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STUDY ON THE VISIBILITY REDUCTION CAUSED BY ATMOSPHERIC HAZE IN GUANGZHOU AREA

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Abstract: In recent years the pollution of aerosol is getting worse and worse in Guangzhou area. The haze weather mainly occurs from October to April of the following year, resulting in visibility deterioration. From the beginning of the 1980's the visibility dramatically deteriorated, obviously increasing haze weather, in which there are three big fluctuations, respectively showing the periods of pollution of dust, sulphate and dust, fine particle from photochemical process and sulphate and dust accompanying the development of economy. The long-term tendency of visibility caused by fog and light fog does not have the tendency due to human activity or economical development and the variation mainly show the inner interannual and interdecadal variation of climate. The deterioration of visibility has close relation to the fine particles in Guangzhou area, with half of PM_{10} surpassing the limits set by national second graded standard, meanwhile, all values of $PM_{2.5}$ rise above the day-mean limits of American national standard, indicating very high fine particle concentration. The ratio of $PM_{2.5}$ to PM_{10} is also very high, reaching 62% – 69%, especially higher in dry seasons than in rainy seasons.

Key words: Guangzhou area; aerosol cloud; haze weather; visibility deterioration; fine particles pollution

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1 INTRODUCTION

Due to its global climatic effect, the atmospheric aerosol is one of the important forcing factors responsible for global change and has become one of the important fields that have caused wide concerns among scientists in recent years[1-3]. Air pollution is also a common problem facing most of the developing countries during their urbanization and industrialization. Being one of the regions having the fastest economic development across the globe in the last 20 years of the 20th century, the Guangzhou area is also one of those in China in which the aerosol is causing serious air pollution. With large amount of land being exploited on the industrial scale, decreased vegetation, rapidly increased traffic and vigorously developed township factories and workshops in the region, episodes of air pollution happen so frequently that they have aroused much concern in the government and general public. Air pollution is not only hazardous to the health of the inhabitants, but also reduces visibility to pose significant impacts on economic activities and livelihood of the citizens, resulting in negative impressions of an area or city concerned. As the 2010 Asian Games is going to be held in Guangzhou, which will be badly affected if the current frequent incidents of poor visibility continue, it faces a difficult job of improving the air quality and beautifying urban scenes.

Aerosol particles are those in the solid or liquid form that suspend in the atmosphere with the diameter between 10^{-3} – 10^{1} υm. Though with their mass taking up one billionth of the total of the atmosphere, aerosol particles have important contribution to both

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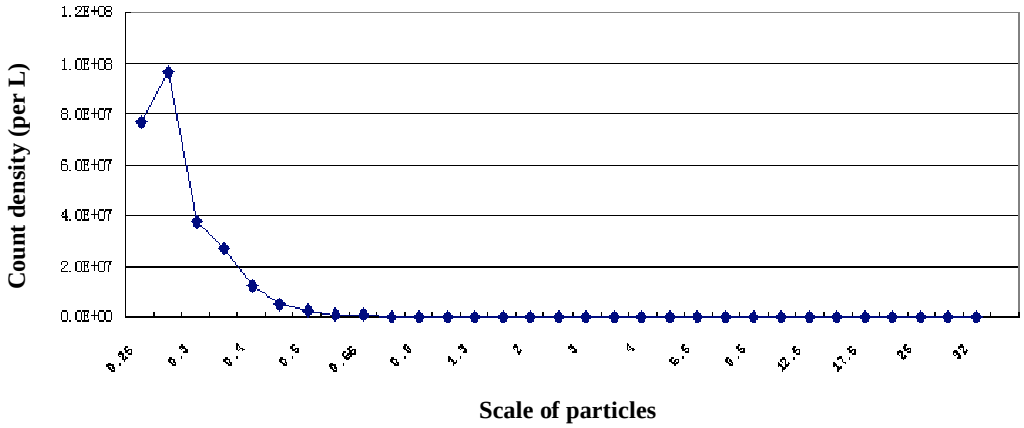

Fig.1 Spectrum of diurnal mean aerosol particles measured at Panyu, Guangzhou, Apr. 19, 2006

the radiative transfer of the atmosphere and water cycles [4]. Aerosols have significant effect on climate change, formation of clouds, variation of visibility, environmental quality, cycles of trace atmospheric elements and peoples' health. Since the Industrial Revolution, anthropogenic activities have resulted in direct emission of huge amount of particles and polluting gases into the atmosphere, with the latter transforming to aerosol particles through chemical reaction in the heterogeneous phase.

