clearing the air about Indoor Plants

CHANCES ARE, you have at least a few houseplants, and you've probably heard that they can clean your air. If not, a quick online search will yield dozens of articles on the subject, and many lists comparing specific plants on their ability to filter airborne toxins. Before you breathe easy though, notice that these lists don't always agree on which species to grow and are vague at best about the science behind their claims.

What do we really know about the air-cleaning abilities of indoor plants, and how can this inform your selections? As it turns out, the situation is much more complex than growing a few houseplants and expecting them to make a big difference.

A number of common houseplants are widely touted as natural air purifiers, but does research bear this out?

MARY YEE

BY AMY GEORGIANNA MCDERMOTT

IN THE BEGINNING

One of the first investigations into the notion that indoor plants can clean the air was conducted by the National Aeronautics and Space Administration (NASA) in the 1980s. At the time, NASA was tasked with building an international space station and long-term air quality inside the completely sealed environment was a concern.

Bill Wolverton, who was a research scientist in the Science and Technology Laboratory at Stennis Space Center, Mississippi, proposed using plants as a natural air filtration system in imitation of their role on Earth. "Since man's existence on Earth depends upon a life support system involving an intricate relationship with plants and their associated microorganisms," Wolverton wrote in the final 1989 report, "it should be obvious that when he attempts to isolate himself in tightly sealed buildings, away from this ecological system, problems will arise."

And indeed, problems did arise: many common building materials, such as plastics and particle board, were known to release pollutants into the air. Some of these chemicals had been linked to health problems including chronic headaches, asthma, and skin irritation. NASA scientists began studying various plants to see if they could reduce or eliminate these toxins in conditions simulating those in a space station.

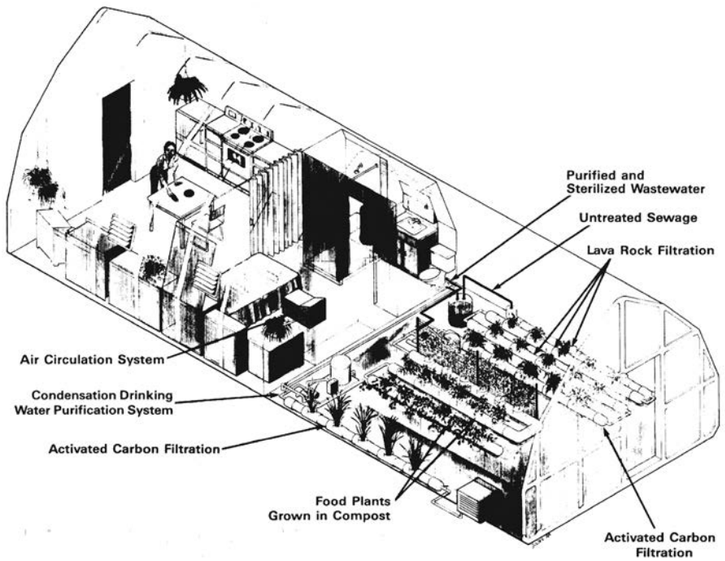
FAVORABLE RESULTS

In the earliest studies, a variety of indoor plant species were sealed, one at a time, in Plexiglas® chambers measuring between 15 and 32 cubic feet. For a sense of scale, a 2013 Toyota Prius has about 22 cubic feet of trunk space. So, these chambers were fairly compact. After NASA scientists injected high concentrations of benzene, trichloroethylene, and formaldehyde—common indoor air pollutants—into the chambers, they found that if a potted plant was present, the air was significantly cleaner after 24 hours.

That sounds very promising, but as Wolverton, who is now an environmental consultant, points out, these results should not be taken out of context. "The small Plexiglas chamber studies gave us the ability to control all test parameters and to introduce a single chemical at a time," he explains. NASA "never intended for a single plant to clean a large space such as a home or office."

To expand upon these initial experiments, NASA built a "closed ecological life support system" called the BioHome at the Stennis Space Center. At 45 feet long by 16 feet wide, it looked a lot like a space-age doublewide trailer. Inside, a kitchen, sleeping area, and bathroom were flanked by a large plant room to test the ability of various species to clean recycled air and raw sewage in a closed loop.

The BioHome allowed Wolverton and his colleagues to conduct "real-world tests, as opposed to a single plant in a small test chamber." They found that human occupants of the BioHome, who initially reported symptoms of exposure to air pollution, could comfortably live in the unit once the plant filtration system was in place.



COURTESY OF NASA (2)

After NASA reported its intriguing findings, other labs began their own experiments. Most of these studies were similar to Wolverton's initial Plexiglas chamber experiments—a rotating roster of houseplant species placed in small test chambers and exposed to one or two common indoor air pollutants. A glut of research published between the late 1980s and early 2000s confirmed NASA's findings: the concentration of pollutants significantly decreased over time in the presence of plants (and their associated soil microbes, which, as it turns out, may actually be doing the heavy lifting—for more on this see box, page 21). It wasn't long before those now-ubiquitous lists of best plants for improving indoor air quality started popping up.

FIELD TESTING

While laboratory tests were an informative first step, they were never meant to model the complexity of real homes and offices. "In science there is always a need for complementary studies in the real world and in laboratory chambers," says Margaret Burchett, an adjunct professor at the University of Technology in Sydney, Australia, and a coauthor of one of the few experimental field studies testing the effect of indoor plants on air quality in office buildings, published in 2007. "Field observations and sampling give us information on correlations between air/soil/water factors and plant behavior."

