

## NOXIOUS GASES IN GREENHOUSES

Christos Likas<sup>1</sup>, Vasiliki Exarchou<sup>1</sup>, Konstantinos Gourgoulisanis<sup>3</sup>, Panagiotis Giaglaras<sup>1</sup>,  
Theophanis Gemptos<sup>2</sup>, Konstantinos Kittas<sup>1</sup>, Paschalis-Adam Molyvdas<sup>4</sup>

<sup>1</sup>Agricultural Construction and Environmental Control Laboratory, University of Thessaly, Larissa, Greece

<sup>2</sup>Agricultural Mechanics Laboratory, University of Thessaly, Larissa, Greece

<sup>3</sup>Department of Pulmonary Medicine, Medical School, University of Thessaly, Larissa, Greece

<sup>4</sup>Department of Physiology, Medical School, University of Thessaly, Larissa, Greece

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**Abstract:** The concentration of NO<sub>2</sub> and SO<sub>2</sub> was measured in a commercial greenhouse from 23/9/1999–25/01/2000. The measurements showed that the level of the two gases is very high in the greenhouse atmosphere. Lung function tests in 42 workers showed that temporary work did not influence significantly the respiratory health status.

**Address for correspondence:** KI Gourgoulisanis, MD, Associate Professor, Medical School, University of Thessaly, 22 Papakyriazi, 412 22 Larissa, Greece. E-mail: Kgourg@med.uth.gr

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## INTRODUCTION

An agricultural worker is defined by the World Health Organization (WHO) as any person engaged either permanently or temporarily, irrespective of legal status, in activities related to agriculture [1, 2]. Researchers have noted the presence of 150 potentially toxic gases arising from agricultural waste [3]. The increasing use of modern technologies, such as greenhouses, has been associated with a long-term storage of gases.

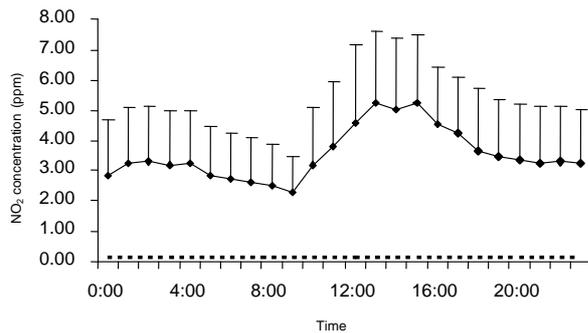
In a greenhouse environment, the concentration of chemically non-reactive fine particles such as sulfates may reach 90% of that outdoors. Consequently, a significant air pollution may occur in the greenhouses. Taking into account that people working in the greenhouses spend as much as 40% of their time indoors, the study of the greenhouse environment may be very important for the protection of workers' health. Greenhouse air pollution could be much higher than outdoor air pollution due to the use of chemicals, fertilizers and combustibles for heating [2, 4].

The aim of this study was the estimation of SO<sub>2</sub> and NO<sub>2</sub> levels in a greenhouse environment.

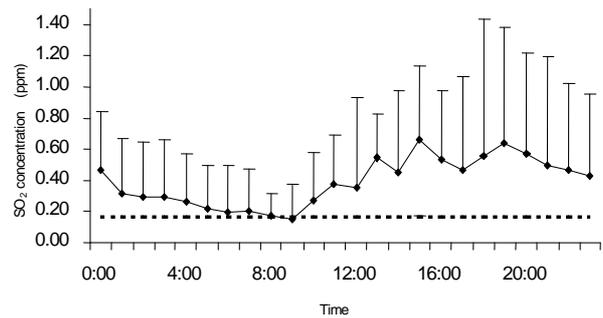
## MATERIALS AND METHODS

In this study, measurements of NO<sub>2</sub> and SO<sub>2</sub> concentration were taken in a commercial greenhouse with gardenia culture in pots. The greenhouse covered with fiberglass is located in the region of Volos in the eastern coastal area of Greece. The measurement period was from 23/9/1999–25/01/2000. Measurements were taken continuously from 0:00–23:00 once a week for nine weeks concerning NO<sub>2</sub> and for eight weeks concerning SO<sub>2</sub>, using a RAE PGM-50 Multi Gas Monitor. The instrument was placed at a height of 1.7 m above the top of the crop. Samples were taken every second and the mean value was recorded every 10 minutes. During the measuring period the greenhouse was not ventilated and the inside temperature varied between 17–23°C during the day and between 12–15°C during the night using a pipe heating system. Fertilizers were applied every 10 days using sprinklers, with the irrigation water.

Forty two workers of greenhouses were asked to complete a questionnaire, which included age, gender, smoking habits, weight and height. They were also asked about their medical history, especially respiratory history,



**Figure 1.** Variation of the hourly concentration of NO<sub>2</sub> in greenhouse air (mean ± S.D.) during nine measured periods, related to the hourly threshold limit value (dotted line).



