

# EXPERIMENTAL STUDY ON THE EFFECT OF CHEONG-GYE STREAM RESTORATION ON URBAN ENVIRONMENT (LONG-PATH MEASUREMENT OF ATMOSPHERIC POLLUTANT SPECIES WITH AN OBSTRUCTION FLASHLIGHT)

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## Commission VI

**KEY WORDS:** Pollution, Spectral, CCD, Environment, GIS, Urban, Research

### ABSTRACT:

The expressway was dismantled in Seoul in July, 2003, and the municipal river was restored in October, 2005. In this study, it is intended that the atmospheric pollutant data and the air temperature data are accumulated in the proof of the relaxation effect of the heat island phenomenon in Cheongcheon.

As a method of researching the atmospheric pollutant, the astronomical telescope was used. Furthermore, as a method of the meteorological observation, an observation data of air temperature at 19:30-20:30 in September 24th 2005 was used in Cheongcheon.

The purpose of this study is twofold. First, we compare the long-path result with the point data simultaneously measured at ground-based monitoring stations. Second, we analyze quantitative evaluation of the effect of Cheong-gye stream restoration on air quality. By publishing the result of being obtained in this study, it is thought it is useful to the improvement of the consciousness for the environment of the citizen.

### 1. Introduction

The expressway was dismantled in Seoul in July, 2003, and the municipal river (Cheong-gye stream) was restored in October, 2005. In this study, it is intended that the atmospheric pollutant data and the air temperature data are accumulated in the proof of the relaxation effect of the heat island phenomenon in Cheongcheon.

In the monitoring of atmospheric pollutant species such as NO<sub>2</sub>, SO<sub>2</sub> and O<sub>3</sub>, conventional point measurements at ground sampling sites lead to concentrations for local environments. It is also 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 more suitable to monitor horizontally averaged concentrations of pollutants (Edner *et al.*, 1993).

In the conventional long-path DOAS method, a continuously emitting light source is employed, and the source (or occasionally a retroreflector) is placed at a certain distance from the observation site. Then the combination of a monochromator and a detector such as a photomultiplier, photodiode arrays, or a charge-coupled device (CCD) serves to spectrally analyze the transmitted light. In the present paper the Center for Environmental Remote Sensing, Chiba University, reports a novel DOAS spectrometer based on a white flashlight source and a compact CCD spectrometer (Yoshii *et al.*, 2003). The motivation of this study is to utilize white flashlights (obstruction lights) installed on tall constructions such as towers, bridges, and stacks for the DOAS measurement. Such white flashlights are widely used for the safety of aviation traffic in many countries. In Japan, it is mandatory for tall constructions (higher than 60m) to operate highly illuminant (more than

2×10<sup>6</sup>cd) white flashlights during the daytime that are detectable in every direction from several kilometers away. Normally, xenon lamps are used for this purpose, giving a strobe emission every 1.5s. Compared with the conventional DOAS measurements, the advantage of the present scheme is evident; if one can find an appropriate obstruction light, as is the case in cities or industrial areas, the DOAS measurement can be carried out without bothering to prepare light sources. After transmission in the atmosphere, the spectral analysis is easily attained by use of a commercially available CCD spectrometer, which enables us to measure the spectrum of the pulsed signal.

Additional advantages associated with the present pulsed DOAS are as follows. First, the background from the sky radiation is easily subtracted because the spectra with and without the strobe flash are distinguished straightforwardly from the difference in the observed intensity. Second, simultaneous observation of several trace gas species is feasible if the relevant spectral features fall within the considered wavelength interval of the lamp and the CCD. Third, when the spectral intensity of the flashlight is known at the strobe site, the transmitted spectra bring about the information on the aerosol extinction along the optical path.

The purpose of this study is twofold. First, we compare the long-path result with the point data simultaneously measured at ground-based monitoring stations. Second, we analyze quantitative evaluation of the effect of Cheong-gye stream restoration on air quality.

