CONTRIBUTION OF ORGANIC CARBON AND ELEMENTAL CARBON TO HAZE FORMING PARTICLES IN DELHI

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ABSTRACT

Delhi is one of the ten most polluted cities of the world. The concentration of TSP and PM_{10} in Delhi exceeds by many times the national and WHO standards resulting in adverse effects on human health and atmospheric visibility. The present study was undertaken to determine the concentrations of organic carbon (OC) and elemental carbon (EC) in fine and coarse fractions of PM_{10}. The study was carried out during a period of June – October 2003 in Delhi. The period of study was purposefully chosen to see the effects of pre-monsoon (June-July) and post-monsoon (October) months on PM_{10} concentration. August and September are the main monsoon months in Delhi. The PM_{10} sampling was done by eight-stage Andersen impactors at two different sites - urban and urban background- in Delhi. Concentrations of OC and EC were subsequently measured by ELTRA CS-500 carbon analyzer. In general, the concentration of PM_{10} was more in pre and post monsoon months as compared to monsoon months and it was highest in the month of June when frequent heavy dust-storm conditions prevail. The average PM_{10} concentration varied between 116-488 $\mu g/m^3$which exceeds the national standard of $60\mu g/m^3$. The average concentration of OC and EC in PM_{10} varied between 57-66$\mu g/m^3$ and 13-33$\mu g/m^3$ respectively. Up to 47% of OC and 41% of EC was in fine fraction ($PM_{2.1}$) of PM_{10}. The study concluded that OC and EC were the major components of visibility impairing aerosol in Delhi.

1. INTRODUCTION

There is a serious concern all over the world about rising concentration of fine particulate matter in the atmosphere as it influences earth's radiative balance, visibility and human health. Recent epidemiological evidences support a link between adverse health effects and fine particles [1]. Fine particles are also the major cause of Haze formation and reduced visibility at local and regional levels. The influence of fine particles on earth's radiation balance is manifested directly by scattering and absorbing solar radiation, termed direct aerosol radiative forcing [2]. As a result, fine particles have been targeted for chemical speciation to explore the relationship between particle characteristics and their likely consequences on various aspects of human environment. However, scientific information available concerning various sources of fine particles is limited.

Haze is caused by fine particles that scatter and absorb light before it reaches the observer. As the number of fine particles increases, more light is absorbed and scattered resulting in poor visibility. These particles in general, constitute sulphates, nitrates, carbonaceous materials and crustal materials. Carbonaceous species, organic carbon (OC)

and elemental carbon (EC) are the major constituents of atmospheric fine particulate matter. Elemental carbon is the principal light absorbing species in the atmosphere, playing an important role in the aerosol climatic forcing [3]. Because of its surface characteristics, elemental carbon provides a good adsorption site for many semi volatile compounds such as PAHs. Organic carbon is an effective light scatterer and may contribute significantly to both visibility reduction and direct aerosol climatic forcing [4, 5].

In the tropical countries, such as India, atmospheric haze is a common phenomenon prevailing almost throughout the year. The large increase in emission of fine particles and unique meteorology of the tropics leading to long dry seasons with minimal rainfall are the main causes of haze formation. However, the data on the characterization of these fine particles is very scanty. The present study reports the relative contribution of carbonaceous particles (OC and EC) to haze forming particles in Delhi. Delhi was once rated as world's fourth most polluted city with respect to particulate pollution [6]. Its population of about fourteen million people make use of four million motor vehicles for daily mobility. The present study was conducted for a period of five months-June through October 2003. In India, July to September are generally considered as monsoon months. The study thus covers pre and post monsoon months besides the main monsoon period.

2. EXPERIMENTAL

2.1 Sampling sites

Two sampling sites, representative of different local activities in Delhi were selected for the sampling of PM_{10}. These sites are I) Jawaharlal Nehru University (JNU) and II) Shastri Nagar (SN). Site I, JNU, a huge university campus spread over six Km^2 area is in the southern part of the city. This site is a part of one of the main institutional area notified by Delhi authority. Most part of the campus is occupied by dense forest and shrubs with academic complex buildings and residential houses unevenly distributed, vehicular traffic is negligible and there are no major direct sources of emission. The site II, SN is in the northern part of the city. It is primarily a residential area with many small and medium industrial units. This site is also located in the close proximity of heavily trafficked road. All types of motor vehicles ply on the road throughout the day, thus vehicular and industrial emission are the major sources of fine particles at this site.

