

Decreasing Building Vulnerability to Bioterrorist Threats with Interior Plants

By Dr. Bill Wolverton

Building Ventilation

Since September 11, 2001 the odds of a biological chemical attack in America have greatly increased. An attack such as this could be devastating to a massive number of Americans while having severe economic consequences. The most likely approach terrorists might use is to employ an aerosolizer to release biological and chemical warfare agents into a building's ventilation ducts. Once dispersed, aerosolized toxic substances will rapidly find their way into buildings adjacent to the release area.

For example, though thousands were killed at Ground Zero, many more may be suffering chronic respiratory problems from breathing toxic dust and chemical vapors that entered schools and other nearby buildings through air intake ducts after the Twin Towers collapsed.

No reliable means currently exists for detecting biological agents released into the atmosphere; agents would probably go unrecognized until building occupants began to exhibit symptoms.

Most buildings bring in fresh air through an outside duct and mix it with recirculated air. Since the 1970s "energy crisis," new buildings have been built with a tighter envelope for reducing energy consumption. As a result, more and more buildings have indoor air quality (IAQ) problems due to a buildup of pollutants released from building materials and furnishings.

Building occupants are increasingly exhibiting symptoms indicative of "sick building syndrome." In an effort to combat IAQ problems, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has continually recommended increasing ventilation rates in an effort to purge the air. This approach has three inherent problems: reduced energy efficiency, an assumption of clean outside air,

and increased vulnerability to bioterrorism.

Today, most buildings use only dust filters without "treating" air at all, primarily because it is cost prohibitive. Even if cost were not an issue, high-efficiency particulate filters (HEPA) cannot filter chemical agents. They can only trap biological agents, and cannot destroy them. Some buildings use standard gaseous adsorbent media, such as treated activated carbon, to trap chemical pollutants. Once the HEPA filter or gaseous adsorbent media has been saturated with pathogenic microbes and/or toxic chemicals, how can they be disposed of? If saturated filters or filter media are not changed immediately, they begin to release the chemical pollutants back into the building.

Tommy Thompson, Secretary of Health and Human Services, stated that he is becoming increasingly concerned that ventilation systems in buildings around the country remain too vulnerable to bioterrorists. Public health experts have urged our government to

address this major vulnerability in the nation's security. Tom Ridge, Director of Homeland Security, stated that we must invent innovative ways to protect ourselves against bioterrorism threats in the U.S.

Innovative Method

As a former scientist with the Department of Defense (DOD) in defense of chemical and biological warfare, I appreciate the challenges currently facing the building industry. Later, at NASA, our goal was to develop a completely closed ecological life support system for long-term space habitation. In space, ventilation is obviously not an option. Quite early in our research it became apparent that an earth-like ecosystem capable of treating human waste, purifying and revitalizing the air, and producing food would need to work in concert with mechanical devices to produce long-term sustainability and redundancy. On Earth, a building only needs to purify and revitalize the air, but the same concept applies.

Plants and Their Influence on Human Health and Well-Being

For many years now, plants have been placed in hotels, restaurants, offices, and homes to enhance ambiance. While the aesthetic value of interior plants *is* important, scientists in the U.S., Japan and several European countries have proven during recent years that plants

play a far more significant role in our lives than just decoration. Many physiological and psychological health benefits can be derived from the presence of plants in an indoor environment. The presence of plants has been proven to increase the healing process among the sick. Plants in offices significantly improve worker productivity and reduce sick leave when compared to environments without plants. The interior plantscaping industry has been promoting plants for their non-aesthetic qualities, and the public has quickly grasped the concept. The building industry, however, has been slow to accept the role of plants as anything other than a way to fill an empty corner.

Plant Ecosystems

One of nature's most powerful tools for cleaning the environment stems from the synergistic reactions taking place between plants and their root microbes. This biotechnology is called phytoremediation.

During the last 30 years, scientists have made many discoveries leading to an understanding of how plants can purify both air and water. DOD studies showing plant ecosystems' abilities to remove toxic chemicals from contaminated water were first published in 1973. NASA first published studies in 1984 showing how interior plants

could remove volatile organic chemicals (VOCs) from sealed test chambers. These findings received widespread publicity, and were quite readily accepted by the plant industry and general public. However, the Environmental Protection Agency (EPA) and the building industry were skeptical that plants could play any significant role in solving serious IAQ problems in buildings. They contended that sealed, "static" tests could not be extrapolated into "real world" conditions. To address these issues, NASA and the Associated Landscape Contractors of America (ALCA) initiated a joint program to conduct further studies with plants commonly used by the interior plantscaping industry.

A small, 800 square-foot, tightly sealed structure termed "the Biohome" was constructed to accommodate one person (*see Fig. 1*).



Figure 1 – NASA's Biohome

The Biohome was fabricated and furnished with synthetic materials and had an insulation "R-rating" of 45. Complex chemical analyses of air

samples from within the building showed high levels of a variety of VOCs. Upon entering the building, individuals exhibited common symptoms associated with “sick building syndrome,” including watering eyes, burning throat and respiratory discomfort.

Several containers of plants and one small, fan-assisted planter using a mixture of activated carbon and potting soil were placed in the Biohome. After several days, chemical analyses confirmed that most of the VOCs had been removed. More importantly, upon entering the building, no one experienced any discomfort, proving that interior plants and high-efficiency plant filters can purify and revitalize air in non-ventilated, hermetically sealed buildings. Additional studies in a home environment showed that plants actually reduce the number of mold spores and other airborne microbes instead of increasing them (as some had suggested). Further studies have shown that plants’ ability to remove VOCs increases with exposure time due to microbial adaptation, and that microbes in the rhizosphere (root area) play a major role in the chemical removal process.

Colleagues and I conducted the early studies at NASA and later studies at my privately owned company. However, scientists in Germany, Australia and Japan have recently confirmed

these findings and added new knowledge in the field. There is now sufficient scientific evidence to support the concept of using interior plants to provide good IAQ in hermetically sealed buildings having little or no mechanical ventilation.

Having many plants in an indoor environment is a common occurrence in hotels, offices, and restaurants. A visit to Opryland Hotel in Nashville or hotel chains such as Embassy Suites will confirm the euphoric indoor environment created by interior plants. The missing link, however, is that the clean air from the plant-filled spaces is not normally introduced into the surrounding rooms.

Hospitals in Japan are adding plants to take advantage of their air-cleaning properties. In many instances, existing buildings such as these need only modifications to their HVAC systems to create a closed internal air recirculating system, thus reducing their vulnerability to bioterrorism. Additionally, high-efficiency, plant-based filters can increase internal air purification and create a small positive pressure, if needed.

High-efficiency plant-based filters employ the adsorption properties of activated carbon, germicidal irradiation of ultraviolet light, and chemical degrading properties of plants and their root microbes to create

a bioregenerating (self-sustaining) filter system. This process increases the filtering ability of each plant by several hundred times. Actree Corporation (Japan) is designing and will manufacture modular, built-in units for use in larger buildings (see *Fig. 2*). A small, portable unit is currently on the market in Japan.

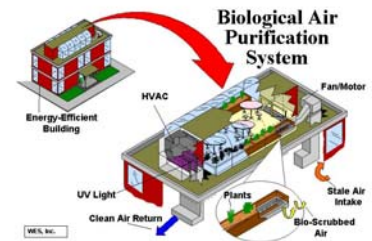


Figure 2 – Biological Air Purification Concept

In our post 9-11 world, bioterrorism is an imminent threat that we must prepare to counteract. Can the building industry continue to ignore the promising role interior plants can play in creating a safer, healthier indoor environment?

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