CHARACTERIZATION OF AEROSOL TYPE BASED ON AEROSOL OPTICAL PROPERTIES FOR METRO CITIES IN INDIA (2004-2019)

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ABSTRACT

Aerosols source can be anthropogenic or natural aerosols include smoke, dust, exudates from trees and geyser vapor and anthropogenic aerosol particulate air pollutants and smoke include natural aerosols. In this study is form October 2004 to September 2019 are extracted using Moderate Resolution Imaging Spectroradiometer (MODIS) & Ozone Monitoring Instrument (OMI) of remote sensing data across four metro cities in (Chennai, Mumbai, New Delhi & Kolkata) India. AOD, AE, AI, SSA, daily, monthly mean and annual variations between 2004-2019. And also classify aerosol based on various seasons such winter (Dec-Feb), Pre monsoon (March-May), Monsoon (Jun-August), Post Monsoon (Sep-Nov) Aerosol classify into 4 type (Marinetime, Dusty, Urban, Biomass burning), (winter, Pre monsoon, Monsoon, Post Monsoon). AOD, AE, AI, SSA, monthly mean and annual variations between 2004-2019. The daily mean maximum values of AOD, AE, AI and SSA is 0.69, 1.55, 1.41, 0.93. and minimum values are 0.39, 1.34, 1.00, 0.92. maximum monthly mean variation of AOD, AE, AI ,SSA is 0.72, 1.54, 1.31, 0.93, and maximum yearly mean variation are 0.72, 1.54, 1.31, 0.93. similarly minimum monthly mean variation of AOD, AE, AI ,SSA is 0.39, 1.19, 0.20, 0.92, and minimum yearly mean variation are 0.38, 1.21, 0.22, 0.92. The rise in AOD over Delhi and Kolkata can be due to increased urbanization and burning of biomass. and overall classification of dominated zones are maximum values in marinetime of monthly mean values are in maximum (32%) in Chennai and minimum (9%) in New Delhi, and maximum values in Dusty of monthly mean values are in maximum (24%) in New Delhi and minimum (9%) in Mumbai. and maximum values in Urban of monthly mean values are in maximum (42%) in Chennai, and minimum (21%) in New Delhi, and maximum values in Biomass Burning of monthly mean values are in maximum (46%) in New Delhi, and minimum (9%) in Chennai. For dominated zones are maximum seasonal classification for marinetime (25%) in Pre monsoon and minimum (8%) in monsoon, and maximum seasonal classification for Dusty (36%) in Monsoon and minimum (6%) in Winter. and maximum seasonal classification for Urban (41%) in Pre monsoon and minimum (5%) in monsoon, and maximum seasonal classification for Biomass burning (37%) in post monsoon and minimum (13%) in Pre monsoon. AODs decreased at Chennai and Mumbai high-altitude locations. AODs and wind speeds increased over New Delhi.

Keyword: - *Aerosol Optical Depth, Aerosol Type, Spatiotemporal Variation*

1. INTRODUCTION

Aerosols are solid and/or liquid particles suspended in the mixture of carrier gasses. Mostly the carrier gas is air. The size of aerosol particles usually ranges from few hundred micrometers to few nanometers in diameter. The chemical composition and their physiochemical properties are instable and changes with due course of time while they remain in the atmosphere by undergoing various physical and chemical transformation processes.

The ambiguous nature of aerosol particles leads to the uncertainty in various processes such as cloud formation, reduced visibility meteorological interactions, earth's radiation budget, effects on atmospheric chemistry and human health. Therefore Deep and detailed knowledge of aerosol optical properties and their types at regional and global level along with their special temporal variation is necessary to obtain the accuracy in the radiative transfer affect which is responsible for global climatic changes. This study is aim to analyze the spatio-temporal variation of multiple aerosol optical properties at the metro cities of India for the duration of 2004 2019. Daily mean variation of Aerosol Optical Depth (AOD), Angstrom Exponent (AE), UV Index AI, and Single scattering albedo (SSA).