2.2 Sampling

The sampling of PM_{10} was carried out at both the sampling sites by eight stage Anderson cascade impactor for a period of five months June to October 2003. The samplers were run for a period of 70-80 hours in order to obtain a deposition of sufficient quantity of particulate matter over glass fiber filter paper. Samplers were run with a constant flow rate of 28.1*l* min^{-1}. The samples obtained were desiccated till they weighed constant before analysis.

2.3 Analysis

PM_{10} samples were analyzed for the determination of OC and EC by Carbon analyzer (ELTRA CS-500). The sample filter was divided into two equal halves from which total carbon (TC) and organic carbon (OC) were quantified with thermo-graphic method. The filters were burnt in oxygen atmosphere and the released CO_2 was measured by IR spectroscopy. For OC the filter was heated up to 620^oC and for TC up to 700^oC. EC was calculated by subtracting OC from TC [7].

3. RESULTS AND DISCUSSION

The study was aimed at understanding the distribution pattern of OC and EC in fine and coarse fraction of PM_{10} at two representative sites in Delhi. Site I (JNU), is an institutional area having negligible vehicular emission without industrial activity. Site II (SN) is a thickly populated area, with small and medium industrial units all around and having a close proximity with heavily traffic road. The sampling for PM_{10} was carried out for five months period from June to October 2003.

The monthly average concentrations of PM_{10}, its fine and coarse fractions, OC and EC in these two fractions are given in Table 1 and 2 for Site I JNU and Site II SN respectively. The percentage distribution of OC and EC in fine and coarse fraction of PM_{10} is given in Figure 1 and 2 for the two monitoring sites.

The average concentration of PM_{10} ranged between 221.50μgm^{-3} at site JNU to 328.02μgm^{-3} at site SN. This exceeds by 3-5 times the national standard value of 60μgm^{-3}. PM10 comprised of 29% fine fraction and 71% coarse fraction at site JNU and 35% of fine and 65% of coarse fraction at site SN. The average concentrations of PM_{10}, fine and coarse fractions at SN are higher than those at JNU. This is mainly because of the absence of any direct source of emission at JNU. However, the existing values at JNU could also have been influenced to some extent by meteorological factors, as this site is in the downwind direction and therefore receives significant quantity of emission from the industrial areas of Delhi located mostly in the upwind direction.

Sampling months	Coarse fraction (>2.1μm)			Fine fraction (<2.1μm)			PM_{10} Total		
	PM	OC	EC	PM	OC	EC	PM	OC	EC
June	358.80	35.19	11.96	64.81	25.10	6.02	423.61	60.29	17.98
July	189.81	47.37	5.86	81.02	27.65	4.83	270.83	75.02	10.07
August	64.81	24.10	7.68	52.08	23.69	5.16	116.89	47.79	12.84
September	88.29	26.14	7.26	67.46	24.60	5.40	155.75	50.74	12.66
October	81.02	26.31	6.76	59.03	25.48	5.94	140.43	51.78	12.70
Average	**156.55**	**31.82**	**7.90**	**64.88**	**25.30**	**5.47**	**221.50**	**57.12**	**13.25**
SD	**123.28**	**9.69**	**2.37**	**10.78**	**1.47**	**0.51**	**127.59**	**11.03**	**2.89**

Table 1: **Concentrations (μgm^{-3}) of OC and EC in fine and coarse fractions of PM_{10} at site I, JNU**