**Figure 2.** Variation of the hourly concentration of SO<sub>2</sub> in greenhouse air (mean ± S.D.) during eight measured periods, related to the hourly threshold limit value (dotted line).

and about using drugs. Additionally, they were asked about the number of examinations by a doctor, particularly by a pulmonologist, each year during the last three years for respiratory system symptoms.

All persons were clinically examined and the results were recorded, especially those from thorax auscultation. All workers were asked to bring a recent thorax radiograph and were submitted to spirometry. They were all submitted to three trials in sitting position and the optimum was recorded. The weight and height, without shoes, were measured and the predicted values, of dynamic volumes and flows were estimated. The values from the optimal trials for forced vital capacity (FVC), forced expiratory volume in first second (FEV<sub>1</sub>), the ratio FEV<sub>1</sub>/FVC, peak expiratory flow (PEF) and forced expiratory flow (FEF) were estimated. The participants who complained of expectoration more than 60 ml daily, for at least three months for two continuous years, and had obstructive pattern in lung function test, were diagnosed with chronic bronchitis.

## RESULTS

The mean hourly concentration of NO<sub>2</sub> varied from 2.31–5.29 ppm (Fig. 1) and the mean hourly concentration of SO<sub>2</sub> varied from 0.15–0.66 ppm (Fig. 2). The highest average values were recorded at 13:00 for NO<sub>2</sub> and at 15:00 for SO<sub>2</sub>. The lowest average values were recorded at 9:00 for both NO<sub>2</sub> and SO<sub>2</sub>.

Table 1 shows that the temporary work in a greenhouse (on average 6.6 years) does not increase the expected chronic bronchitis prevalence associated with smoking habit. Temporary work seems to protect greenhouse workers from lung health problems.

## DISCUSSION

The results of our study showed increased values of gases in the greenhouse, especially those of NO<sub>2</sub>.

Indoor air pollutants usually differ in type and concentration from outdoor air pollutants. Indoor

pollutants include environmental tobacco smoke, biological particles (such as pollen, mites, moulds, insects, microorganisms producing SO<sub>2</sub> etc.), non biological particles (such as smoke), VOCs (Volatile Organic Compounds), NO<sub>x</sub>, lead, radon, CO, asbestos, various synthetic chemicals and others. Degradation of indoor air quality has been associated with a range of health effects, including discomfort, irritation, chronic pathologies and various cancers.

NO<sub>2</sub> has deleterious effect on the lung's natural defense mechanisms, mucociliary clearance, alveolar macrophages and the immune system. Chronic exposure leads to a general deterioration of lung function. Healthy non smoking young adults who have been exposed to 1, 2, and 3 ppm NO<sub>2</sub> did not show an increased susceptibility to the infection with influenza virus. Pulmonary function and airway reactivity were not altered by exposure to 600 ppb or by intermittent brief exposures to 2 ppm NO<sub>2</sub>. On the contrary, continuous exposure to 1.5 ppm for 3 h increased airway reactivity. The National Ambient Air Quality Standard is 0.147 ppm (300 µg/m<sup>3</sup>) in hourly period [5, 6]. The increased values of NO<sub>2</sub> which were observed in the greenhouse may be attributed to the activity of the plants [5], to the direct release from fertilizers and to the activity of the microorganisms [6].

SO<sub>2</sub> is a particularly noxious air pollutant. It forms an irritating sulfuric acid on contact with moist mucous

**Table 1.** Characteristics of greenhouse workers.

|                                                 |       |
|-------------------------------------------------|-------|
| Workers                                         | 42    |
| Women/men                                       | 20/22 |
| Average age (years)                             | 34.2  |
| Smokers                                         | 14    |
| Average employment period in greenhouse (years) | 6.6   |
| Chronic bronchitis (workers)                    | 2     |
| FEV <sub>1</sub> < 80% predicted values         | 3     |
| FEV <sub>1</sub> < 60% predicted values         | 0     |

membranes. The National Ambient Air Quality Standard is 0.17 ppm in hourly period [5, 6]. 0.5 ppm SO<sub>2</sub> produces increased airway resistance in exercising asthmatics. 8 ppm SO<sub>2</sub> produces throat irritation in healthy adults and exposure to 10 ppm SO<sub>2</sub> for 10 min produces bronchospasm. In our study, workers were present in the greenhouses from 7:00 to 15:00 every day. The presence of SO<sub>2</sub> in the greenhouse is attributed to the activity of the microorganisms [6, 7].

Consequently, the detection of noxious gases in greenhouses seems to be very useful. Healthy workers usually show no changes in lung function following temporary exposure. Nevertheless, the values of NO<sub>2</sub> and SO<sub>2</sub> measured in our study could cause respiratory symptoms, especially in asthmatics.

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