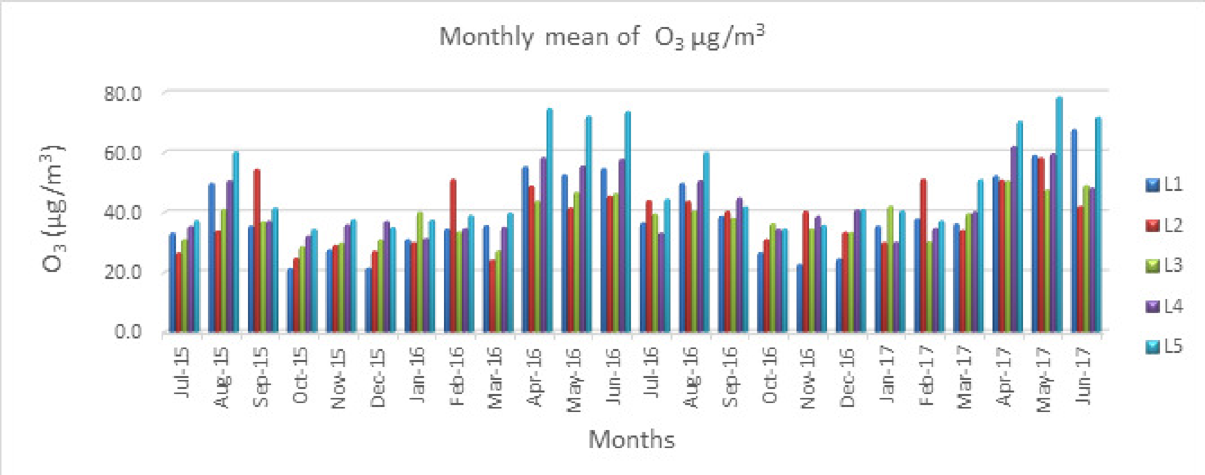

Figure 5 Monthly Variation of O_3 µg/m³ at selected location from Jul 2015 to Jun 2017

Table 1 Seasonal mean of PM_{10}at each selected location from Jul 2015 to Jun 2017

Locations	**Pre monsoon**		**monsoon**		**post monsoon**		**summer**	
	2015-2016	2016-2017	2015-2016	2016-2017	2015-2016	2016-2017	2015-2016	2016-2017
L1	113.3	123.6	87.9	112.7	124.1	127.3	140.0	166.3
L2	118.6	135.1	99.3	103.0	111.8	111.1	147.5	154.3
L3	115.2	121.0	93.3	98.9	102.4	107.9	141.5	149.0
L4	138.3	144.7	100.3	102.6	114.4	125.5	175.5	162.2
L5	133.8	143.2	97.6	107.0	114.9	117.6	181.1	185.2

Table 2 Seasonal mean of PM2. 5 at each selected location from Jul 2015 to Jun 2017

Location	**Pre Monsoon**		**monsoon**		**post monsoon**		**summer**	
	2015-2016	2016-2017	2015-2016	2016-2017	2015-2016	2016-2017	2015-2016	2016-2017
L1	66.9	79.3	49.3	67.9	71.5	72.4	94.9	103.9
L2	70.8	74.4	55.6	59.4	82.5	81.0	109.1	116.4
L3	65.6	70.7	45.7	67.3	74.7	74.6	98.2	111.3
L4	68.3	77.4	51.4	74.1	76.5	95.6	78.6	121.6
L5	67.3	97.1	56.1	77.3	81.0	88.0	84.5	140.7

