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A method to identify the point source of indoor gaseous contaminant based on limited on-site steady concentration measurements

Xinke Wang (✉), Wei Tao, Yuanyuan Lu, Fenghao Wang

School of Human Settlements and Civil Engineering, Xi'an Jiaotong University, Xi'an 710049, China

Abstract

Identification of potential contaminant sources in buildings is an important issue for indoor pollutant source control. In this paper, a method based on the characteristics matrix derived from the transport governing equation is proposed, and the procedure to identify the contaminant source is presented. Compared with the methods in the literature, the new method is more suitable for the identification of steady point contaminant sources because it only requires limited on-site concentration measurement data without historical information. As a demonstration case, a 2D room with a known flow field validated by the experiment in the literature is selected. A steady point source is presumed at a certain point and the concentration field is calculated by computational fluid dynamics (CFD). Then the concentration data at the specified sampling points are used to identify the source position. Without the measurement error, the method can work well when the concentration measurement data at only two sampling points are given. However, when concentration measurement errors are considered, sampling points need to be increased to improve the identification accuracy. For the simulated 2D case, nine sampling points are sufficient for acceptable accuracy when the relative measurement error is 10%. Effects of positions of the source and the sampling points, and the uncertainty of the flow field simulation on the identification results, as well as the limitation of the method are also discussed.

Keywords

source identification,
indoor air quality (IAQ),
steady concentration,
computational fluid dynamics (CFD)

Article History

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1 Introduction

People spend more than 87% of their time indoors (Kim et al. 2001). However, since the energy crisis in 1970s, less outdoor fresh air is supplied into buildings and more air-tight measure is made in buildings for building energy saving. At the same time, more chemical products emitting lots of chemical contaminants are applied indoors. Consequently, indoor air quality (IAQ) becomes worse in the urban buildings and some significant adverse symptoms on occupants' comfort, health, productivity arise such as headaches; eye, nose, or throat irritations; heart disease and even cancer (Yang et al. 2001).

Source control is a primary and the most effective way to improve indoor air quality. However, for source control it is often difficult to identify the locations of the contaminant sources. An imaginary effective solution to find contaminant source is to measure the concentrations of indoor contaminants in as many positions as possible to identify the point with maximum concentration value as the position of the contaminant source. But in reality, the expense will limit the method. Therefore, some modeling methods together with limited sensors are developed. Sreedharan (2006, 2007) successfully employed Bayesian probability theory to identify the gaseous pollutant source by interpreting real-time monitoring information from the concentration sensor network. Recent years, so-called inverse modeling methods were developed rapidly for the more accurate identification of indoor contaminant sources. These inverse modeling methods were classified as forward methods, backward methods and probability methods (Liu and Zhai 2007). The forward methods employed a trial-error simulation process to find a contaminant source that can promise the best fitting between the predicted concentration and the measured

E-mail: wangxinke@mail.xjtu.edu.cn