We also try to identify the aerosol type in selected cities (Chennai, Mumbai, New Delhi & Kolkata) from entire period of October 2004 to September 2019 depending on their source of origin- maritime, dusty, urban, biomass burning co relating the aerosol loading (AOD) and particle size (AE). And also classify aerosol based on various seasons such winter (Dec-Feb), Pre monsoon (March-May), Monsoon (Jun-August), Post Monsoon (Sep-Nov) Aerosol classify into 4 type (Marinetime, Dusty, Urban, Biomass burning), (winter, Pre monsoon, Monsoon, Post Monsoon).

In addition to all these impacts listed, aerosols also play a role essential positions in the Earth's radiation budget. They have got Indirect impact by contact with various atmospheric conditions to affect the formation of components, such as water vapour, the lifespan of clouds. The direct influence of aerosols includes atmospheric radiation reflection, scattering, and absorption.

2. MATERIALS AND METHODS

2.1 Study Area

In this paper, October 2004 to September 2019 classified aerosol styles entire period over cities, (Chennai, Mumbai, Delhi, Kolkata) for using regular information obtained from MODerate Resolution Imaging (MODIS) Sensors from Aqua and OMI. Which is the most metro cities in India. In this study various parameters are obtained locations. In this study obtained the data from Giovanni satellite with the help of latitude and Longitude of various locations. AE is used to define the spectrum dependence of the aerosol and AI values are given in the total absorbing column. Spray from within the ultraviolet bands. The MODIS equipment was launched as part of the Aqua platform on 1 October 2004 on board the NASA Earth Observation System (EOS) Aqua platform.

Table -1: These are selected monitoring stations for Aerosol optical Properties

SL NO.	Region	State/Union territory /Capital	Lat.(N)	Long. (E)	Elevation (MSL)
1.	Chennai	Tamilnadu	13.0	80.2	16
2.	Mumbai	Maharashtra	18.9	72.8	11
3.	New Delhi	Delhi*	28.5	77.1	233
4.	Kolkata	West Bengal	22.6	88.4	6

Fig -1: Study area locations for Aerosol optical properties are (a) Chennai (b) Mumbai (c) Kolkata and (d) Delhi

2.2 Data Description and Collection

Giovanni is a platform that shows Earth science data directly on the Internet from NASA satellites and can be retrieved data October 2004 to September 2019 city of (Chennai, Mumbai, Delhi, Kolkata) MODIS Terra form, i.e. Aerosol Optical depth, Angstrom Exponent, Aerosol Index and Single Scattering Albedo without the complexity of conventional methods of data collection and analysis.

2.3 Aerosol identification was done by using the data provided in Table 2

Aerosol type can be classified with the help of table 2, for (Marinetime, Dust, Urban and Biomass burning)

Aerosol types	**Aerosol optical depth (AOD)**	**Angstrom exponent (AE)**
Maritime	< 0.3	0.5–1.7
Dust	> 0.4	< 1.0
Urban	0.2–0.4	> 1.0
Biomass burning	> 0.7	> 1.0

3. RESULTS AND DISCUSSIONS

3.1 Daily variation in aerosol optical properties

In this paper, October 2004 to September 2019 classified aerosol styles entire period over metro cities, (Chennai, Mumbai, Delhi, Kolkata). In this study various parameters are obtained for these locations. The geo-locations of the selected study locations are mentioned in Table 1.

Table -3: Daily Mean of Aerosol Optical properties.

