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Study on mercury in airborne particulates from different functional areas of Jiaozuo City, China

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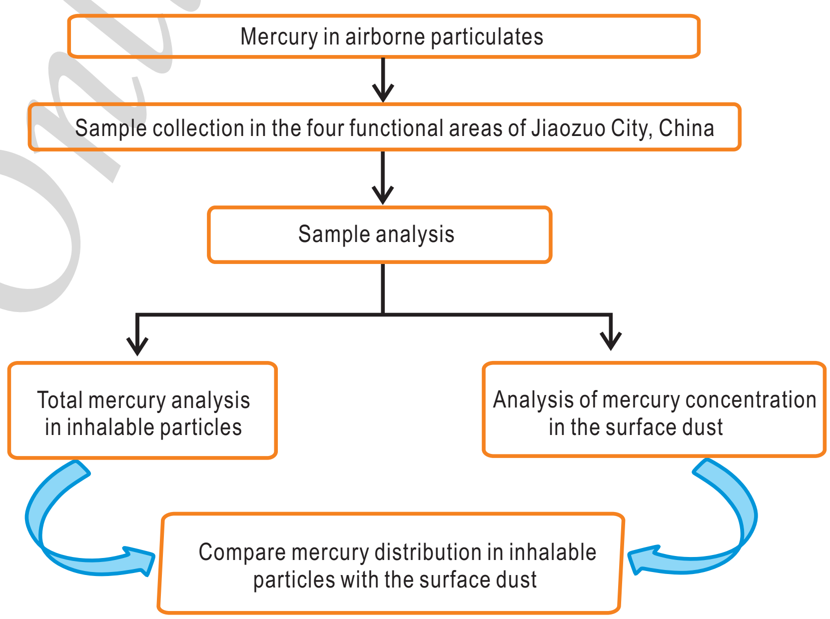
Abstract

Aim : A study was conducted with an aim to further understand the air environmental quality of Jiaozuo City, China and characteristics of pollutants by comparing the concentration of mercury in inhalable particles and dust of four functional areas.

Methodology : The sampling filter for inhalable particles was dried at 500°C for 2 hrs before use. The dust samples were dried and grinded, and to all the samples nitric acid and hydrofluoric acid was added for nitrification. The concentration of mercury was determined by Atomic Fluorescence Spectrometer after microwave digestion.

Results : The average concentration of mercury in inhalable particulate matter was 4.44 ng m^{-3}. was higher than the global background values. The concentration of mercury in the dust ranged from 0.45 to 1.51 µg g^{-1} and the average value was 0.86 µg g^{-1}, which was 13.23 times higher than soil natural background value of mercury (0.065 µg g^{-1}) in China. The analysis results of corresponding relationship indicated that mercury in inhalable particulate matter and dust originate from different sources.

Interpretation : The commercial and traffic activities may have a certain influence on the content of mercury in airborne particulates in Jiaozuo City.



Introduction

Atmospheric particulate matter and dusts are the main cause of air pollution, which exist widely. Particulates contain a variety of chemical elements, including organic and inorganic compounds. Trace elements are the most important among the inorganic compounds (Yap *et al*., 2011; Nazir *et al*., 2011). Mercury is a unique heavy metal element with variable oxidation states, and in atmosphere it mainly exist in gaseous phase which can be divided into gaseous elemental mercury-Hg^{0}, reactive gaseous mercury -Hg^{2+} and particulate mercury (Liu and Luo, 2012; Xu *et al*., 2015; Sun *et al*., 2013). Mercury is highly toxic and harmful to human beings and environment, which has aroused great attention around the world (Li, 2010; Feng *et al*., 2013; Olayan and Thomas, 2015; Matchavariani *et al*., 2015). Generally, mercury in the environment originates from natural as well as anthropogenic source. Natural sources include volcanoes, forest fires, geothermal vents and evaporation from soil and water (Kim *et al*., 2009). According to the United Nations Environment Programe, the anthropogenic mercury emission is about 1960 t, accounting for about 30% of the total amount of atmospheric mercury emissions (UNEP, 2013). Besides, anthropogenic emissions are mainly from coal combustion, which accounts for 45% of the total global anthropogenic emissions (Xu *et al*., 2011).Currently, the production and consumption of coal in China is high as compared to other countries. The proportion of coal is more than three quarters in the total energy consumption, and coal-power plant is one of the most important source of mercury pollution in the urban environment. Unfortunately, this situation tends to last for a long period in the near future.

