

Living Filters in Urban Design

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Toxic volatile substances emitted as gases from many paints, carpets, and fabrics often accumulate in the stagnant circulation zones common to indoor home and office urban environments.¹ Such polluted air can pose short- and long-term exposure dangers of particular concern today because classical HEPA and carbon filtration systems ineffectively remove some of the more notorious airborne gases, such as formaldehyde.²

Living plants are a traditional approach to managing indoor air pollution. But the natural air filtration capacity of vegetation, while effective at maintaining air quality within the global environment, proves of limited value in a normally ventilated interior environment without either a very large number of leafy plants—seventy spider plants for a 420 square meter interior environment, according to one estimate³—or the aid of human design and engineering.

Outside, convection and diffusion send pollution past vegetation, where toxic gases absorb onto exposed surfaces, especially leaves, and are degraded by natural metabolic processes.⁴ Inside, we sit and stand on, walk past and under, and sometimes even place our faces on the sources of pollution that contaminate the air we breathe. Indoor vegetation, though it may exist, generally has little chance to clean toxic air before we inadvertently sample it.

NASA researchers in the mid-to-late 1980s approached the indoor filtration problem by

introducing the idea of blowing dirty air past indoor vegetation.⁵ To improve air filtration, researchers redirected dirty air through plant soil, where root systems and associated microorganisms could provide a second degree of metabolic transformation. This combination of ventilation and soil filtration led to a series of early prototype living filters capable of cleaning dirty air.

If previous plant filter designs did not succeed as commercial indoor air filters, it appears at least in part due to the upper speed limit of filtration imposed by the need to avoid drying out plant soil while passing dirty air through it. Plant filters, designed with the basic functionality proposed in the late 1980s, are very efficient at removing toxic gases from the air, but their rate of removal is minor compared to traditional HEPA and carbon filters.⁶ This makes plant filters effective when placed within local stagnant zones, though frequently ineffective when placed within the robust convection patterns characteristic of most indoor environments.

Mindful of these constraints, we have recently approached the indoor air problem through the design of a living air filter that is both more efficient than the original NASA plant filter design and with aesthetic properties that merit display in many interior environments. The filter is of relatively low cost and has the easy intuitive maintenance traditionally associated with plant care. Designed by the French designer Mathieu Lehanneur in collaboration with the author for the



opening in 2007 of the experimental art and design center Le Laboratoire in central Paris, the filter Bel-Air directs dirty air through the leaves and soil of potted plants, over a water bath and back into the environment with a speed approximately an order of magnitude greater than the original NASA design.

Bel-Air was exhibited at the Museum of Modern Art in New York during the Design and the Elastic Mind exhibition and won a Popular Science Invention of the Year Award in 2008. It is now available commercially as the air filter Andrea. Plant filters such as Andrea are conceivable from small to large scale. Such a living filter strategy might play a role in sustainable urban architecture of the future.

1 L. Mølhave, "Volatile Organic Compounds, Indoor Air Quality and Health," *Indoor Air* 1 (2004): 357–376

2 W. Chen et al., "Performance Evaluation of Air Cleaning/Purification Devices for Control of Volatile Organic Compounds in Indoor Air," Syracuse University Report, 2004.

3 B. C. Wolverton, R. C. McDonald, and E. A. Watkins, Jr., "Foliage Plants for Removing Indoor Air Pollution from Energy-Efficient Homes," *Economic Botany* 38 (1984): 224–228.

4 Martina Giese, Ulrike Bauer-Dorant, C. Langebartels, and Henrich Sanderman, Jr., "Detoxification of Formaldehyde by the Spider Plant (*Chlorophytum comosum*)," *Plant Physiology* 104 (1994): 1301.

5 B. Wolverton, "Foliage Plants for Improving Indoor Air Quality," National Foliage Foundation Interiorscape Seminar, Hollywood, Florida, June 19, 1988.

6 Chen et al., "Performance Evaluation."