SL NO.	**CITY**	**AOD DAILY (Mean±stdev)**	**AE DAILY (Mean±stdev)**	**AI DAILY (Mean±stdev)**	**SSA DAILY (Mean±stdev)**
1.	Chennai	0.437±0.233	1.343±0.488	1.018±0.204	0.938±0.018
2.	Mumbai	0.397±0.217	1.550±0.387	1.005±0.483	0.922±0.023
3.	New Delhi	0.699±0.408	1.397±0.434	1.416±0.737	0.921±0.023
4.	Kolkata	0.634±0.404	1.516±0.351	1.127±0.487	0.933±0.021

3.2 Average monthly mean values along with annual average mean variation of AOD, AE, AI and SSA

Chennai

Fig 2 shows the monthly and annual averaged mean values of AOD, AE, AI and SSA for New Delhi from the statistical analysis of the data, it was observed that the maximum value of monthly averaged mean AOD was 0.81 and occurred in June 2008. While the minimum value was 0.19 and occurred in December 2015. The annual mean

value of AOD ranged from 0.37 (2004) to 0.53 (2018). The maximum of monthly averaged mean AE was 1.75 and occurred in December 2011. While the minimum value was 0.02 and occurred in August 2009. The annual mean value of AE ranged from 1.00 (2015) to 1.53 (2004). The maximum of monthly averaged mean AI was 1.80 and occurred in January 2019. While the minimum value was 0.20 and occurred in February 2017. The annual mean value of AI ranged from 0.04 (2007) to 0.86 (2019). The maximum of monthly averaged mean SSA was 0.98 and occurred in September 2013. While the minimum value was 0.90 and occurred in October 2005. The annual mean value of SSA ranged from 0.93 (2019) to 0.94 (2007).

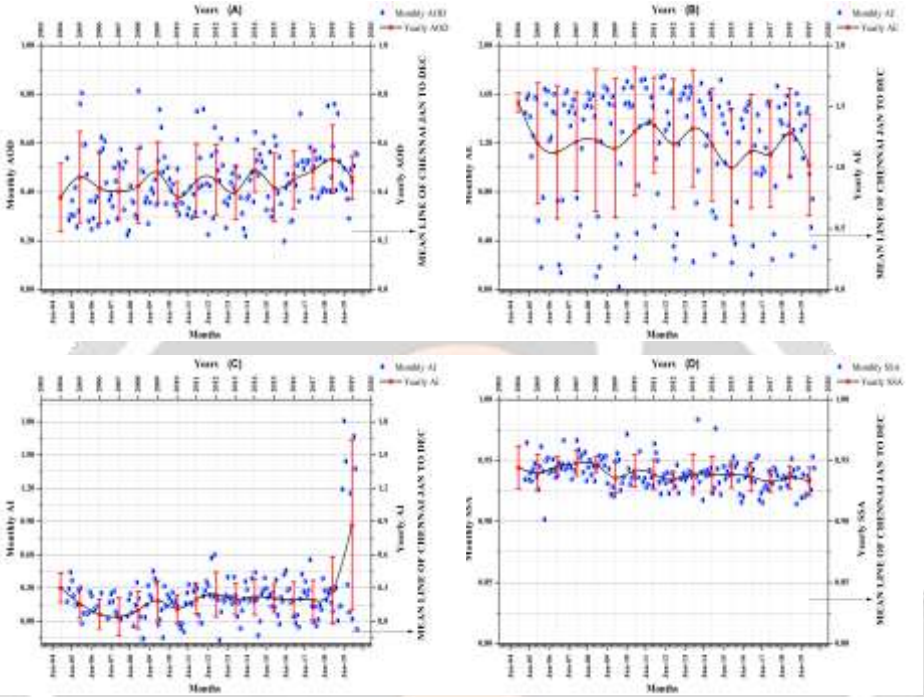


Fig. 2 Average mean value along with annual average mean variation (a) AOD, (b) AE, (c) AI and (d) SSA) of Chennai

Mumbai

Fig 3 Mumbai shows the monthly and annual averaged mean values of AOD, AE, AI and SSA for New Delhi from the statistical analysis of the data, it was observed that the maximum value of monthly averaged mean AOD was 1.87 and occurred in July 2014. While the minimum value was 0.12 and occurred in July 2018. The annual mean value of AOD ranged from 0.44 (2004) to 0.78 (2015). The maximum of monthly averaged mean AE was 1.8 and occurred in July 2014. While the minimum value was 0.35 and occurred in June 2005. The annual mean value of AE ranged from 1.35 (2019) to 1.57 (2009). The maximum of monthly averaged mean AI was 2.02 and occurred in April 2017. While the minimum value was 0.58 and occurred in July 2012. The annual mean value of AI ranged from 0.90 (2004) to 1.15 (2019). The maximum of monthly averaged mean SSA was 0.98 and occurred in August 2014. While the minimum value was 0.90 and occurred in December 2017. The annual mean value of SSA ranged from 0.93 (2017) to 0.94 (2007).

