

Measurement of NO₂ and aerosol in the urban atmospheric using DOAS with a PC projector light source

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Recently the atmospheric pollution has been improved in Japan as a whole, when compared with situations two decades ago. Some problems, however, remain in places such as urban roadside areas, where the environmental standards have not been achieved. Therefore, efforts are required for monitoring anthropogenic air pollution, especially the combustion products such as nitrogen oxides and particulate matters. The main pollution species in urban areas in Japan are nitrogen dioxide (NO₂) and suspended particulate matter (SPM), usually referred to as PM₁₀. The conventional point sampling of these pollutants at ground stations leads to concentrations for local environments. In order to evaluate average pollution conditions, it is valuable to obtain additional information of regional concentrations measured over a certain distance, e.g., several hundred meters to several kilometers.

Differential optical absorption spectroscopy (DOAS) in the visible and near-UV region is suitable for monitoring horizontally averaged concentrations of pollutants. In the conventional long-path DOAS method, a continuously emitting light source is employed, and the source is placed at a certain distance from the observation site. The use of aviation obstruction lights (white flashlights) makes it possible to employ a simple detection system that consists of a telescope and a compact CCD spectrometer. The DOAS method acquires a data point every five minutes, much more frequent than the data (every one hour) provided from the Ministry of the Environment Atmospheric Environmental Regional Observation System (AEROS).

The drawback of the use of aviation obstruction light as a DOAS source is that in accordance with the regulation, the light intensity is diminished at dusk and dawn, and during the nighttime, blinking red lights replace the flashlights. Thus, the DOAS measurement is limited to the daytime, around 5 a.m. to 7 p.m. during the summer. Moreover, the measurement cannot be carried out where no obstruction flashlight is situated. Alternatively, here we propose the use of a commercially available PC projector as a white-light source. This is relatively inexpensive, yet the possibility of unattended, continuous operation is quite suitable for the DOAS measurement. This light source is portable, and it can be used during both daytime and night time.

The purpose of this study is to demonstrate the capability of the PC projector as a DOAS light source. The long-path, continuous measurements have actually been performed, and the resulting concentrations of pollutants are compared with the data from nearby ground-based monitoring stations. We report the results of three recent campaigns: Seoul city in South Korea, Nagano city and Chiba city in Japan. The restoration of the Cheong-gye stream in Seoul city has contributed to alleviate the urban pollution situations. The environmental standards of NO₂ and SPM have been mostly attained in Nagano city, while heavy traffic still causes problems in the urban Chiba city area. In these measurements, we measured optical thickness due to NO₂ absorption and aerosol extinction in the lower troposphere (atmospheric boundary layer) using nearly horizontal optical paths in a height range of 15-100m from the ground level.

A reasonable temporal correlation was found between the result of the long-path measurement using DOAS method and the data of NO₂ concentration from a ground station near each optical path in Seoul city and in Chiba city. Moreover, a reasonable correlation was found between the aerosol optical thickness using DOAS method and the data of SPM concentration from a ground station in these cities. However, the comparison was difficult in Nagano city between the NO₂ concentration from DOAS and the ground (AEROS) data, mainly due to the small concentration of pollutants, and in addition, occasional snow fall in the mountain region where the PC projector light source was placed.