### 2. Study area and Experiment

#### 2.1 Study area

Seoul city is located in the northwest of Korea. The area of the city is 605.52km<sup>2</sup>, and its population about 10,000,000

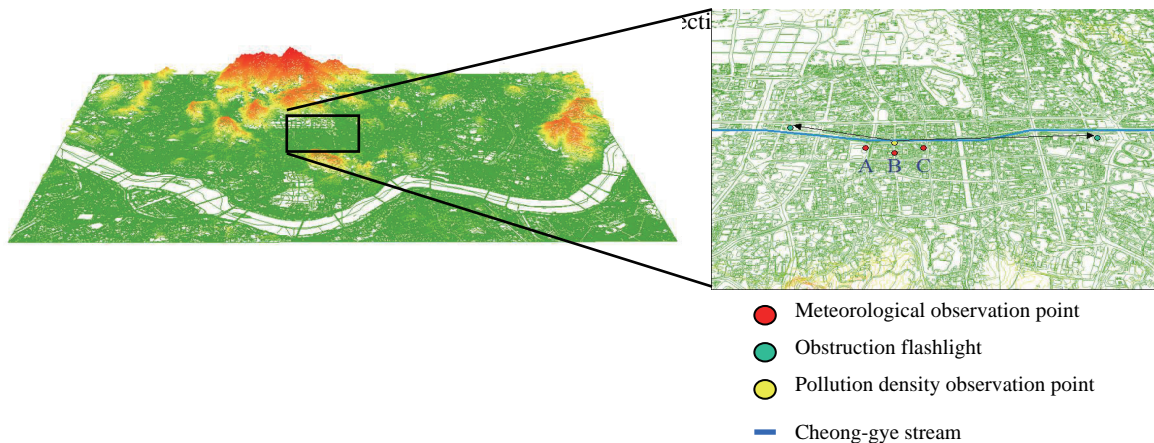


Fig. 1 Study area (Seoul city)

inhabitants. The topography of the study area is steep range of hills mountain land. In short, ups and downs of land are steep. The study area is around restored a cheong-gye stream in 1 October, 2005. The cheong-gye stream flowing from west to east in the city center of Seoul was an inner-city river with the length of 10.92 km joining to the Han-gang river.

## 2.2 Experimental method

### (a) Measurement of atmospheric pollution

Fig. 2 shows a schematic of the experimental setup. An astronomical telescope (Meade, DS-115), with an aperture diameter of 115 mm and a focal length of 910mm, is employed to focus the image of a point light source located at a far distance. The image is formed near the eyepiece location (the eyepiece itself is removed from the telescope) where the entrance slit (1 mm high and 5 μm wide) of a CCD spectrometer (Ocean Optics, USB2000) is placed. The CCD consists of 2048 elements and is sensitive in a wavelength range of 200-800 nm, resulting in an average resolution of 0.3 nm/pixel. This CCD spectrometer is composed of a fixed grating and a linear CCD array with a mechanically stable, crossed Czerny-Turner design. No moving parts are incorporated, resulting in high reliability and compactness (89 mm wide × 63 mm deep × 34 mm high). The CCD gate duration is set at 300 ms in the experiment. Between successive gate periods, there exists a time lag of 7 ms, in which each spectral data is sent to a personal computer (PC) through the universal serial bus. The data acquisition can be attained successfully even when no trigger (synchronous with the flashlight) is applied to the CCD spectrometer.

### (b) Meteorological observation

In September 24<sup>th</sup> 2005, an observation data of air temperature at 19:30-20:30 was used in Cheongcheon. The goal of the observation was to know change in air temperature at sunset. All the observation points are on the paving of asphalt.