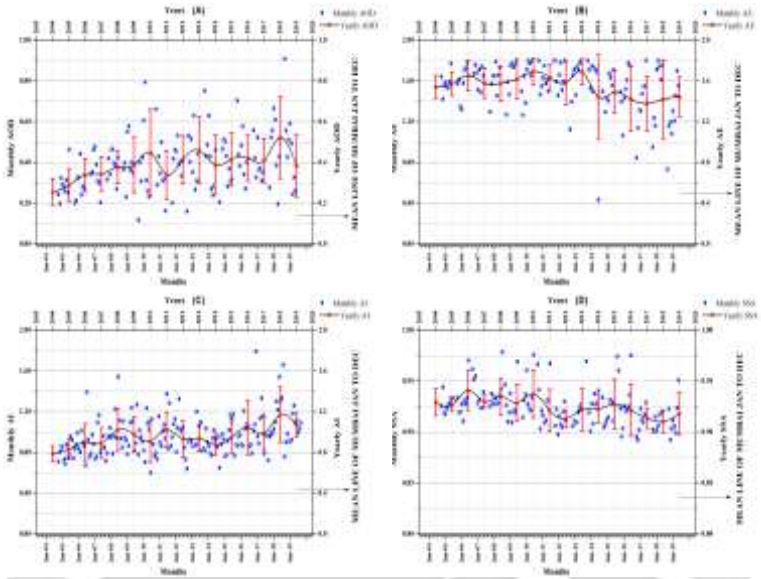


Fig. 3 Average mean value along with annual average mean variation (a) AOD, (b) AE, (c) AI and (d) SSA of Mumbai

New Delhi

Fig 4 shows the monthly and annual averaged mean values of AOD, AE, AI and SSA for New Delhi from the statistical analysis of the data, it was observed that the maximum value of monthly averaged mean AOD was 1.53 and occurred in August 2019. While the minimum value was 0.38 and occurred in February 2005. The annual mean value of AOD ranged from 0.62 (2009) to 0.79 (2012). The maximum of monthly averaged mean AE was 1.79 and occurred in April 2019. while the minimum value was 0.53 and occurred in April 2017. The annual mean value of AE ranged from 1.37 (2005) to 1.60 (2004). The maximum of monthly averaged mean AI was 2.72 and occurred in May 2018. While the minimum value was 0.56 and occurred in August 2011. The annual mean value of AI ranged from 1.19 (2013) to 1.55 (2018). The maximum of monthly averaged mean SSA was 0.97 and occurred in July 2005. While the minimum value was 0.88 and occurred in April 2010. The annual mean value of SSA ranged from 0.91 (2017) to 0.93 (2008).

