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Carbonaceous Aerosol Characterization and their Association with Meteorological Parameters at an Industrial Region in Delhi, India

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ABSTRACT

The present study has been carried out focusing on the characterization of carbonaceous aerosol near an industrial region in New Delhi, India. It also determines the variation of carbonaceous species during the summer monsoon (SM) and winter monsoon (WM), interprets the morphological description of aerosol particles, identifies the major sources of carbonaceous aerosol, and recognizes the role of meteorological parameters in terms of OC-EC variability. PM_{10} samples were collected and atmospheric organic carbon (OC) and elemental carbon (EC) were determined during SM and WM seasons in 2016–2017. Owing to high combustion and emission activities in the industrial area, the OC concentration was 70.3±53.7 and 94.3 ± 40.3 μgC/m³ during the SM and WM, respectively, with an overall average of 79.9±44.9 μgC/m³, and the EC concentration was 50.8 ± 53 and 62.6±49.8 μgC/m³, respectively, with an overall average of 58.3±46.7 μgC/m³. The morphological observations of collected particles were studied and the char/soot particles, iron-rich particles, and aggregates of calcium sulfate particles were observed during both seasons. The OC/EC ratio suggested the presence of mixed sources at the industrial location, predominated by industry and motor vehicle emissions. The relationship of carbonaceous aerosol with meteorological variables was also studied, and it was found that temperature, atmospheric stability, wind direction, and rain intensity significantly affect the levels of OC as compared to that of EC during both seasons. Furthermore, it was also noticed that high intensity rain decreases the carbonaceous aerosol significantly and vice versa.

AIM OF THE STUDY

1. To determine the variation of carbonaceous species during the SM and WM season.
2. Interpret the morphological variability of aerosol particles
3. Identify the role of meteorological parameters in terms of OC-EC variability.

MATERIALS & METHODS

Table1. Sampling Sites

S. No.	Station	Code	Nature of Sampling Site
1	Okhla Industrial area, New Delhi	OK	• Dominated by industrial activities and roads having high traffic density.

