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# Atmospheric black carbon deposit in Beijing and Zhangbei, China

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**Abstract**

Atmospheric black carbon deposition is important to the Globe Carbon Cycle. In this study, monthly atmospheric dust samples were collected in urban Beijing and rural Zhangbei. Results showed that black carbon concentrations of the dust samples varied between 4.52 $mg.g^{-1}$ and 18.8 $mg.g^{-1}$ in Beijing and from1.60 $mg.g^{-1}$ to 5.17 $mg.g^{-1}$ in Zhangbei. Seasonal variations of black carbon concentrations of the two areas were consistent. Black carbon concentrations and corresponding dust amount were negatively correlated of the two areas. Annual atmospheric dust black carbon flux of Beijing and Zhangbei were 1659 $mg.m^{-2}$ and 1504 $mg.m^{-2}$, respectively. Atmospheric Black Carbon of Beijing came mainly from perennial human activities such as industrial and traffic, thus seasonal variation of black carbon flux of Beijing was not obvious; while black carbon flux in Zhangbei was mainly carried by airborne topsoils which controlled by monsoon, in winter and spring, dust storm weather occurred frequently, black carbon flux of this period was much higher than other season.



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## 1. Introduction

Black carbon is widely distributed in surface environment, which has always been the product of incomplete combustion of fossil fuels and biomass; human activities have recently increased its environmental concentrations [1]. Recent researches found the black carbon forms vary widely, which involves a series of polycyclic aromatic hydrocarbons, element carbon, soot's, charcoals, etc [2-4]. As important part of globe carbon cycle [5], black carbon may transport organic pollutants and heavy metals [6], as a useful tracer for land fire history [7], affect the heat budget

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of the earth surface[8].

This study was design to develop and apply a method of black carbon measurement to determine black carbon concentrations in the atmospheric dust of different season in Beijing city and the Zhangbei county, then estimated the atmospheric black carbon deposition flux of the two areas and the seasonal concentration variation. Furthermore, the sources and the transit process of the atmospheric black carbon would be discussed.

## 2. Experimental

### *2.1. Study region*

The study region is located in the northern region of the North China Plain(Fig. 1), the climate is monsoon climate and the prevailing wind direction is northwesterly in winter, and southeasterly in summer. Beijing and surrounding areas are located on a plain at elevations of 20–60 meters. The Yanghe River valley extends from the Zhangbeihighland to the Beijing plain. Zhangbei is located in northwest of Beijing and at the head of Yanghe River valley, this area is much higher than Beijing plain with an altitude of over 1,000 meters. Most of this region is covered by quaternary loess[9]. The surrounding Mountains consist mainly of alkalic igneous rocks[10].

### *2.2. Sampling methods*

Atmospheric dusts were collected by wet method with the glycol solution (20%) as the collect medium, the dust collectors were made of polypropylene[11]. The collectors would be covered in rain days and kept uncovered at rainless time. Samples were monthly collected (from March 2008 to February 2009), after clean out the impurity such as leaves and insects, the samples were dried in evaporating dish at the temperature 80□.

### *2.3. Analytical methods*

Chemical thermo oxidation(CTO) method is reliable and reproducible in analyzing black carbon materials which produced in fossil fuel burning such as soot, char and bituminous coal[4].The method used in this study is modified from Lim et al.[12], Masielloet al.[13]and Hammes et al.[14], the average recovery rate was 88 % when added diesel soot as label, the procedure is as follows:

1. Put 1g dust sample into microtubes, added 10 ml of 3 mol. $L^{-1}$ HCl for removing non silicate minerals, microtubes were centrifuged and the liquid decanted after 12 hours.

2.10ml mixture of 8 mol. $L^{-1}$ HF and 2 mol. $L^{-1}$ HCl were added for removing silicate minerals, reaction for 12 hours, repeated the steps to romove silicate minerals thoroughly.