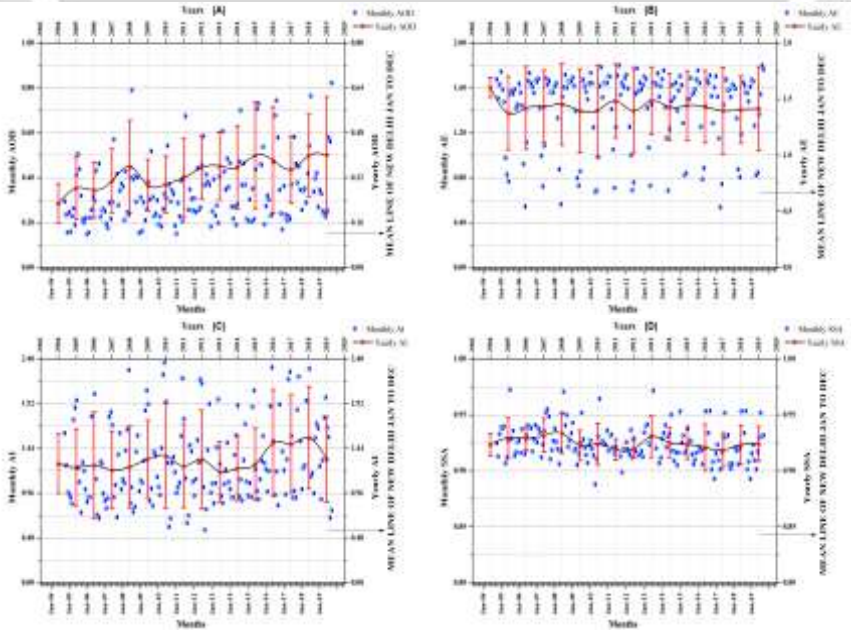


Fig. 4 Average mean value along with annual average mean variation (a) AOD, (b) AE, (c) AI and (d) SSA) of New Delhi

Kolkata

Fig shows the monthly and annual averaged mean values of AOD, AE, AI and SSA for New Delhi from the statistical analysis of the data, it was observed that the maximum value of monthly averaged mean AOD was 0.90 and occurred in September 2018. While the minimum value was 0.11 and occurred in September 2009. The annual mean value of AOD ranged from 0.25 (2004) to 0.52 (2018). The maximum of monthly averaged mean AE was 1.8 and occurred in September 2011. While the minimum value was 0.43 and occurred in June 2014. The annual mean value of AE ranged from 1.37 (2017) to 1.69 (2010). The maximum of monthly averaged mean AI was 1.79 and occurred in December 2016. While the minimum value was 0.60 and occurred in June 2010. The annual mean value of AI ranged from 0.79 (2004) to 1.17 (2018). The maximum of monthly averaged mean SSA was 0.97 and occurred in July 2008. While the minimum value was 0.89 and occurred in November 2016. The annual mean value of SSA ranged from 0.91 (2018) to 0.94 (2006).

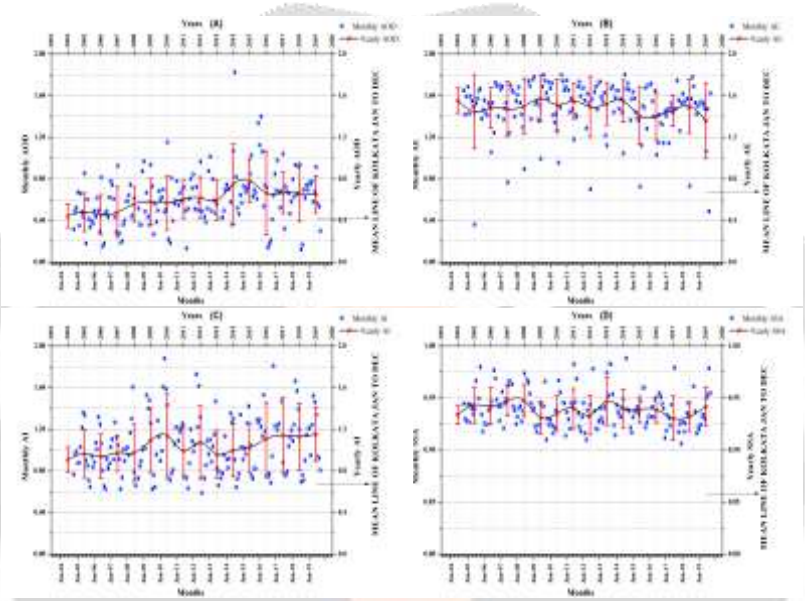
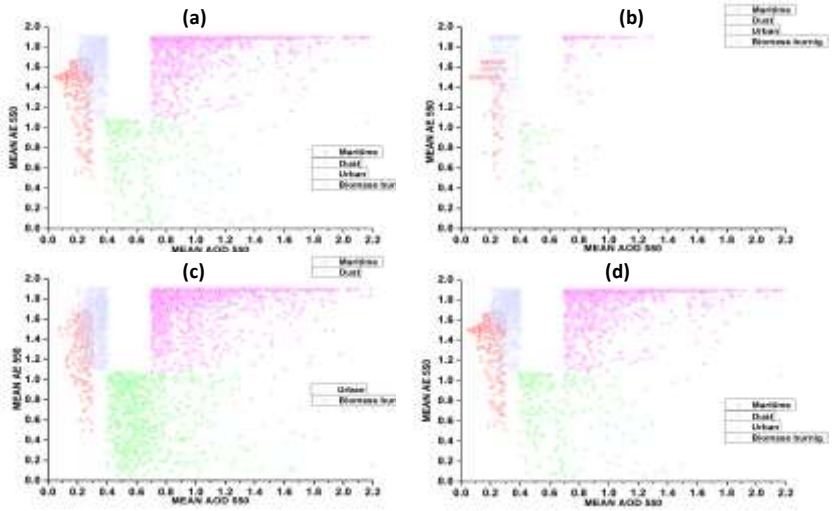