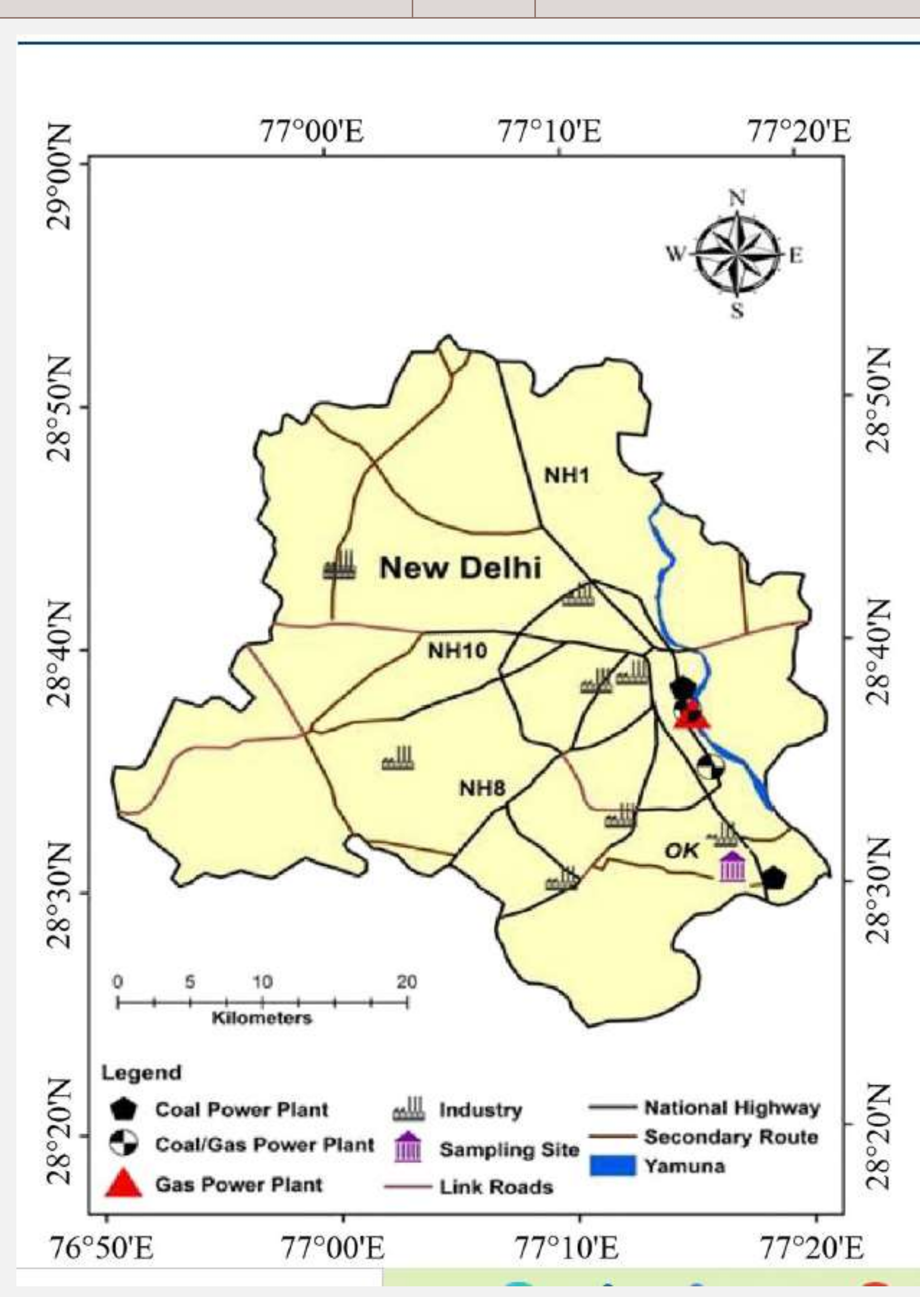

Fig.1 Map of the study area showing sampling sites

Sampling Protocol and Analysis

• **PM_{10} samples:** collected on Quartz GF/A (8"x10") glass fiber filters using Respirable Dust Sampler (Model MLRDS-002, Mars Bio-analytical Pvt. Ltd) at a constant flow rate of 1.1 m³/min during May 2016 to April 2017.

Analysis:
•The OC and EC accumulated on the quartz filters were analysed by the DRI Model 2001 (Thermal/Optical Reflectance) using IMPROVE-A protocol, mentioned in Chow *et al*., (1993).
•Scanning Electron Microscope (SEM) (Carl Zeiss AG-EVO® 40 Series Model) was used for morphological characterization of aerosol.

RESULTS & DISCUSSION

Parameters	SM (average ± SD)	WM (average ± SD)	Avg. (mean ± SD)
PM_{10}	144.1 ± 53.7	210.4 ± 50.7	174.6 ± 64.0
OC_2	14.0 ± 10.2	22.6 ± 19.6	18.2 ± 14.6
OC_3	23.7 ± 11.5	36.3 ± 14.9	30.5 ± 13.6
OC_4	5.9 ± 3.4	3.6 ± 2.0	4.6 ± 2.8
EC_1	37.9 ± 32.8	76.0 ± 34.6	58.3 ± 36.0
EC_2	1.2 ± 0.6	3.0 ± 4.4	2.1 ± 3.0
EC_3	0.2 ± 0.2	0.4 ± 0.3	0.3 ± 0.2
OC	70.3 ± 53.7	94.3 ± 40.3	79.9 ± 44.9
EC	50.8 ± 53	62.6 ± 49.8	58.3 ± 46.7
TC	121.1 ± 104.8	156.9 ± 80.4	138 ± 85.5
OC/EC	3.9 ± 4.4	2.8 ± 3.2	3.4 ± 3.7
OC/PM_{10}	0.46 ± 0.16	0.44 ± 0.12	0.44 ± 0.13
EC/PM_{10}	0.28 ± 0.21	0.16 ± 0.23	0.25 ± 0.22

Table 2
Descriptive Statistics for the Levels (Average ± Standard Deviation) of PM_{10}, OC, EC, and Their Fractions With Different Ratios of Average PM_{10}, OC, and EC During SM, WM and Overall Study Period

