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1. Foliage Plants for Indoor Removal of the Primary Combustion Gases Carbon Monoxide and Nitrogen Dioxide.

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Abstract. Foliage plants were evaluated for their ability to sorb carbon monoxide and nitrogen dioxide, the two primary gases produced during the combustion of fossil fuels and tobacco. The spider plant (*Chlorophytum elatum var. vittatum*) could sorb 2.86 μg CO/cm^2 leaf surface in a 6 h photoperiod. The golden pothos (*Scindapsus aureus*) sorbed 0.98 μg CO/cm^2 leaf surface in the same time period.

In a system with the spider plant, $\geq$99% of an initial concentration of 47 ppm NO_2 could be removed in 6 h from a void volume of approimately 0.35 m^3.

One spider plant potted in a 3.8ℓ(1 gal) container can sorb 3300 μg CO and effect the removal of 8500 μg NO_2 per hour, recognizing the fact that a significant fraction of NO_2 at high concentrations will be lost by surface sorption, dissolving in moisture, etc.

Additional Index Words: foliage plants, carbon dioxide, nitrogen dioxide, combustion gases, spider plants, golden pothos, *Chlorophytum elatum var. vittatum, Scindapsus aureus.*

Introduction. Two primary sources of indoor air pollution are tobacco smoking and the combustion of fossil fuels in heaters, gas stoves, water heaters, etc. Combustion products are becoming an even greater threat to our health due to increased sealing of homes, offices, and other structures for energy conservation. Reduced ventilation contributes to a buildup of such gaseous combustion products as carbon monoxide (CO) and nitrogen dioxide (NO_2).

Carbon monoxide is a product formed during incomplete combustion. Hemoglobin has 210 times the affinity for CO than it has for oxygen; consequently, very low concentrations of carbon monoxide in the air can substantially elevate the carboxyhemoglobin concentration in the blood. Three to five percent saturation of hemoglobin with CO may adversely affect one's ability to detect small, unpredictable environmental changes. At 4 to 5% saturation, patients with cardiovascular disease can exacerbate their symptoms (National Research Council, 1977).

During cooking with a gas range, carbon monoxide levels can increase up to 500 ppm (National Research Council, 1981). Carbon monoxide levels of 2.5-15 ppm have been measured in restaurants. The main source was attributed to tobacco smoking (Seppänen and Uusitalo, 1977). Other measurements of CO in confined areas have indicated buildups of 30-90 ppm (Russel *et al.*, 1973; Seppänen, 1977; and Srch, 1967).

The current EPA standards for carbon monoxide are 9 and 35 ppm for 8 and 1 h average exposures, respectively. At 9 ppm CO and 8 h, 1.4% saturation of hemoglobin with CO will occur during heavy activity. At 35 ppm and 1 h, 2.9% saturation will occur during heavy activity (National Research Council, 1977).

Indoor combustion can also contribute to the buildup of nitrogen dioxide. Nitrogen dioxide concentrations equal to or greater than the current ambient air quality standard of 0.05 ppm are not unusual in kitchens where gas is used for cooking. At these concentrations, nitrogen dioxide may affect sensory perception, especially dark adaptation, and produce eye irritation (National Research Council, 1976; Goldsmith and Friberg, 1977). Nitrogen dioxide can produce transient and long-term damage to both small bronchial airways and alveolar tissue. Exposure of rats to a minimum of 2 ppm nitrogen dioxide for 4 hours stimulated the differentiation of nonciliated cells into mature clara cells and ciliated cells in the bronchial airways (Evans and G. Freeman, 1980). This effect raises the possibility that chronic exposure could lead to chronic bronchitis.

The National Aeronautics and Space Administration (NASA) at the National Space Technology Laboratories (NSTL) has conducted research for many years on the use of natural systems for wastewater treatment and water reclamation. This research has been expanded to include the evaluation of foliage plants for air filtration and purification in closed systems such as space stations and energy-efficient homes. The first studies concentrated on formaldehyde removal and found that the spider plant (*Chlorophytum elatum var. vittatum*) is particularly efficient in removing this organic from contaminated air (Wolverton *et al.*, 1984).

This paper contains data from experiments where foliage plants were tested for their ability to remove the two primary combustion gases, carbon monoxide and nitrogen dioxide.

Materials and Methods. A. Experimental Apparatus. The system shown in Fig. 1 consists of a Plexiglas cubical chamber, 73.7 cm on each inside edge. The removable top was fitted with a rubber gasket and clamps. To this top was