Atmospheric Environment 144 (2016) 37–46

Contents lists available at ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

Indentifying the major air pollutants base on factor and cluster analysis, a case study in 74 Chinese cities

Jing Zhang [a], Lan-yue Zhang [a], Ming Du [b], Wei Zhang [b], Xin Huang [c], Ya-qi Zhang [a], Yue-yi Yang [c], Jian-min Zhang [d, *], Shi-huai Deng [a, **], Fei Shen [a], Yuan-wei Li [c], Hong Xiao [c]

[a] Institute of Ecological and Environmental Science, Sichuan Agricultural University, Chengdu, 611130, Sichuan, PR China
[b] Si Chuan Environmental Monitoring Center, Chengdu, 611130, Sichuan, PR China
[c] College of Environmental, Sichuan Agricultural University, Chengdu, 610031, Sichuan, PR China
[d] State Key Laboratory of Hydraulics and Mountain River Engineering, Sichuan University, Chengdu, 610056, Sichuan, PR China

HIGHLIGHTS

- Factor analysis is employed to indentify the major air pollutants in spring, summer, autumn, and winter.
- Cluster analysis is employed to discuss the spatial and seasonal distribution of air pollution in 74 Chinese cities.
- The fresh ideas for indentifying the emission source of air pollution in large time scale would be obtained.

ARTICLE INFO

Article history:
Received 9 June 2016
Received in revised form
21 August 2016
Accepted 23 August 2016
Available online 25 August 2016

Keywords:
Air pollutants
Emission sources
Factor analysis
Cluster analysis

ABSTRACT

This article investigated the major air pollutants and its spatial and seasonal distribution in 74 Chinese cities. Factor analysis and Cluster analysis are employed to indentify major factors of air pollutants. The following results are obtained (1) major factors are obtained in spring, summer, autumn, and winter. The first factor in spring includes NO_2, PM10, CO, and PM2.5; the first factor in summer and autumn includes PM10, PM2.5, CO and SO_2; in winter, the first factor includes NO_2, PM10, PM2.5, and SO_2. (2) In spring, cities of cluster 5 are the severest polluted by emission sources of SO_2, CO, PM10, and PM2.5; the emission sources of O_3 would significantly influence the air quality in cities of cluster 2; the emission sources of NO_2 could significantly influence the air quality in cities of cluster 3 and cluster 5. (3) In summer, cities of cluster 5 are the severest polluted by automotive emissions and coal flue gas. Cities of cluster 1 are the lightest polluted. Cities of cluster 3 and cluster 2 are polluted by emission sources of SO_2 and O_3. (4) In Autumn, cities of cluster 3 and 4 are the severest polluted by the emission sources of SO_2, CO, PM10, and PM2.5; the emission sources of NO_2 would significantly influence the air quality in cities of cluster 5; the emission sources of O_3 could significantly influence the air quality in cities of cluster 1 and cluster 4. (5) In winter, cities of cluster 5 are the severest polluted by the emission sources of SO_2, CO, PM10, PM2.5, and CO; the emission sources of O_3 could significantly influence the air quality in cities of cluster 1 and cluster 5.

© 2016 Elsevier Ltd. All rights reserved.

1. Introduction

Last two decades, the nexus between environmental issues and economic development is one of the hot issues, which have caused extensive concern (Gao et al., 2011; Zhang, et al, 2013a). In China, rapid industrialization and urbanization has created lots of mega cities such as Beijing, Shanghai, Guangzhou, Cheng du, and so on. Air pollution following with rapid urbanization, population growth, and industrialization has been getting attention, which has been a serious threat to human health (Saskia et al., 2016; Deng et al., 2014). Air environmental issue has extensively attracted public attention, Chinese government has passed a low named 'the action

* Corresponding author. Tel.: +86 13981878609; fax: +86 028 85401807.
** Corresponding author. Tel.: +86 13668135849; fax: +028 86290986.
E-mail addresses: jmzhangscu@qq.com (J.-m. Zhang), shdeng8888@163.com, zcilly@126.com (S.-h. Deng).

http://dx.doi.org/10.1016/j.atmosenv.2016.08.066
1352-2310/© 2016 Elsevier Ltd. All rights reserved.

plan for controlling air pollution' to resolve the air environmental issue.

The components of air pollutants are very complicated. Generally, particulate matter (PM), sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen oxide (NO_x), Ozone (O_3), and organic contaminants extensively attract public attention (Pires et al., 2008). Under the natural conditions, there are some chemical-photo catalytic reactions among air pollutants (Benigno et al., 2012). Both meteorological conditions such as atmospheric temperature, atmospheric pressure, wind speed and directions, and terrain conditions would affect the diffusion of air pollutants (Bhanu et al., 2014). Thus, spatial-temporal differences of air pollutants are hug. It is difficult to identify the major air pollutants of regional scales or large time scale according to the data from environment monitoring stations.