2 DATA AND DEFINITION OF HAZE

In this paper, the data of visibility, humidity and observed weather phenomena from the Guangzhou Meteorological Observatory for 1954 – 2004, optical thickness information as derived by EOS/MODIS satellites in 2001–2003 and data of fine aerosol particles as observed at Panyu, Guangzhou in 2004 – 2005, were used.

A day can be defined as one with the occurrence of atmospheric haze when daily mean visibility is below 10 km, daily mean relative humidity is less than 90% in addition to the absence of other factors such as precipitation for causing low visibility. A day can be grouped into one with the occurrence of light fog when daily mean visibility is below 10 km, daily mean relative humidity is more than 90% in addition to the absence of other factors such as precipitation for causing low visibility [5, 6].

3 CHARACTERISTICS OF FINE AEROSOL PARTICLES

It is known that visibility is associated with the scattering and absorptive capacity of both the particles and gaseous molecules, mainly of the atmospheric particles. If fine particles are processed simply by Reyleigh scattering, then the intensity of scattered light is mainly in inverse proportion with the 4^{th} power of incident light wavelength and directly proportional to the square of particle volume. The volume of the

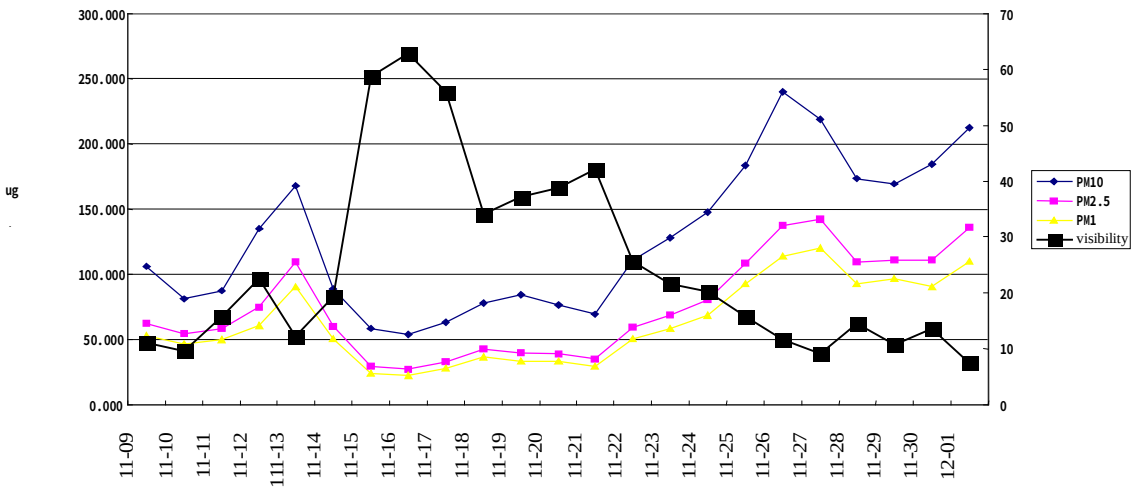

Fig.2 Daily variation of concentration and visibility for PM_{10}, $PM_{2.5}$ and PM_1 in Guangzhou from November 9 to December 1, 2005.

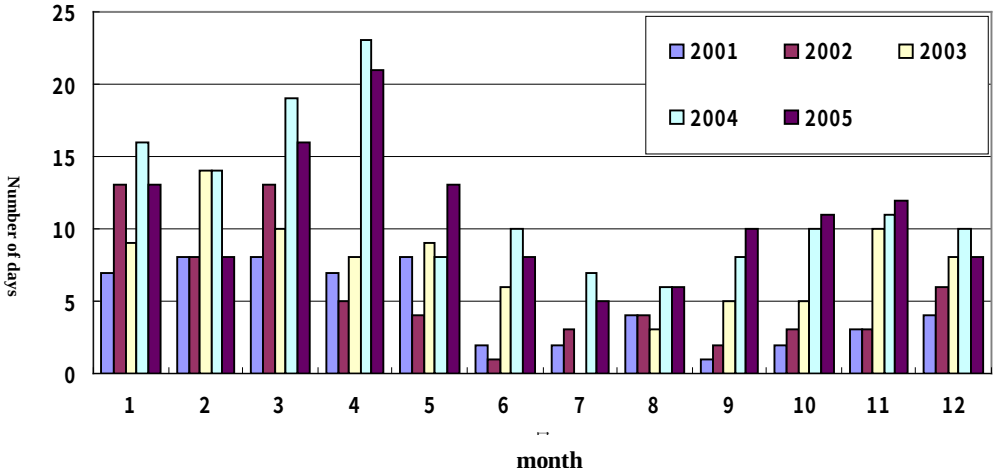

Fig.3 Number of hazy days on a monthly basis from 2001 to 2005 in Guangzhou (MOR<10 km, RH<90%).