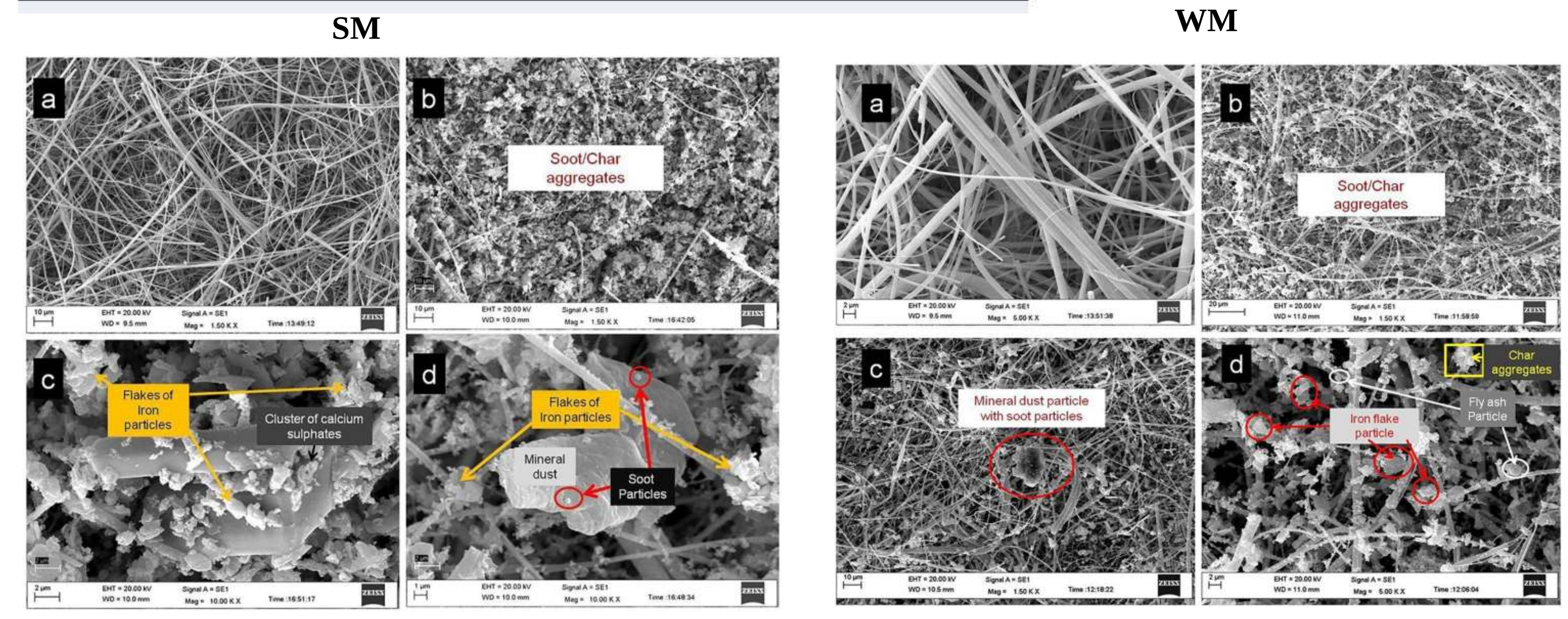

Fig.2 Morphological characteristics of PM_{10} during SM (left side) & WM (right side) season at Okhla site