3.The samples were then reacted with 10 ml mixture of 0.1 mol. $L^{-1}$ $K_2Cr_2O_7$ and 2 mol. $L^{-1}$ $H_2SO_4$ for 48 hours at 50□ to oxidize the unstable organic carbons. Then washed the residues with pure water for three times and centrifuged, thus got black carbon materials.

4.Dried the black carbon materials at 50℃ and weigh up with extreme balance, then black carbon contents of the black carbon materials were tested by PE2400-II element analyzer(U.S.).

## 3. Results and discussion

### *3.1. Black carbon concentration*

The black carbon concentrations of the monthly atmospheric dust varied between 4.52 $mg.g^{-1}$ and 18.8 $mg.g^{-1}$in Beijing (Table. 1), which were higher than those in Zhangbei, the black carbon concentrations of the later were between 1.60 $mg.g^{-1}$ and 5.17 $mg.g^{-1}$.

Result showed that Beijing and ZhangBei had same seasonal monthly black carbon concentrations variations, which were relatively higher in summer-autumn (June to September) than those in other months (Fig.2.).The black carbon concentrations of the two areas had notable positive correlation, the pearson correlation coefficient is 0.8784. The linely distance between Beijing and Zhangbei was about 200km, Zhangbei was on a rural highland faraway from Beijing.The monthly black carbon concentrations of the two areas varied conform, suggested that some black carbon may transported regionally. Black carbon concentrations of the two areas were quite different, Indicates they

Table. 1. Black carbon concentration (mg.g$^{-1}$), dust amount (g.m$^{-2}$) and black carbon flux (mg.m$^{-2}$) of the monthly atmospheric dusts.

| | Beijing | | | Zhangbei | | |
|---|---|---|---|---|---|---|
| | concentration | amount | flux | concentration | amount | flux |
| Mar | 5.55 | 32.1 | 178 | 2.91 | 115 | 336 |
| Apr | 7.83 | 18.5 | 145 | 2.07 | 37.8 | 78.3 |
| May | 4.52 | 31.8 | 144 | 1.82 | 149 | 272 |
| Jun | 27.7 | 7.50 | 208 | 5.17 | 11.2 | 57.8 |
| Jul | 21.7 | 5.94 | 129 | 3.95 | 14.6 | 57.8 |
| Aug | 15.8 | 4.53 | 71.3 | 4.05 | 26.7 | 108 |
| Sep | 18.8 | 5.38 | 101 | 4.77 | 5.94 | 28.4 |
| Oct | 8.20 | 11.3 | 92.8 | 2.05 | 43.9 | 89.8 |
| Nov | 10.1 | 13.3 | 134 | 1.60 | 58.0 | 92.6 |
| Dec | 10.0 | 16.3 | 163 | 1.90 | 40.0 | 76.1 |
| Jan | 7.24 | 23.2 | 168 | 1.79 | 97.1 | 173 |
| Feb | 8.13 | 15.4 | 125 | 1.48 | 90.5 | 134 |

may have different black carbon sources. In urban areas, human activities such as industry and vehicles emission massive of black carbon into atmosphere[14,15], so Beijing may have higher atmospheric black carbon environmental concentration than remote Zhangbei, which may display on the different black carbon concentrations of the atmospheric dusts.

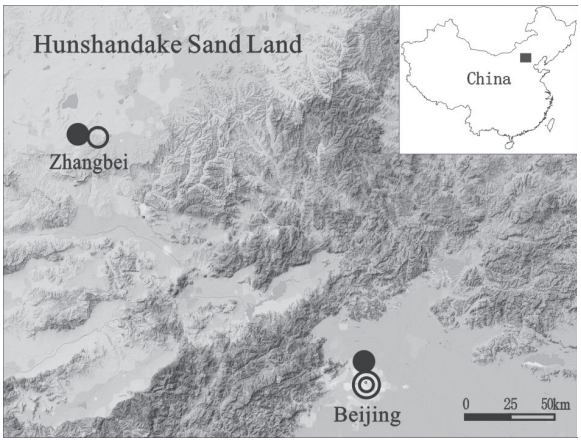


Fig. 1. Map of study region and sampling areas.

