JOURNAL OF ENVIRONMENTAL SCIENCES 36 (2015) 93–101

Available online at www.sciencedirect.com

ScienceDirect

www.journals.elsevier.com/journal-of-environmental-sciences

JOURNAL OF ENVIRONMENTAL SCIENCES

www.jesc.ac.cn

Particulate matter assessment of a wetland in Beijing

Dongdong Qiu[1,**], *Jiakai Liu*[1,**], *Lijuan Zhu*[1], *Lichun Mo*[2], *Zhenming Zhang*[1,*]

1. *College of Nature Conservation, Beijing Forestry University, Beijing 100083, China. Email:* qiudong329@163.com.
2. *Beijing Administrative College, Beijing 100044, China*

ARTICLE INFO

Article history:
Received 23 December 2014
Revised 24 April 2015
Accepted 28 April 2015
Available online 6 July 2015

Keywords:
Wetland
Particulate matter
Meteorological factors
Dry deposition

ABSTRACT

To increase the knowledge on the particulate matter of a wetland in Beijing, an experimental study on the concentration and composition of PM_{10} and $PM_{2.5}$ was implemented in Beijing Olympic Forest Park from 2013 to 2014. This study analyzed the meteorological factors and deposition fluxes at different heights and in different periods in the wetlands. The results showed that the mean mass concentrations of PM_{10} and $PM_{2.5}$ were the highest at 06:00–09:00 and the lowest at 15:00–18:00. And the annual concentration of PM_{10} and $PM_{2.5}$ in the wetland followed the order of dry period (winter) > normal water period (spring and autumn) > wet period (summer), with the concentration in the dry period significantly higher than that in the normal water and wet periods. The chemical composition of $PM_{2.5}$ in the wetlands included NH_4^+, K^+, Na^+, Mg^{2+}, SO_4^{2-}, NO_3^-, and Cl^-, which respectively accounted for 12.7%, 1.0%, 0.8%, 0.7%, 46.6%, 33.2%, and 5.1% of the average annual composition. The concentration of PM_{10} and $PM_{2.5}$ in the wetlands had a significant positive correlation with relative humidity, a negative correlation with wind speed, and an insignificant negative correlation with temperature and radiation. The daily average dry deposition amount of PM_{10} in the different periods followed the order of dry period > normal water period > wet period, and the daily average dry deposition amount of $PM_{2.5}$ in the different periods was dry period > wet period > normal water period.

Introduction

In recent years, because of the acceleration of urbanization, urban air quality has decreased, and the dust formed by solid particles is becoming the major urban air pollutant (Guo et al., 2010). PM_{10} and $PM_{2.5}$ refer to particulate matter classes whose aerodynamic equivalent diameters are less than 10 and 2.5 μm, respectively (Yang et al., 2000). In the last two years, particulate matter pollution in Beijing and other metropolitan cities has gotten worse, which has led to the persistence of fog and haze that severely impairs travel. Many studies (Yang et al., 2000; Zhu et al., 2013; Dockery et al., 1993; An et al., 2000) have found that increasing concentrations of particulate matter in the atmosphere have a close relationship with the incidence of coughing and other respiratory symptoms, lung function reduction, and asthma. The number of premature deaths caused by particulate matter has been increasing every year, and research on reduction of particulate matter has become crucial. There are many reports on the influence of forests in regulating and intercepting PM_{10} and $PM_{2.5}$ (Matsuda et al., 2015; Wu et al., 2012; Becker et al., 2000; Nguyen et al., 2015). Many studies (Yang et al., 2005; Nowak et al., 2006; Escobedo and Nowak, 2009; Sharma and Roy, 1997) have found that forests have a significant effect in absorbing atmospheric pollutants and in improving air quality.

* *Corresponding author*. E-mail addresses: may_ron@126.com (Jiakai Liu), zhenmingzhang@bjfu.edu.cn (Zhenming Zhang).
** These authors contributed equally to this work.

http://dx.doi.org/10.1016/j.jes.2015.04.016

The influence of wetlands, which are also referred to as the "kidneys of the earth," in regulating and intercepting PM_{10} and $PM_{2.5}$ is becoming an important topic. Many studies (Liu et al., 2003; Hao et al., 2008; Sun et al., 2010; Loïc and Luc, 1998) have led to the conclusion that wetlands can reduce particulate matter to some extent, by increasing atmospheric relative humidity within a certain range, thus promoting particulate matter settling. By analyzing collected soil, sediment, and air samples, Liu et al. (2003) performed a preliminary study of polycyclic aromatic hydrocarbon (PAH) pollution and its sources in the Lalu wetland in suburban Lhasa and found that PAHs in the wetland soil mainly came from the atmosphere. Sun et al. (2010) analyzed the vertical and horizontal distribution of atmospheric aerosols in the Hengshui Lake wetland by an aerial survey and found that the aerosol concentration over Hengshui Lake was lower than that of the surrounding land; furthermore, the range of the concentration of particles became smaller in the horizontal direction with height and the arithmetic average diameter of aerosol particles over the land was greater than those over Hengshui Lake.