Table 3 Seasonal mean of SO_2at each selected location from Jul 2015 to Jun 2017

Locations	Pre monsoon		monsoon		post monsoon		summer	
	2015-2016	2016-2017	2015-2016	2016-2017	2015-2016	2016-2017	2015-2016	2016-201
L1	15.4	15.7	8.7	10.4	16.9	16.2	17.5	19.8
L2	14.1	13.1	10.5	13.8	16.6	17.8	20.1	21.6
L3	15.9	15.3	12.2	14.6	17.3	19.5	22.2	34.3
L4	11.6	18.1	9.2	12.5	13.6	22.7	23.7	29.8
L5	13.2	14.2	10.8	13.5	12.4	29.0	18.2	31.1

Table 4 Seasonal mean of NO_2at each selected location from Jul 2015 to Jun 2017

Locations	Pre monsoon		monsoon		post monsoon		summer	
	2015-2016	2016-2017	2015-2016	2016-2017	2015-2016	2016-2017	2015-2016	2016-2017
L1	26.9	25.4	14.1	15.2	20.2	20.7	34.5	36.6
L2	24.3	28.1	13.0	13.2	28.1	29.8	33.9	35.6
L3	22.4	24.0	14.2	16.6	16.4	19.0	28.6	31.0
L4	28.0	23.1	17.1	18.8	27.2	22.2	38.7	40.9
L5	22.3	31.6	12.4	15.1	22.3	29.3	35.2	55.9

Table 5 Seasonal mean of O_3at each selected location from Jul 2015 to Jun 2017

Locations	Pre monsoon		monsoon		post monsoon		summer	
	2015-2016	2016-2017	2015-2016	2016-2017	2015-2016	2016-2017	2015-2016	2016-2017
L1	39.6	41.7	23.5	24.7	33.8	36.6	54.3	59.8
L2	38.4	42.8	27.1	35.0	35.1	38.4	45.4	50.5
L3	36.4	39.4	29.8	34.8	33.7	37.4	45.7	49.1
L4	41.1	43.0	35.1	38.1	33.7	35.0	57.3	56.7
L5	46.5	48.9	35.7	37.2	38.8	43.0	73.6	73.7

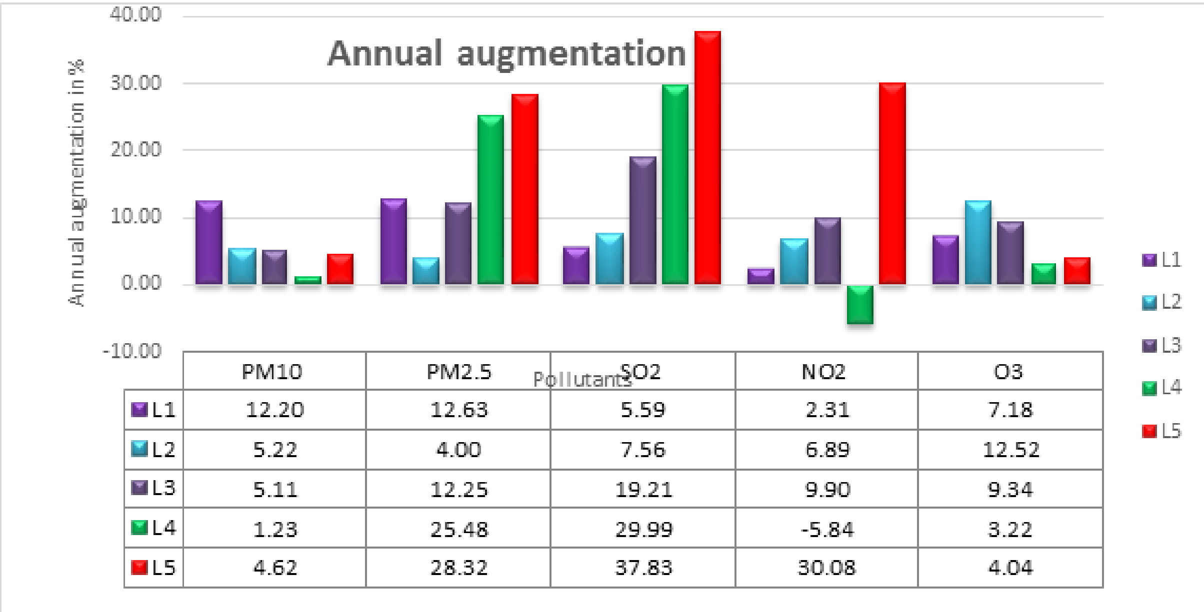

Figure 6 Annual augmentation assessment from Jul’15-Jun’16 to Jul’16-Jun’17)

