Measurement of anthropogenic VOCs and their impact on Environment

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Abstract

Volatile Organic Compounds (VOC) in the air can adversely affect human health. Many types of VOC are emitted by human activities, ranging from vehicle exhaust to chemical release from manufacturing processes and solvent evaporation from a wide range of industrial and domestic activities. VOCs have therefore become widely distributed in the environment, and monitoring their levels is important both as a public health measure and for giving advice on patterns of release.

The researcher has developed a passive sampling gas chromatography method for determining ambient VOC levels, and has applied the method to VOC monitoring in Shizuoka City, Japan. Passive sampling offers considerable advantages over pump systems which include its inherent simplicity and ease of deployment. Since the method does not require an electricity supply, it can be used in any location. The researcher also briefly discusses some results of VOC distribution monitoring.

Key words: VOC/ monitoring/ distribution/ passive sampling

1. Introduction

The adverse health effects of exposure to volatile organic compounds (VOCs) are recognised as being a major public health concern in urban and industrialised areas (Cocheo et al., 2000; Sarigiannis et al., 2011; Ongwandee et al., 2011). Environmental standards for several VOCs, including benzene, have been advised by the UN WHO and been made mandatory in Japan and Thailand.

Recent attention to global warming has suggested that climate change will increase the evaporation rate of VOC and increase emmissions from many sources. For example, gasoline emission from gasoline tank in the car can increase. Therefore there is a growing need to monitor VOCs in the environment. Some VOCs also affect global warming directly. It is well known that molecule for molecule methane produces 21 times as much warming as CO_2 (IPCC, 2007).

The original design of VOC samplers relied on pumping atmosphere through collectors or detectors – thus sampling was an active process. The

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passive sampler described here is small, light weight, device that is inexpensive and easy to handle (Olansandan et al., 1999; Amagai et al., 1999; Kume et al., 2008; Roukos et al., 2009). This apparatus is suitable for monitoring VOCs in the ambient air. We have developed simple measurement method for VOCs.

2. Materials and Methods

This study was undertaken in Shizuoka, a city in central Japan. Since it faces Pacific Ocean, the wind blows from the ocean in the summer season. On the contrary, the wind blows from the northern mountains in the winter season. Most of the city is business district and residential area. The VOC passive samplers were deployed at various locations across the city.

The passive sampler for collecting VOCs comprised a porous PTFE tube packed with activated charcoals (Passive gas tube, Shibata Sci Technol. Ltd., Tokyo).

Sampling was performed by exposing the sampler to the environment at the sampling point for 24 hours. To produce a reliable contour map for VOC, at least 20 sampling points were necessary. After sampling, the sampler was return to the original aluminum-plastic bag, and sealed. It was stored in the refrigerator at -20ºC until analysis.

VOCs were extracted with the solvent before GC/MS analysis. Extraction solvent was carbon disulfide (Suitable for Industrial Hygiene Analysis; Wako Pure Chem. Ltd., Osaka) and it was distilled once before use.

Activated charcoal in the passive sampler was put into the test tube. Distilled carbon disulphide was added to the test tube, and the solution was ultrasonicated for 10 min. The test tube was centrifuged for 10 min, and the supernatant was transferred to the vial for GC/MS analysis (Amagai et al., 2002). Ultrasonication was done with ultrasonic bath (UT-305, Sharp Co.), and centrifugation was performed with refrigerated centrifuge (05PR-22, Hitachi). GC/MS instrument was GC6890/MSD5792A (Agilent Technol., Santa Clara), GC column was Supelcowax10 (60 m in length, 0.32 mm i.d., 1 μm in film thickness; Sigma-Aldrich Co., St Louis). Helium gas for carrier of GC/MS was >99.995% pure (Taiyo Sanso Ltd., Tokyo).

GCMS produces mass chromatograms of benzene, toluene, xylenes and some benzene alkyl derivatives (Fig 1). Aliphatic hydrocarbons can also be determined with this system. To determine halogenated hydrocarbons, such as chloroform, GC/ECD is used instead of GC/MS.

Contour maps were created using G-sharp software (Nihon denshi Keisan Ltd., Tokyo).