The Beijing Olympic Forest Park has an intact wetland environment that plays a vital role in conservation and ecologically beneficial environmental construction in Beijing (Li et al., 2014; He et al., 2010). Therefore, it is a suitable model for wetland regulation and interception of particulate matter. We selected the Beijing Olympic Forest Park wetland for this study and investigated the concentration variations, influencing factors, and amounts of dry deposition of PM_{10} and $PM_{2.5}$ in the wetland in different periods within a year. Information about the wetland's influence on regulating and intercepting PM_{10} and $PM_{2.5}$ was obtained. The results of this study may provide theoretical and technical support for construction and protection of urban wetland parks.

1. Materials and methods

1.1. Experimental size

The Beijing Olympic Forest Park is located in the North Olympic Park, Chaoyang District, Beijing. It covers an area of 680 ha and is the largest city park in Beijing. Its geographic coordinates are 40°01′03.73″N and 116°23′09.81″E (Fig. 1). The study area has a warm temperate semi-humid continental monsoon climate with an annual average temperature of 12.9°C and an average annual rainfall of about 600 mm (Hu et al., 2006). Rainfall is concentrated in summer, while in other seasons the air is dry.

The Beijing Olympic Forest Park has a rich variety of vegetation types. The tree configuration in the park is mainly mixed forest, including 530,000 trees and shrubs of more than 180 species that present different features across the four seasons (Dong et al., 2006). One of the most attractive areas in the park is the artificial wetland, which has many functions, including protecting water quality, esthetic appreciation, research and education, and ecological maintenance (He et al., 2010). With a large body of clear water and many species of aquatic plants, including reeds (*Phragmites australis*), cattails (*Typha angustifolia* L.), and canna (*Canna indica* Linn.), the wetland presents a pristine natural wetland landscape.

Because most of the human population is concentrated south of Olympic Forest Park, the sampling apparatus was placed on the central island in the northern part of the park. This minimizes the influence of local anthropogenic emissions and makes the island an ideal observation site to assess the particulate matter. Sample plots were 60 m long from north-to-south and 50 m in width from west-to-east, with two vertical gradient sampling points at 0.5 and 1.5 m. There is no significant local source of air pollutants near the monitoring station. In order to quantify the relationship between relative humidity and concentration of PM, we also monitored PM concentration over the bare land surrounding the wetlands as a reference. Climates were similar for the two sites.

1.2. Sampling procedure

A DustMate particulate matter sampler (DUSTMATE, Turnkey Instruments Ltd., UK), a suspended particulate pollutant sampler (TH-150C, Westernization instrument Technology Co., Ltd., China), and a small weather station (Kestrel 4000 Pocket Weather Meter, Nielsen-Kellerman, Boothwyn, PA, USA) were installed at each sampling point to collect particulate concentration and composition and meteorological data (Fig. 2). The meteorological data included temperature, wind speed, relative humidity, and

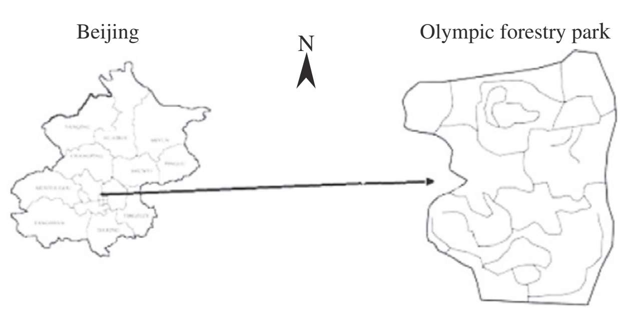

Fig. 1 – Study area and the locations of the sampling sites.

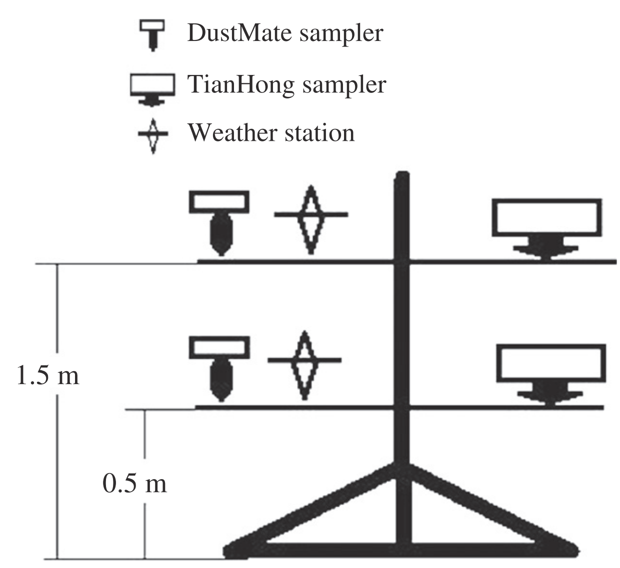

Fig. 2 – Schematic of instrument placement.