The emission sources of air pollutants are diverse and complicated. Automobile exhaust, exhaust from fossil fuel burning, and factory waste gases are the three major emission source of air pollutants (Dragana and Tatjana, 2008). Generally, an air pollution source would emit several kinds of air pollutants (Zhang et al., 2013a). The kinds of air pollutants are usually determined by the composition of fossil fuels. E.g. more than one hundred pollutants would be emit from automobile exhaust, with CO, hydrocarbon, NO_x, PM as major air pollutants (Rahman and Kim, 2012). The compositions of fossil fuels are difference, the kinds of air pollutants in exhaust from fossil fuel burning would be difference. Generally, coal-fired exhaust mainly includes the following air pollutants, such as CO, PM, NO_x, and SO_2; the air pollutants in natural gas exhaust is mainly CO and methane (CH_4).

The concentration of air pollutants observed by environment monitoring point is uncertainty when the research object is referred to regional scale and large time scale. According to the monitoring data of air pollutants, it is difficult to identify the major air pollutants or emission sources. Identifying the major air pollutants is conducive to knowledge the current situation of air pollution, and filtering the major emission sources would help to control air pollution. Thus, it is necessary and significant to identify the major air pollutants by scientific method.

The present investigation aims to (1) use factor analysis to identify the major air pollutants based on the monitoring data of monthly air pollutants in 74 Chinese cities; (2) cluster 74 Chinese cities into five categories and filter the possible major emission sources. Then, the major air pollutants of 74 Chinese cities in different seasons are obtained, which is public attention. The major air pollutants would guide the policies makers to set scientific policy to improve air quality.

The rest of this article is structured as follows. Section 2 introduces factor analysis and cluster analysis. Section 3 shows the results of factor analysis, which identify the major air pollutants. Section 4 shows the results of cluster analysis, which filter the possible major pollution source of every kind of cities. Section 5 discuss the major emission sources of air pollutants, which are conducive to make policies according to the results of factor and cluster analysis, and then obtain some conclusions.

2. Methods

2.1. Data collection and pre-process

Both seasonal average concentration and annual average concentration of air pollutants are calculated by monthly average concentration of air pollutants. In China, spring begins in March and continues through May; summer begins in June and continues through August; autumn begins September and continue through November; winter begins December and continue through February of next year. Thus, seasonal average concentration of air pollutants in spring, summer, autumn, and winter was calculated by arithmetic mean for corresponding month.

The magnitude of concentration of particulate matter smaller than 2.5 μm (PM2.5), particulate matter smaller than 10 μm (PM10), SO_2, nitrogen dioxide (NO_2), CO, and the average concentration of ozone in 8 h (O_3-8H) are difference. To avoid ignoring the influence of air pollutants with low concentration (small magnitude), concentration of air pollutants were transformed to a robust z-score as described in Eq. (1).

$$x_{i,j} = \frac{\boldsymbol{pollutants_{i,j}} - \mathrm{mean}(\boldsymbol{pollutants_j})}{\mathbf{std}(\boldsymbol{pollutants_j})} \tag{1}$$

where, $x_{i,j}$ represents the robust z score of the jth air pollutants at ith city ($x_{i,j}$ includes standardized values of PM2.5, PM10, SO_2, NO_2, CO, and O_3-8H). $Pollutants_{i,j}$ represents concentration of the jth air pollutants in ith city. Mean($pollutants_{i,j}$) represents the arithmetic mean concentration of the jth air pollutants in all city. Std($pollutants_{i,j}$) represents the standard deviation of jth air pollutants concentration in all city.

2.2. Factor analysis

Factor analysis is considered as a powerful, linear, unsupervised, pattern recognition technique that can be used as a mathematical tool for analyzing, classifying, and reducing the dimensionality of numerical data sets in a multivariate problem (Zhang et al., 2014).

2.2.1. The principle of factor analysis

There is some correlation among air pollutants concentration (PM2.5, PM10, SO_2, NO_2, CO, and O_3). Thus, factor analysis could be employed to reduce the dimensionality of variables. According the theory of factor analysis, either of following equations can be obtained.

$$\begin{aligned} F_1 &= a_{1,1}PM2.5\prime + a_{1,2}PM10\prime + a_{1,3}SO_2\prime + a_{1,4}NO_2\prime + a_{1,5}CO\prime + a_{1,6}O_3\prime \\ F_2 &= a_{2,1}PM2.5\prime + a_{2,2}PM10\prime + a_{2,3}SO_2\prime + a_{2,4}NO_2\prime + a_{2,5}CO\prime + a_{2,6}O_3\prime \\ &\cdots \\ F_n &= a_{n,1}PM2.5\prime + a_{n,2}PM10\prime + a_{n,3}SO_2\prime + a_{n,4}NO_2\prime + a_{n,5}CO\prime + a_{n,6}O_3\prime \end{aligned} \tag{2}$$

$$\begin{bmatrix} F_1 \\ F_2 \\ \cdots \\ F_n \end{bmatrix} = \begin{bmatrix} a_{1,1} & a_{1,2} & \cdots & a_{1,8} \\ a_{2,1} & a_{2,2} & \cdots & a_{2,8} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n,1} & a_{n,2} & \cdots & a_{n,8} \end{bmatrix} [PM2.5\prime PM10\prime\, SO_2\prime\, NO_2\prime\, CO\prime\, O_3\prime]^T \tag{3}$$

where, F_i is the ith factors that explains air pollutants; $a_{i,j}$ is the

Download English Version:

https://daneshyari.com/en/article/6335626

Download Persian Version:

https://daneshyari.com/article/6335626

Daneshyari.com