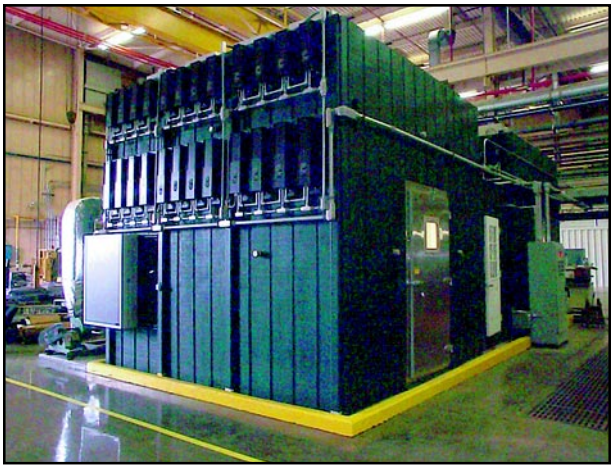
Phytoremediation Studies in Environmental Chambers

U.S. EPA Test and Evaluation Facility Research Project

Project Objectives:

The objective of this project is to conduct phytoremediation studies in a controlled environment. In order to conduct these studies, two environmental growth chambers were designed and constructed. These chambers were custom-built and have the ability to automatically monitor and control temperature, humidity, lights and air flow rates over a wide range of environmental conditions. Specific experiments will be designed and conducted for phytoremediation evaluations.



Environmental Relevance:

Phytoremediation is the name given to a set of processes which involve the use of vegetation for the treatment of contaminated soil or water. The process uses plants and their rhizospheric (the area immediately surrounding the roots) microorganisms to remove contaminants located in the contaminated matrix. Although it has been shown that some contaminant levels decrease in the presence of growing plants, there is still uncertainty and debate as to whether the mechanism of that decrease is destruction of the pollutant by the plant or volatilization through the process of normal plant transpiration.

Plant volatilization has been difficult to measure during phytoremediation. Small-scale greenhouse studies are subject to errors due to measuring limitations. Field-scale measurement systems are not sensitive enough for the low levels of natural plant transpiration rates. To accurately measure the interactions between plant, soil, water, and air, it was necessary to fabricate growth chambers with a 'closed' environment where these interactions can be measured accurately. Two environmental chambers equipped with a variety of electronic sensors and control equipment were built for this purpose at the U.S. EPA Test and Evaluation (T&E) Facility in Cincinnati, Ohio. These two environmentally controllable growth chambers are capable of sustaining plants, accurately maintaining environmental conditions, and monitoring a variety of airborne contaminants.

Top Photo: The environmental chambers located at the U.S. EPA T&E Facility, Cincinnati, Ohio.

Bottom Photo: The air handling unit, carbon/zeolite bed, and other components of the environmental chambers.

Design Features:

The two identical environmental chambers, located within the T&E Facility, incorporate unique design features. The inside dimensions of each chamber are 12 ft by 12 ft by 12 ft. The inside walls of the chambers are constructed of polished stainless steel with heavy insulation (R-value of approximately 30). The chambers have a stainless steel insulated freezer-type door.

Each chamber is equipped with 16 light fixtures consisting of 32 light bulbs, with one metal halide and one sodium vapor bulb in each fixture. The combined wavelength of light emitted by these bulbs cover the photosynthetically active radiation (PAR) portion of the sunlight spectrum (wavelengths between 400nm to 700 nm). The maximum PAR lighting produced in the chamber is approximately 300 mmols photons /s/m^2.

The chamber system is equipped with a powerful heating, ventilation and air conditioning (HVAC) system that includes a 10-ton chiller, electric heater and humidifier. The combination of the light and HVAC system is capable of simulating outside environments and seasonal variations including day and night cycle, adjustable temperatures between 40 and 100° F, humidity control, and variable air flow rates to simulate wind effects.

The operating conditions and parameters of the environmental chambers are controlled by a computerized control system that can monitor and control temperature, humidity, air flow rate, and light intensity. Features of the control system include continuous data logging, trend graphs, and system alarms. The control system is housed in the control room adjacent to the chambers.

Each chamber contains 12 sampling ports to obtain representative air samples. These samples can be analyzed via a gas chromatograph housed in the control room.

Teflon sheets have been used to cover the windows and light fixtures to minimize any contaminant interaction during experiments.

Possible Projects:

Specific experiments can be designed to be conducted in the environmental chambers. Some of the possible projects are discussed below:

- Methane interaction with uncompacted planted alternative landfill cover systems.
- Contaminant uptake and/or volatization.
- Compare and evaluate the effectiveness and mechanisms associated with two types of technologies: phytoremediation and bioremediation. Plant species for phytoremediation will be selected based on the soil and contaminant characteristics. Various plants (trees, grasses, legumes, and aquatic plants) have been shown to be able to treat many classes of contaminants. The contaminant degradation mechanisms to be studied will include:
    - Volatilization from the soils
    - Volatilization from the plant
    - Degradation within the soil
    - Metabolism within the plant

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