Fig. 5 Average mean value along with annual average mean variation (a) AOD, (b) AE, (c) AI and (d) SSA) of Kolkata

3.3 Types of aerosol (Marinetime, Dusty, Urban, Biomass burning) during the study period October 2004 to September 2019

These results indicate Fig. 6 (a) Chennai, (b) Mumbai, (c) New Delhi and (d) Kolkata shows that overall classification of aerosol type based on AOD, AE, the Chennai city was dominated by (42%) Urban followed by Marinetime (32%), Dusty (16%) and Biomass burning (9%). For Mumbai city was dominated by (45%) Urban followed by Marinetime (31%), Biomass burning (14%) and Dusty (8%).For New Delhi city was dominated by (46%) Biomass burning followed by Dusty (24%), Urban (21%) and marine time (8%). For Kolkata city was dominated by (42%) Biomass burning followed by Urban (29%), marinetime (18%) and Dusty (9%).



Overall classification of aerosol type (Marinetime, Dusty, Urban, Biomass Burning) based on AOD, AE for Fig. 6 (a) Chennai (b) Mumbai (c) New Delhi and (d) Kolkata

3.3 SEASONAL CLASSIFICATION (Winter, Pre monsoon, Monsoon, Post monsoon)

Fig 7 (a) The Urban aerosols dominated (54%) in winter, while the minimum contribution (7%) was observed in Monsoon. The dusty aerosols showed major contribution (78%) in Monsoon while minimum contribution (6%) was observed in Pre monsoon. The biomass burning aerosol dominated (19%) for Post monsoon. whereas minimum contribution (3%) was observed during Monsoon. The maritime aerosol dominated (39%) in Pre monsoon. whereas minimum contribution (11%) was observed in Monsoon.

Fig 7 (b) The Urban aerosols dominated (65%) in Pre monsoon, while the minimum contribution (0%) was observed in Monsoon. The dusty aerosols showed major contribution (13%) in Post monsoon while minimum contribution (0%) was observed in Monsoon. The biomass burning aerosol dominated (23%) for winter. whereas minimum contribution (0%) was observed during Monsoon. The maritime aerosol dominated (33%) in Post monsoon. whereas minimum contribution (0%) was observed in Monsoon.