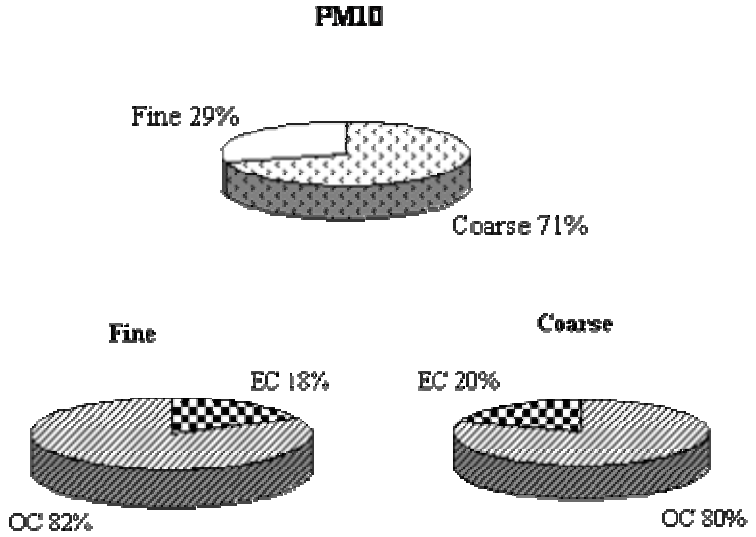

Figure :1 Percentage distribution of OC and EC in fine and coarse fractions of PM_{10} at site I, JNU

Sampling months	Coarse fraction (>2.1μm)			Fine fraction (<2.1μm)			PM_{10} Total		
	PM	OC	EC	PM	OC	EC	PM	OC	EC
June	344.91	44.94	19.56	134.26	37.13	11.49	474.17	82.07	31.05
July	204.86	34.29	16.02	121.53	31.62	6.85	326.39	65.91	22.87
August	113.43	28.76	10.93	47.45	18.62	7.39	160.88	47.37	18.32
September	118.06	26.88	20.15	81.35	33.71	8.92	190.40	60.59	29.06
October	299.48	40.36	35.21	188.80	34.00	26.35	488.28	74.36	61.56
Average	**216.15**	**35.05**	**20.37**	**114.68**	**31.02**	**12.20**	**328.02**	**66.06**	**32.57**
SD	**104.67**	**7.63**	**9.07**	**53.75**	**7.20**	**8.11**	**153.23**	**13.27**	**16.97**

Table 2: **Concentrations (μgm^{-3}) of OC and EC in fine and coarse fractions of PM_{10} at site II, SN**

OC concentration in coarse fraction of PM_{10} ranged between 31.82μgm^{-3} at site JNU to 35.05μgm^{-3} at site SN, whereas in fine fraction it was 25.30 and 31.03μgm^{-3} respectively. EC concentration in coarse fraction of PM_{10} varied between 7.90 μgm^{-3} at site JNU to 20.37μgm^{-3} at site SN, and in fine fraction it was 5.47 and 20.20μgm^{-3} at these sites respectively. EC concentration at JNU in both coarse and fine fractions seems to be quite less as compared to that of at SN. Higher concentration of EC at SN especially in fine fraction can

be attributed to vehicular and industrial emission of that area. In general, both the fractions of PM_{10} contain very high concentration of OC as compared to EC at both sites. OC concentration is as high as four times the EC concentration in fine fraction which is mainly responsible for haze formation.

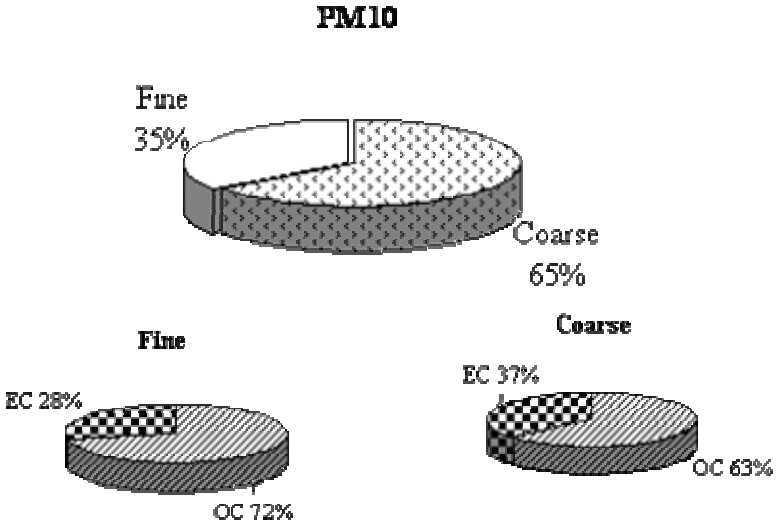

Figure 2: Percentage distribution of OC and EC in fine and coarse fractions of PM_{10} at site II, SN

It could therefore be agreed upon that among carbonaceous compounds, OC contributes much more than EC to haze formation in Delhi. However, together as a group they contribute up to 50% of the visibility-impairing aerosols followed by sulfate, nitrate and soil dust.

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