particle has direct linkage with its scale and concentration. For a given wavelength of the incident light and regardless of the effects of chemical composition of gases and particles, the factors that govern the intensity of the scattered light are the scale and concentration of the particle[7]. Fig.1 shows that there are 17000 particles of 1 μ m and 9×10^6 particles of 0.25 μ m; the number of giant particles differs from that of submicron particles by 10^6 times; the diameter is 0.28 μ m for the peak spectrum of aerosols with the mean at 0.31 μ m . It is then known that the worsening of visibility is mainly associated with fine particles, whose proportion gets even larger when there are episodes of low visibility caused by serious aerosol pollution.

Tab.1 gives the seasonally mean mass concentration of PM_{10} and $PM_{2.5}$ observed. It shows that the ratio of $PM_{2.5}$ to PM_{10} is very high (between 62% and 69%), especially, it is higher in the dry season than in the rainy season, much larger than the observation we made 15 years ago[8]. Fig.2 indicates that fine particles take up large percentages when visibility decreases. It shows that the aerosol pollution in the area of Guangzhou is mainly that of fine particles. Fine particles usually associate with the transformation of gaseous particles. Relative to the slow process in which SO_2 gas forms sulphate particles via chemical oxidization, gaseous particles rapidly transform to organic nitric particles through photochemical oxidization driven by ultraviolet rays, due to precursor matters discharged mainly with automobile exhausts [9 - 13]. It is just why visibility rapidly deteriorates so rapidly in Guangzhou area in recent years.

From the number of days (given on a monthly basis) in which hazy weather (MOR<10 km, RH<90%) occurred in the past 50 years in the area (figure omitted), it is shown that visibility has been worsening dramatically since early 1980's and three main fluctuations have been experienced.

It is also known from Fig.3 that the number of hazy weather days has been increasing from 64 in 2001 and 85 in 2002 to 98 in 2003, 144 in 2004 and 132 in 2005. In other words, haze occurred once in every four days or less. The weather is more often seen in the dry season than in the rainy season and occurred in 23 days in the most frequent month.

Tab.1 Seasonally mean mass concentration (μ g/m^3) of PM_{10} and $PM_{2.5}$ observed in 2004 – 2005 and percentage of fine particles

Seasons	$PM_{2.5}$	PM_{10}	$PM_{2.5}/PM_{10}$
Mar. – May	74.2	116.6	62.7
Jun. – Aug.	65.2	106.0	62.6
Sept. – Nov.	102.4	167.0	62.8
Dec. – Feb.	117.4	169.5	69.8

For analyses of other aspects, refer to the Chinese edition of the journal.

4 CONCLUSIONS

Visibility was very good for the period from 1954 to 1978 in the area of Guangzhou, with less than 40 hazy days annually, in which visibility was below 10 km. Since early 1980's, however, visibility has been deteriorating rapidly with significant increase of hazy weather and as many as 200 days in the year of most occurrences (1997). It is closely associated with the

increase of economic capacity of the region. There were three main fluctuations, representing three periods of compound pollution caused by dust, sulphate plus dust, and fine particles with photochemical processes plus dust, respectively. The long-term variation tendency of visibility caused by fog and light fog is without any tendency change due to mankind activity or economic development and mainly reflects variations on the interannual and interdecadal scales inherit in the climatic cycle.

In recent years, the worsening aerosol pollution and atmospheric transparency in the area of Guangzhou is closely related with mankind activity and levels of economic development, with significant regional characteristics. There are always aerosol clouds and areas of higher concentration are over the western part of the Pearl River Delta west of the estuary. Hazy weather mainly occurs from October to the following April.

The worsening of visibility in Guangzhou area is mainly linked with fine particles. Half of the monthly PM_{10} mean values are higher than the limit of daily mean concentration for Level 2 of the Chinese standard (150 μ g/m^3) while all of the monthly $PM_{2.5}$ mean values are above the limit of daily mean concentration for the American standard (65 μ g/m^3), especially, the monthly mean concentration from October to the following January is almost twice as large as the limit, with extremely high concentration of fine particles. In addition, the ratio of $PM_{2.5}$ to PM_{10} is very high (between 62% and 69%), which is higher in the dry than in the rainy season. It shows that the aerosol pollution in the area of Guangzhou is mainly caused by fine particles.

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