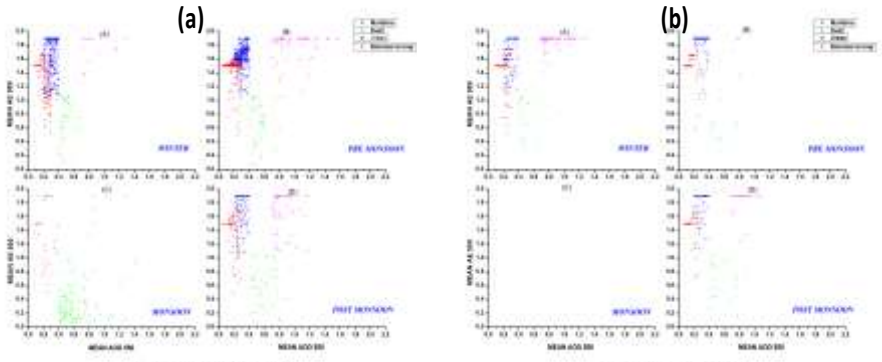


Fig 7 (c) The Urban aerosols dominated (39%) in winter, while the minimum contribution (7%) was observed in monsoon. The dusty aerosols showed major contribution (60%) in Pre monsoon while minimum contribution (1%) was observed in winter. The biomass burning aerosol dominated (82%) for Post monsoon whereas minimum contribution (8%) was observed during pre monsoon. The maritime aerosol dominated (10%) in Pre monsoon. whereas minimum contribution (2%) was observed in Post monsoon.

Fig 7 (d) The Urban aerosols dominated (38%) in Post monsoon, while the minimum contribution (7%) was observed in Monsoon. The dusty aerosols showed major contribution (45%) in Monsoon while minimum contribution (3%) was observed in winter. The biomass burning aerosol dominated (63%) for winter. whereas minimum contribution (30%) was observed during Post monsoon. The maritime aerosol dominated (27%) in Post monsoon. whereas minimum contribution (10%) was observed in winter.

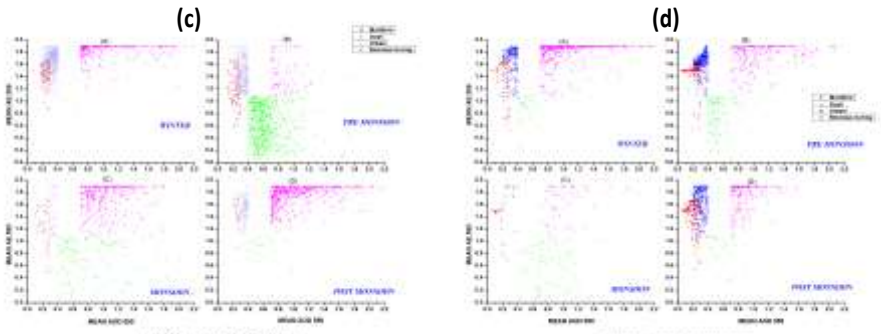


Fig. 7 Seasonal classification of aerosol type (Marinetime, Dusty, Urban, Biomass Burning in winter, Pre monsoon, Monsoon, Post Monsoon) based on AOD, AE for (a) Chennai (b) Mumbai (c) New Delhi and (d) Kolkata

4. CONCLUSIONS

This study presented aerosol optical properties (AOD, AE, AI, SSA) utilizing MODIS, AQUA, and TERRA satellites direct solar measurements from Giovanni radiometers for different pollution. In this study was an attempt to analyze the temporal variation of aerosol properties (AOD, AE, AI, SSA) for the period of October 2004 to September 2019 over metro Cities of India. On daily annual mean values are observed location is 0.69, 1.55, 1.41, 0.93 and monthly mean basis different average values of observed 4 metro cities location of India and daily maximum variation of AOD, AE, AI, SSA are placed above (Table 3) respectively. Daily maximum with annual mean values are 0.53, 1.41, 0.88, 0.93. in this study overall classification (Marinetime, Dusty, Urban, Biomass Bunrning) maximum percentage is (32%) in marinetime, (24%) in Dusty, (46%) Urban, and Biomass burning is (46%). Seasonal with the help of (AOD and AE) basis maximum overall classification in marinetime, dusty, urban biomass burning in (fig 3.3) is (25%) in Pre monsoon, (36%) in monsoon, (41%) in pre monsoon, (37%) in monsoon. These results suggest that MODIS–Aqua AOD retrievals give good estimates of AOD over metro cities in India. These findings become important and useful in the context of regional and global climate change due to aerosols.

5. REFERENCES

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