## 3. Result

### 3.1 Analysis of the DOAS spectrum

The quantitative analysis of trace compounds is based on Lambert Beer's law (e.g., Fuqi, 2005).

$$I_1 = I_0 \cdot e^{-\alpha L C} \dots (1)$$

where  $I_1$  and  $I_0$  denote the light intensity at a specific wavelength with and without absorption, respectively. In addition,  $\alpha$ ,  $L$  and  $C$  denote the absorption coefficient, the length of open path, and the mixing ratio of trace gas,

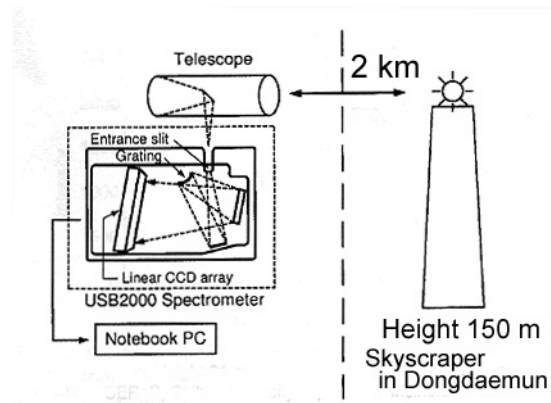


Fig. 2 Experimental setup for measuring NO<sub>2</sub>

broad band absorption has little spectral structure, the DOAS technique only considers the narrow band structure. Therefore, for the derivation of concentrations, the differential cross sections ( $\Delta\alpha$ ) over several wavelength channels are taken into account. The cross sections for the wavelengths (gases) of interest has been pre-recorded by the manufacturer and stored in the analyzer's memory. The strength of absorption for each trace gas however, varies as a function of wavelength. Thus, to optimize the detectibility of each gas for the DOAS system, wavelength region of the strongest absorption was selected and used for each gas such as: 265.7-304.4 (O<sub>3</sub>), 280.7-319.3 (SO<sub>2</sub>), and 406.2-444.2 nm (NO<sub>2</sub>). Fig. 3 shows for the two data spectrums compared in the analysis. The difference in the bias level between the two spectra is ascribed mainly to the difference in the aerosol optical thickness. Fig. 4 shows monthly average of NO<sub>2</sub> during January, 2001 to October, 2005. However, the air quality standards of NO<sub>2</sub> in Seoul is 0.05 ppm (the value of annual average), the value of NO<sub>2</sub> in Chongae 4 ga is more than 0.05 ppm during July 2003 to June 2005. The influence of construction is stronger than the influence of the autoexhaust. However, it is worth observing atmospheric pollutant species, since the value of NO<sub>2</sub> in Chongae 4 ga is low after restored a cheong-gye stream.

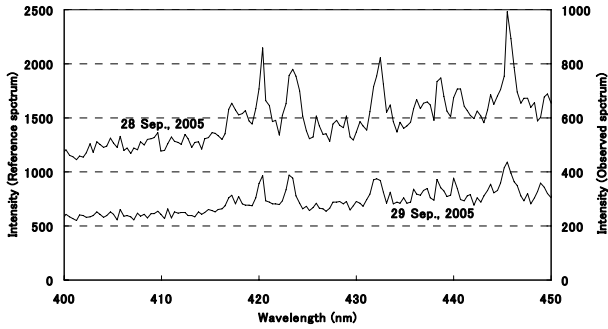


Fig. 3 Observed spectrum (28 September, 2005 16:00-17:00 JST) and reference spectrum (29 September, 2005 9:35-9:40 JST).