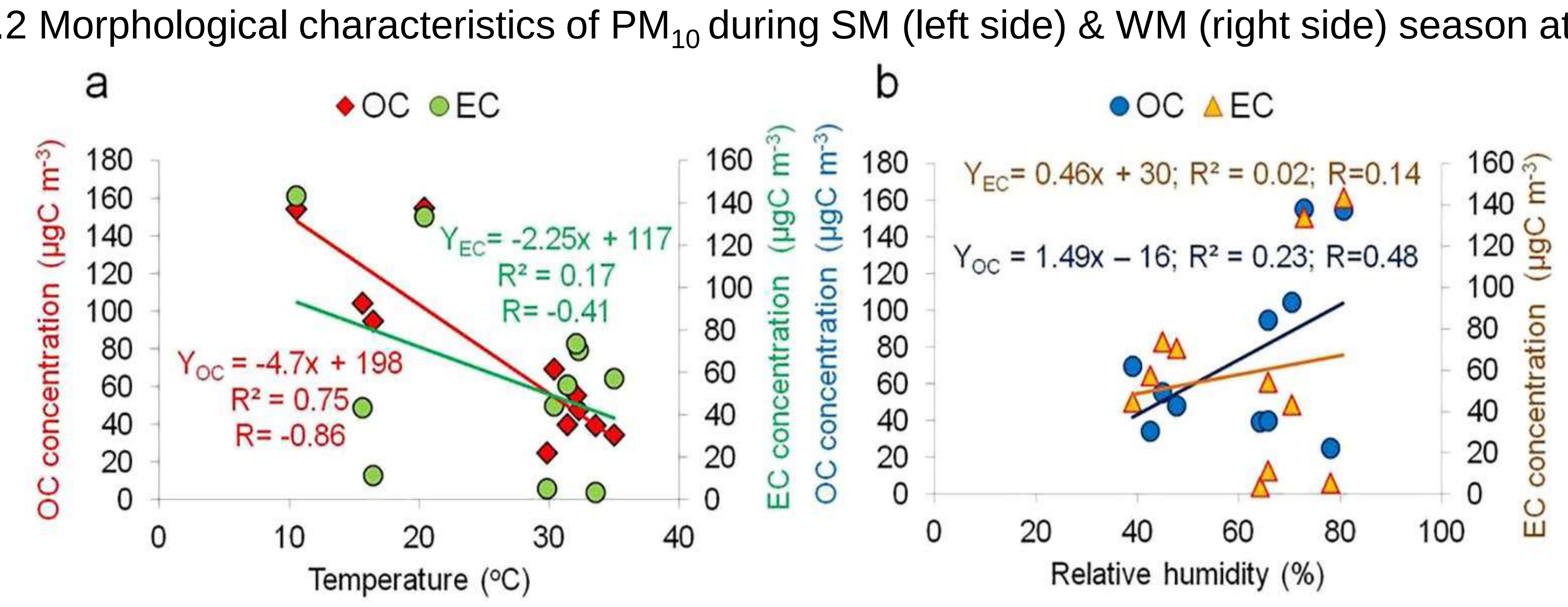

Fig.3 Relationship of carbonaceous aerosol with (a) temperature (°C) and (b) relative humidity (%).

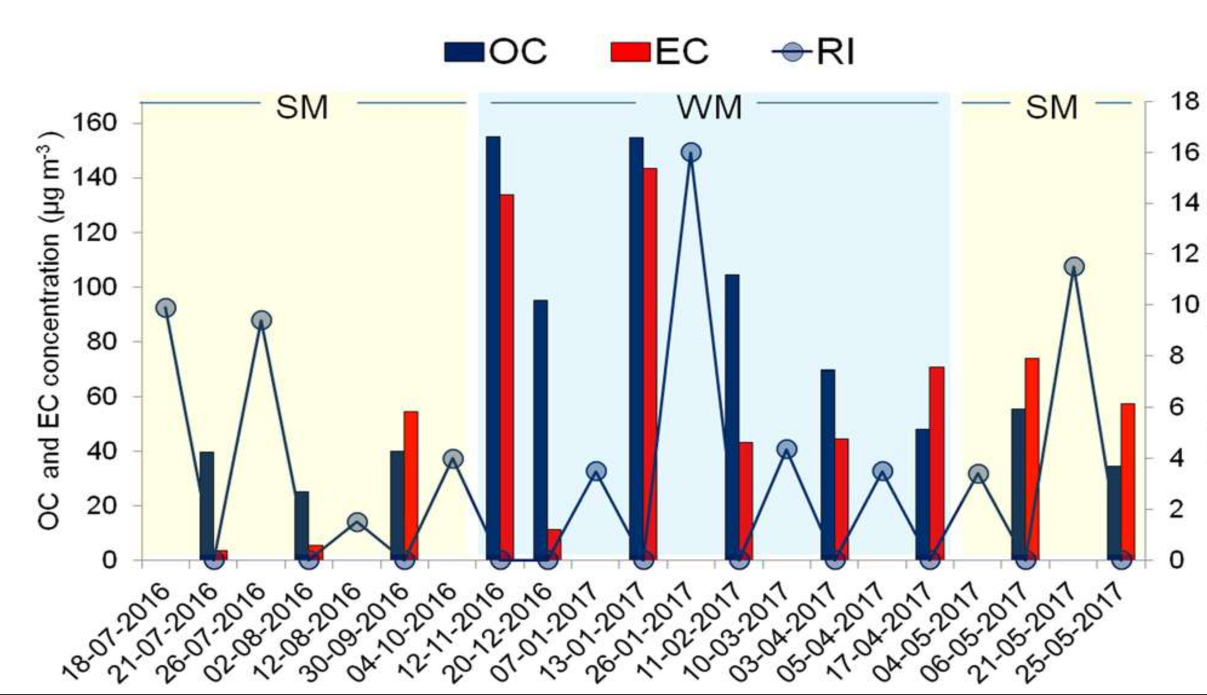

Fig.4 Time series of rain intensity with carbonaceous aerosol concentration.

CONCLUSION

• Study showed a relatively higher OC and EC levels in PM_{10} & TSP_{RW} during the NM season than in the M season.
•Morphological analysis of PM_{10} showed that the fresh & aged soot particles, Fe-rich particles, crystal of sulphate of Ca/K and clay particles predominated at JNU site and char/soot particles, iron-rich particles, Fly ash particle, and mineral particles were observed at OK site.
• Meteorological parameters like wind, ambient temperature, percentage humidity, and rain intensity played a significant role affecting the levels of OC as compared to that of EC during both seasons.
• It was also observed that the high-intensity rain decreases OC significantly as compared to EC from atmosphere.

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