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Review of Identification Methods for Indoor Pollutant Sources

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Abstract

Source identification has been a challenging research topic in the area of indoor air quality which is an inverse problem in physics and mathematics as the process is to find unknown causes from known consequences. This paper studied a large number of research results of predecessors, and grouped the indoor pollutant sources identification methods into direct methods, probability and statistics methods and optimization methods. Although the indoor pollution source identification method has made great progress, but is still under the experimental conditions, and the simulation process was greatly simplified. The future research on the inverse problem of indoor pollutants should be more connected with the actual situation. More comprehensive species of pollutants, more complex way that pollutants release, and greater variety of sources type should be carried on in research. In addition, the development of more advanced methods to improve the identification rate is the priority.

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Keywords: Inverse problem; Direct Methods; Probability and statistics methods; Optimization methods; PTR-MS.

1. Introduction

The control of indoor pollutants has been becoming an important tributary and research hot spot in the building environment and related fields. The mostly used methods of pollution control are pollution source control, fresh air systems and air purification[1]. If pollutants could be controlled at the source, the subsequent workload of ventilation and air purification will be declined significantly. To prove effectiveness of pollutant source control, it demands accurate and quick prediction of position and emission intensity of pollution source. However, to meet above requirements, professionals have to approach pollution source to measure parameters precisely, even that are

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toxic substances released by explosive containers, which always put professionals' safety in risk and lead to low distinguish efficiency of polluting character so as to reduce the response speed of the initiative pollution control. In general, it's necessary and urgent to develop a method which can distinguish potential pollutant sources by limited remote data input sensors. Tracing pollution source information by data of sensors is a kind of inverse problems.

Throughout domestic and overseas research results, inverse problem theories have been widely applied in underground water source, seismic origin, acoustic source, heat source, atmosphere environment and some other research fields. Despite a late application in indoor air pollution sources, with accelerating attention to indoor air quality, inverse problems have been developed rapidly in indoor pollution. The main characteristic of inverse problems is ill-posedness, which means the solution does not necessarily exist. Even it exists, the solution may not be unique, besides, it does not continuously depend on the changes of observing data[2]. As Alifanov[3] pointed out, the numerical solution of inverse problems are unstable. As a result, the core issues is to find a proper way to improve numerical stability in inverse problems solving process to obtain the only solution.

Nomenclature

QR	Quasi-reversible
PR	Pseudo-reversible
GC/MS	Gas Chromatography-Mass Spectrometer
PTR-MS	Proton Transfer Reaction- Mass Spectrometry
ACO	Ant Colony Optimization
SA	Simulated Annealing
GA	Genetic Algorithm
ANN	Artificial Neuro Network
PSO	Particle Swarm Optimization

2. Methods

For years scholars have made unremitting exploration and efforts to identify sources of pollution problems, and developed some systematic methods. Rao et al.[4] summed up the source estimate approach to forward modeling and backward modeling methods. Forward modeling methods, which describe the atmospheric transport from sources to receptors, use forward-running transport and dispersion models or computational fluid dynamics models which are run many times, and the resulting dispersion field is compared to observations from multiple sensors, e.g., Bayesian inference method. Forward methods aims at finding the relevant features of the source that make the concentration difference between simulations and observations minimized. Backward modeling methods typically use only one run in the reverse direction from the receptors, in order to determine the unknown upwind sources. Liu and Zhai[5] studied various inverse modeling methods for indoor emission sources and summarized the methods into three major categories: forward, backward, and probability inverse modeling methods. Under the assumed sources conditions, the forward method carries out disseminated simulation of forward airflow and pollutant by error text means. The backward methods start from the end state, and use negative time step in the simulation to get the evolution of concentration and fluctuation history of sources. Probability methods focus on assessing the probability associated with fixed events, for example, the probability of pollutants at some locations. In the probability method, the source information is determined by maximize or minimize the objective function, and uncertainty analysis can be carried out directly. Zhang[6] summarized the progress of the inverse modeling to identify the indoor pollution sources, and research profile of inverse modeling in the field of heat transfer, water pollution and air pollution, then grouped the research methods to identify indoor air sources into four categories, namely analytical method, probability method, optimization method, and direct method. Chen[7] turned the localization research results of leakage source into two categories: method based on probability and statistical theory and method based on optimization theory. Method based on probability and statistical theory uses the prior information of unknown