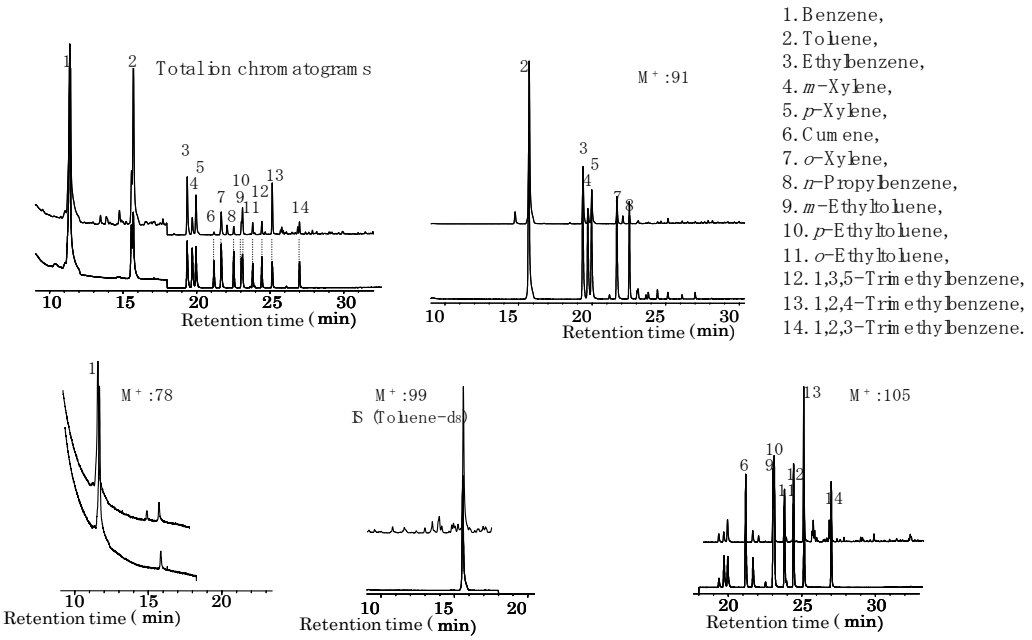

Figure 1 A typical mass chromatograms of benzene and its derivatives. Chromatograms of standard solution (lower chromatograms of each figure) and sample extract (upper ones).

3. Results and Discussion

Since benzene is a human carcinogen (IARC supp. 7), its health effect have been concerned.

Benzene concentrations in Shizuoka, Japan showed both spatial and temporal (seasonal) variations (Fig. 2). These maps can be relatively easily made for any city because the sampling method is simple and an electricity supply is not necessary.

The ratio of maximum to minimum concentration varied between 1.7 - 4.3, and this suggest that benzene concentrations were rather constant within the Shizuoka city. The geometric mean concentrations across the city varied between 0.64 - 2.4, and this suggest that variations between days were also small. The primary source of benzene is thought to be gasoline car exhaust and industry (Kume et al., 2008; Roukos et al., 2009). Since there were few factory that emitted benzene, the primary source is the car in Shizuoka. Then benzene concentrations were rather uniformly.

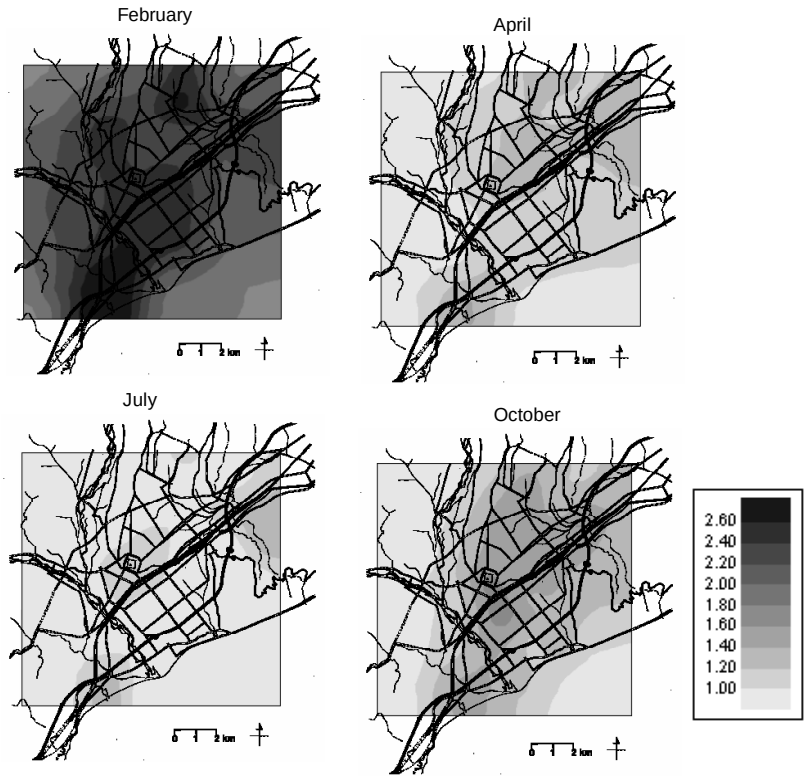

Figure 2 Benzene distributions in Shizuoka, Japan

This study has demonstrated the utility of this monitoring system, we can measure tens of VOC simultaneously. We therefore conclude that the methods developed are useful for monitoring distributions of VOCs in cities in the developed and developing countries, and are able to describe variations in VOC day by day, season by season and spatially. There seems to be no impediment to this system being applied to measure personal exposure and indoor pollution VOCs. This should in turn lead to better quantified risk assessments of VOCs.

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