Rising mercury in the atmosphere has attracted the attention of Chinese government, and accordingly many studies on anthropogenic mercury emission have been conducted. Zhang *et al*. (2011) used the methods of emission factors and grey prediction to investigate the atmospheric mercury emissions from anthropogenic sources in the city of Chongqing. The results indicated an annual average increase of 16.20% from 2009 to 2015. Wu *et al*. (2017) predicted the atmospheric mercury emission of China's nonferrous metal smelting industry under different scenarios and analyzed the contribution of main emission abatement measures. Hui *et al*. (2017) developed the atmospheric mercury emission inventories for coal fire power plants, coal fire industrial boilers and coal fire residential stoves in 2010 and 2012, and predicted the atmospheric mercury emission from the coal combustion sector by 2020 and 2030 based on scenario analysis to evaluate the effectiveness of different control measures in the future. Jiaozuo City has a long history of being heavy industry. Its industrial layout is unreasonable, functional areas are sophisticated and urban infrastructure is poor, which makes the urban air pollution caused by anthropogenic factors more prominent.

In the present study, four typical urban functional areas were selected to collect the samples of inhalable particles and surface dust. The present study was conducted with an aim to assess the atmospheric quality of Jiaozuo City and characteristics of pollutants by comparing the concentration of mercury in inhalable particles and dust of four functional areas, so as to provide a theoretical basis and practical significance for the city's environmental management and protection.

Materials and Methods

Study area and sample collection : The present study was conducted in Jiaozuo City, China. The climate of the study area is warm temperate continental monsoon with average temperature ranging between 12.8 to 14.9°C, annual precipitation of 603.5mm and frost-free period of 231days. Four sampling sites in the city were selected (Fig.1) Coal fire power plant (Jiaozuo power plant), Commercial area (Wanfang Technical College), Traffic area (Jiaozuo tourist bus station) and Cultural area (Henan Polytechnic University).

In order to study the direct influence of atmospheric dust on human body, the dust was collected from 1.5-2 m near the surface. The sampling ensured no rain for seven days, and each sampling was done under similar climatic condition and the sampling time ranged from 48 to 68 hr. The dust on wooden doors and windows, surface of glass, roof platform, air conditioner shell and other non-paint wooden objects were swept into the polyethylene plastic bags. To make the samples representative, two batches of 80-100 g samples were collected in two or three streets every 1-2 m distance in each sampling area, and sieved uniformly to mix into a comprehensive sample. In total of four samples were collected from four functional areas. All the airborne particulate samples were collected with a TE-20-800 type 8 atmospheric sampler classification, manufactured by an American Tisch Company. The particle cutting aerodynamic equivalent particles size were 9.0, 5.8, 4.7, 3.2, 2.1, 1.1, 0.65 and 0.43 μm. The aerosol samples were collected on a 0.45μm pore size quartz fiber membrane filters at 28.3 $l \cdot min^{-1}$ flow-rate.

Sample analysis : Befor sampling each filter was oven dried at 500°C for 2 hrs. After complete drying, the filters were weighted by a 1/10000 precision electronic weighing scales. The mass concentration of particulate matters were analyzed by gravimetric method. The dust samples were ground by agate mortar filtered with 200 mesh sieve and stored in sampling bags. The concentration of mercury was determined by Atomic Fluorescence Spectrometer a sample was randomly selected from every 10 samples and the sample was repeatedly measured for 4 times. The relative standard deviation was between 0.02%~5.19%, which indicated a high precision of the instrument.

Results and Discussion

The concentration of mercury in different size particles ranged from 0.54~2.30 ng m^{-3}, 0.10~0.65 n gm^{-3}, 0.14~0.37 ng m^{-3} and 0.15~0.65 ng m^{-3}, respectively in coal fire power plant, traffic, commercial and cultural area, respectively (Fig. 2). The average