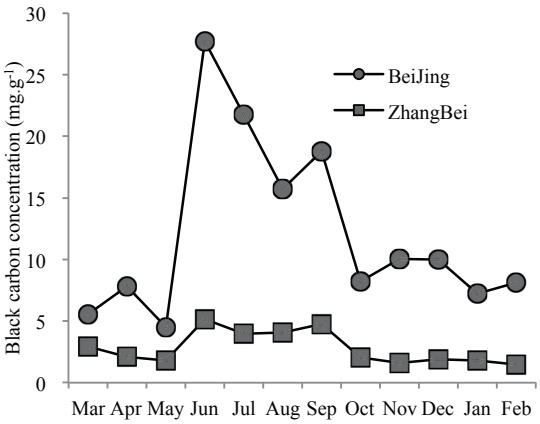


Fig. 2. Seasonal variations of monthly dust black carbon concentrations.

The study region is located in the east of Asian dust source zone, and on the track of the Asian dust transport to Pacific[16]. Dust storm weather mainly occurred in winter-spring (December to May), dust amount of this period were much higher than other season, which accounted for 74.1% and 76.8% of the annual dust amount in Beijing and Zhangbei, respectively. According to Yang[17] and this study[18], atmospheric dust of this region mainly originated from local topsoil. The black carbon concentrations of topsoils near sampling sites were 1.15 mg.g$^{-1}$ and 0.95 mg.g$^{-1}$ in Beijing and Zhangbei, respectively, they were much lower than the corresponding atmospheric dust. Although over more black carbon was emitted in winter and early spring heating process, the black carbon concentrations of atmospheric dusts were relatively lower, this might be caused by the effect of "dilute". In winter and spring, the surface lacked vegetation cover, in addition the dust weather erupted frequently[19], more additional topsoil was transported by air then became atmospheric dust, black carbon concentrations of these topsoil were low, which could "diluted" the black carbon concentrations of the atmospheric dust. The contrary of this happened in

summer and autumn, during this time, high black carbon concentrations corresponded to low dust amount. Black carbon concentrations were normalized to element aluminum, the normalized values and corresponding dust amounts were negatively correlated of the two areas, which could clearly reveal the" dilute" effect (Fig. 3.).

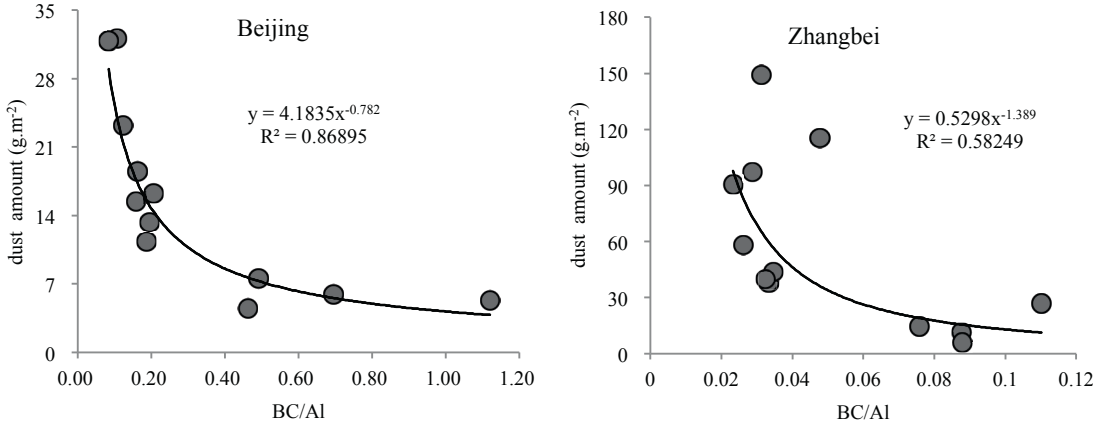


Fig. 3. Correlation of Al-normalized monthly dust black carbon concentration (BC/Al) values and dust amounts.