4. CONCLUSION

The respirable particulate matters and gaseous pollutants were continually increasing in the atmosphere due to various factors. The overall assessment give unblemished view about atmospheric air pollution and Respirable particulate matters (PM10 & PM2.5) are mainly respirable for the contamination of air quality. Observed data revealed, that the respirable particulate matters (PM_{10} & $PM_{2.5}$) were unambiguously increased from 2015 to 2017. Likewise gas pollutants of SO_2, NO_2 and O_3 also considerably increased.

Cumulative comparison of seasonal augmentation evidenced that the concentration of air pollutants were comparatively higher during the seasons of July 2016-June 2017 than the seasons of July 2015-June 2016. In addition the study experienced the highest level of pollutants during summer season when comparing other seasons. The measured predominant positive percentage of annual augmentation clearly indicates the continual increment of air pollutants in the study areas. Due to the uninterrupted urbanization, tremendous growth of vehicles and industrialization, air pollutants were constantly increased in the atmosphere and it is unambiguously proved by this study and outcomes of this work.

This study founds and indicates that, "The Significant positive annual augmentation was seen in Chennai city, were the air quality continuously contaminating and level of pollution increasing day by day".

REFERENCES

[1] V. Pandey, A. Kumar, A. Pal, N. Singh and M. Yunus. Status of Ambient Air Quality in Lucknow City, Indian Journal of Environmental Protection, 19(3), 1999, 181-184.

[2] Tanzir Chowdhury and Mohammad Imran, Morbidity Costs of Vehicular Air Pollution: Examining Dhaka City in Bangladesh, Environmental and Resource economics, 47(10), 2010, 225 - 248.

[3] Yatagama Lokuge S Nandasena, R. Ananda, Wickremasinghe and Nalini Sathiakumar, Air pollution and health in Sri Lanka: a review of epidemiologic studies, BMC Public Health, 300 (10), 2010.

[4] E. T. Wilkins, E. T, Air pollution and the London fog of December 1952, Journal - Royal Sanitary Institute, 74(1), 1954 ; 1–21

[5] E. Gerald e. Streit, Mexico city air quality: progress of an international collaborative project to define air quality management options, Atmospheric environment, 30 (5), 1996, 723-733.

[6] B. Brunekreef, N.A. Anssen, J. De Hartog, H. Harssema, M. Knape , and P. van Vliet, Air pollution from truck traffic and lung function in children living near motorways, Epidemiology, (8), 1997, 298-303

[7] G Hoek, B. Brunekreef, S. Goldbohm S, P. Fischer, P.A. Van den Brandt, Association between mortality and indicators of traffic-related air pollution in the Netherlands: A cohort study. Lancet 360, 2002, 1203-1209.

[8] T. Senthilnathan, Measurement of urban ambient air quality of Chennai city, Indian Journal of air pollution control volume, 8(1), 2008, 35-47.

[9] Ramasamy Jayamurugan, B. Kumaravel, S. Palanivelraja and M. P. Chockalingam, , Influence of temperature, relative Humidity and seasonal variability on ambient air quality in a coastal urban area, International Journal of Atmospheric Science, Vol. 2013, 2013, 1-7

[10] His-Hsien Yang, Ching-Min Yang, Chih-Ho Wung, Chu-Chin Hseieh, Hsiao-Hsuan Mi and Tze-Wen Chi, Emission and Dry Deposition Characteristics of Metal Elements form Engineering Constructive Sites, Aerosol and Air Quality Research, 1 (1), 2001,

[11] D S Khandbahale and R S Saler, Ambient Air Quality Monitoring in Nashik city - (Maharashtra,,India), Bionano Frontier, 6 (2), 2013.