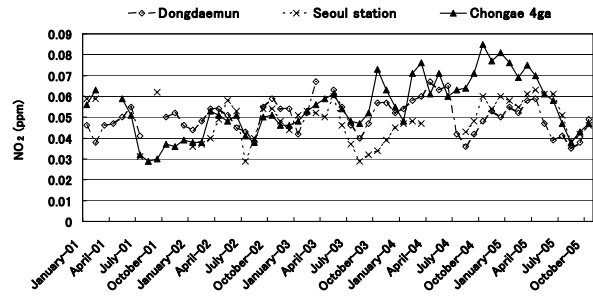


Fig.4 Monthly average of NO<sub>2</sub> around the road

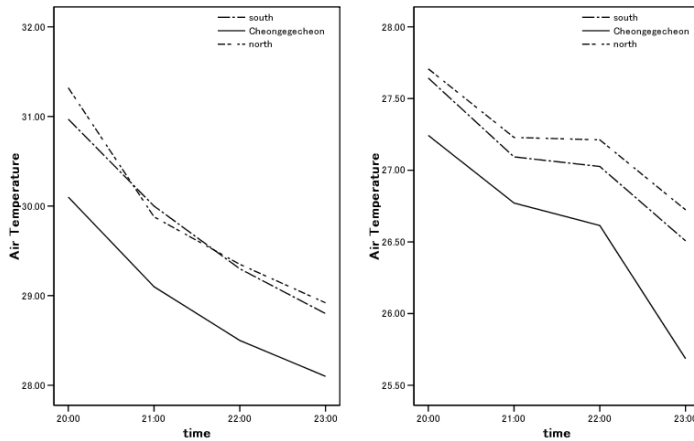


Fig. 5 Daily variation of air temperature (Left:2004, Right:2005) (North-South)

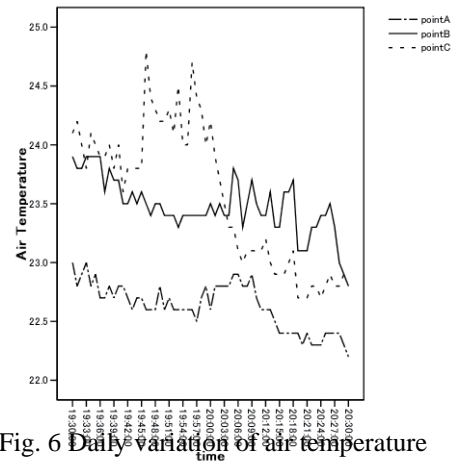


Fig. 6 Daily variation of air temperature (2005) (East-West)

### 3.2 Relation of building form and air temperature

Fig. 5 (North-South) and Fig. 6 (East-West) show the change in air temperature obtained according to the air temperature measurements. At first the decreases in the air temperatures are seen in Cheonggecheon according to Fig. 5. In general, there is relaxation effect of air temperature in the river, and away from the river, the air temperature tends to be high. Next, the air temperature of point A is the lowest according to Fig. 6. It is thought that the density in the building influences the air temperature.

Radiant quantities  $R$  from the ground surface when there is an obstacle are shown by the next formula.

$$R = \sigma T^4 - \gamma \sigma T_1^4 - (1 - \gamma) \Gamma \sigma T_a^4 \dots (2)$$

where,  $\sigma$ : Stefan constant,  $T$ : Ground surface temperature,  $T_1$ : Ground surface temperature of obstacle,  $T_a$ : Air temperature,  $\Gamma$ : The emission absorption quantity by the atmosphere and the emission absorption quantity by the planckian radiator ratio,  $\gamma$ : The spatial ratio which the obstacle occupies.

In addition,  $0 < \gamma < 1$  and  $0 < \Gamma < 1$  is. At the early morning of the city, it is thought  $T_1 > T_a$  and  $T > T_a$ . If the value of  $R$  decreases, cooling rate of the ground level becomes small. As a result, ground surface temperature of the city becomes high in comparison with suburb. In addition, when altitude of the building is high, in order to reflect multiplex with the wall surface, the structure of the city is likely to be heated

A(28%)      B(54%)      C(46%)

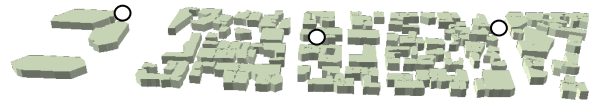


Fig. 7 pattern diagrams of building (Density in the building of 120m in radius from observation point).

(e.g.Kawamura, 1964). In this study, it thought about the relation of the density of the building and the air temperature.

As a result, there is a proportional trend between the air temperature and the density in the building, in other words when the air temperature is high the density of the building is also high, and vice versa. It is necessary to investigate an accurate architectural form in order to examine the relation of a detailed architectural form with the air temperature in the future. The atmospheric pollutant species observation and the meteorological observation in Seoul will be studied, and the relaxation effect of the heat island phenomenon of the municipal river will be clarified. Thus, it is possible to contribute to the creation of the municipal river and the promotion of maintenance in Asian cities.

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