### *3.2. Black carbon deposition flux*

Dust black carbon deposition fluxes were calculated from black carbon concentrations and corresponding dust amount (Fig. 4.), the annual flux were1659 mg.m$^{-2}$ and 1504 mg.m$^{-2}$ in Beijing and Zhangbei, respectively. Though Zhangbei is a remote agricultural area, which nearly had the same black carbon deposition flux as Beijing, this should attribute to the great dust amount of Zhangbei. Annual dust amount of Zhangbei was 691 g.m$^{-2}$, which was much higher than that of Beijing (185 g.m$^{-2}$). The control factors of black carbon deposition flux were different in the two areas. Black carbon deposition flux mainly caused by higher black carbon concentrations in Beijing, whereas dust amount was dominant in black carbon deposition flux of Zhangbei.

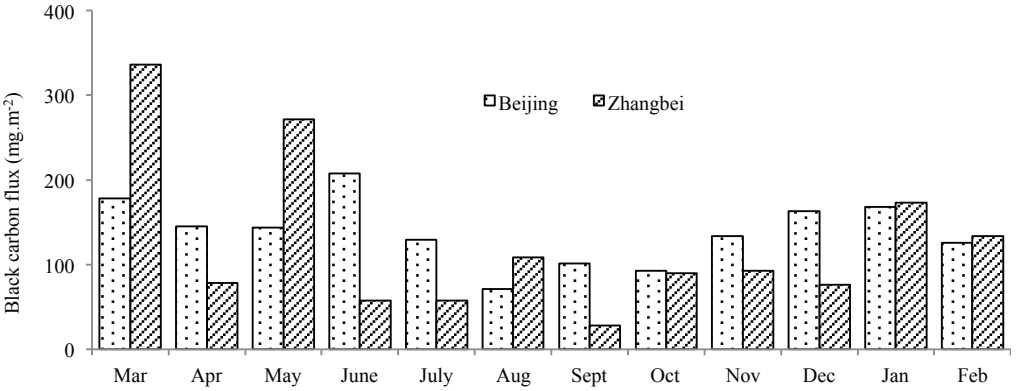


Fig. 4. Monthly dust black carbon flux of Beijing and Zhangbei.

Seasonal black carbon deposition flux variations of Beijing were different from Zhangbei. Black carbon of Beijing mainly originated from the local industrial, transportation and other human activities, these activities were perennial, strength with little change in the seasons, so the seasonal fluctuation of black carbon flux was not obviously; though human activities were weak in Zhangbei, considerable black carbon came from seasonal dust storm input rather than from human activities, dust storm was affected by monsoon, so black carbon flux had great seasonal variation.

## 4. Conclusion

Influenced by intense human activities, the black carbon concentrations of atmosphere dusts were much higher in Beijing than those in Zhangbei. The relatively high black carbon concentrations in summer-autumn were mainly due to the reduced dust amounts. Dust amount controlled by monsoon, was one of the most important factor affecting the seasonal variation of black carbon concentration. Frequently dust weather in winter and spring could transform a lot of topsoil into atmospheric dust, thus "diluted" the black carbon concentration of the bulk atmospheric dust, hence the Al-normalized black carbon concentrations values negatively correlated to the corresponding dust amounts.

Annual atmospheric dust black carbon flux of Zhangbei approximated to Beijing, there was no obvious difference between urban and rural areas, suggested that in this region, human activities were not always the main control factor of black carbon flux. The main black carbon source of Beijing were the perennial human activities such as industry and vehicles, whereas the atmospheric black carbon mostly came from airborne topsoil in Zhangbei, so seasonal black carbon flux fluctuated stronger in Zhangbei than that in Beijing.

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