[12] Ki-Hyun Kim, S.A. Jahan, E. Kabir, A review of human health perspective of air pollution with respect to allergies and asthma. Environment International, 59, 2013, 41-52.

[13] l. a. Jimoda, Effect of particulate matter on human health, the ecosystem, climate and materials: a review, facta universitatis series, working and living environmental protection , 9(1), 2012, 27 – 44.

[14] William F. Mcbonnell, Naomi nishino ishikawa, Floyd F. Perterson, Lie hong chen and David E. Abbey. Journal of exposure analysis and environmental epidemiology, 2000 (10), 2000, 427-436.

[15] Bhat Mohd Skinder, Afeefa Qayoom Sheikh, Ashok K. Pandit and Bashir Ahmad Ganai, Brick kiln emissions and its environmental impact: A Review, Journal of Ecology and the Natural Environment, 6 (1), 2014, 1-11.

[16] A.K. Dwivedi, and B. D. Tripathi, Pollution tolerance and distribution pattern of plants in surrounding area of coal-fired industries. Journal of Environmental Biology, 28(2), 2007, 257-263.

[17] N. Sateesh Hosamane, G.P.Desai, Urban air pollution trend in India – Present scenario, International Journal of Innovative Research in Science, Engineering and Technology, 2 (8), 2013, 3738-3747.

[18] P. Balashanmugam, A. R. Ramanathan and V. Nehru Kumar, Ambient Air Quality Monitoring in Puducherry" in International Journal of Engineering Research and Applications, 2 (2), 2012, 300-307.

[19] A K. Al-Khalaf, influence of meteorological and related factors on surface ozone patter at Makkah stations, Journal of Environment Science, 11(1), 2006, 1-19.

[20] S K. Goyal, S.V. Ghatge, P. Nema, S.M Tamhane, Understanding urban vehicular pollution problem vis-à-vis ambient air quality- Case study of a megacity (Delhi, India), Environmental Monitoring and Assessment, 119, 2006, 557-569.

[21] B S. N. Raju, Fundamentals of air pollution, Oxford and IBH, New Delhi, 1997.

[22] Devendra Dohare and Vijayant Panday, Monitoring of Ambient Air Quality in India - A Review, Dohare, International Journal of Engineering Sciences & Research Technology, 3(12), 2014, 237-244.

[23] B. Suresh Kumar Reddy , L.S.S. Reddy, Jun-Ji Cao , K. Raghavendra Kumar, G. Balakrishnaiah, K. Rama Gopal, R.R. Reddy, K. Narasimhulu, Shyam Lal and Y. Nazeer Ahammed, Simultaneous measurements of surface ozone at two sites over southern Asia. A comparative study. Aerosol and Air Quality Research, (11), 2011, 895–902.

[24] M Pulikesi , P. Baskaralingam , D. Elango , V. N. Rayudu, V. Ramamurthi and S. Sivanesan, Air quality monitoring in Chennai, India, in the summer of 2005, Journal of Hazardous Materials, 136 (3), 2006,589-596.

[25] S Harikrishnan, S. Pradeep, M. Ramalingam, N. Prasanna, V. Manivasagan. Ambient Air Quality Monitoring and Possible Health Effects Due to Air Pollution in Hosur Town, Tamilnadu, India , Universal Journal of Environmental Research and Technology, 2(4),2012, 254-26

[26] P. Prabakaran, V. Krishnasamy, A. Manikandan and V. Rambabu, Consequence of Meteorological Factors on Gaseous Pollutants and Seasonal Erraticism in the Ambient Air of Chennai City, Indian Journal of Environmental Protection, 2017, 37(6), 461-474.