To test plants in the "real world," the Australian researchers conducted a series of trials in three separate office buildings over a nine-week period. Similar to the lab-based chamber studies, the researchers found that spaces with plants had significantly lower concentrations of air pollutants.

"We found that three plants per office were enough always to reduce total [air pollution] below health risk levels," says Burchett.

CHALLENGES TO THE RESEARCH

But when it comes to our homes and office spaces, do these lab and field studies tell us anything definite? John Girman, former director of the Indoor Environments Center for Analysis and Studies at the Environmental Protection Agency (EPA), says no.

In 2009, while working with the EPA's Indoor Environments Division, Girman coauthored the first critical review of the indoor air phytoremediation research. Published in the *Proceedings of Healthy Buildings,* the report was coauthored with Tom Phillips, an air pollution specialist in the Indoor Air Quality Program of the California Air Resources Board, and Hal Levin, a research architect and head of the Building Ecology Research Group, a California consulting firm based in Santa Cruz.

Built in the late 1980s at NASA's Stennis Space Center in southwest Mississippi, the BioHome, shown in the photo above and as a schematic on the left, housed some of the earliest experiments testing whether indoor plants could remove pollutants from the air and from sewage.

Overall, the review took issue with the small size of experimental test chambers, the scarcity of field studies, the unrealistic treatment of pollutants, and other methodological issues. On the results of Burchett's 2007 field study, for instance, the critique pointed out that "variations in ventilation may have been responsible for any apparent pollutant reductions," and that individual pollutant "concentrations did not appear to be reduced" in the study. Furthermore, it noted that the five-minute duration of the weekly air sampling was "insufficient to characterize indoor concentrations."

One of the most glaring problems the review raised was the use of small, sealed test chambers in laboratory studies. In them, one plant takes up a larger relative

volume than it would in a typical home or office. You would need a small forest of indoor plants—Girman estimates 680—to replicate the results of the chamber studies in a 1,500-square-foot home.

"There are many variables as to how many plants would be needed to improve indoor air quality," Wolverton agrees. That's because people don't live in sealed Plexiglas houses or NASA-style BioHomes. For example, the ventilation rate of your space is just one variable that's much harder to control in the real world than in a lab setting. And in the very few field studies that have tested the effects of indoor plants on air quality in office buildings, ventilation rate was considered, but never quantifiably measured. "If [polluted] outside air is constantly introduced, conditioned and distributed, it would overwhelm any benefit from plants or any other type of air filter," says Wolverton. Burchett agrees that ventilation can and does overwhelm the benefits of indoor plants, particularly in "newer buildings with stronger air conditioners," she says.

Then there's the issue of the pollutants themselves. The lab studies introduced very high concentrations of airborne chemicals. The change in concentration was then measured over time. But in reality, some pollutants are emitted continuously in relatively small quantities, not in high concentrations all at once. The review notes that the slow, continuous release of toxins into the air could eventually overwhelm a plant's ability to remove them in a way that sudden high concentrations do not.

Our dwellings also tend to be contaminated with a cocktail of chemicals, given off by everything from carpeting and furniture to paint and cleaning solvents. Stanley Kays, professor emeritus in the Department of Horticulture at the University of Georgia, measured upwards of 180 different airborne compounds in a survey of several houses in Athens, Georgia (for a list of common indoor air pollutants, click on the web special linked to this article on the AHS website at *www.ahs.org*).

Rather than replicating a mixture of all those chemicals, most existing experiments only test one or two common pollutants as "models" of reality. Approximating the real world through models is good standard practice in science. Model organisms like *Arabidopsis* plants and fruit flies have taught us volumes about our own human genetics for example. But in the case of these air quality experiments, a few proxy chemicals do not necessarily reflect reality.

That's a problem for two big reasons, says Kays. First, "we don't have very good information on the maladies that you can expose yourself to"—we have little idea how a lot of these chemicals could influence human health, let alone plant metabolism, or at what concentration they might become dangerous. And second, chemicals can interact to create synergistic effects.

Considering that billions of possible chemical combinations can occur, it's clear that researchers have barely scratched the surface so far. Based on the limited existing studies, Girman's review ultimately concluded that "indoor plants have little, if any, benefit for removing indoor air [pollution] in residential and commercial buildings." The official stance of the EPA is similarly bleak: "[T]here is currently no evidence that a reasonable number of houseplants will remove significant quantities of pollutants in homes and offices and consistently improve indoor air quality."

For Kays, the jury is still out. "In theory it works, but the bottom line is there just isn't enough research that's been done," he says.

Resources

Critical Review: How Well Do House Plants Perform as Indoor Air Cleaners? by J. Girman, T. Phillips, and H. Levin. *Proceedings of Healthy Buildings* (Vol. 23, pp. 667–672, 2009). *http://nepis.epa.gov* (publication number: 402-F-92-003).

How to Grow Fresh Air by B.C. Wolverton. Penguin Books, New York, NY, 1997.

Plants: Why You Can't Live Without Them by B.C. Wolverton and Kozaburo Takenaka. Roli Books, New Delhi, India, 2010.

Red-margined dragon tree *(Dracaena marginata)* is often listed as an indoor plant that can help remove airborne pollutants, based on results of studies NASA conducted in the 1980s.

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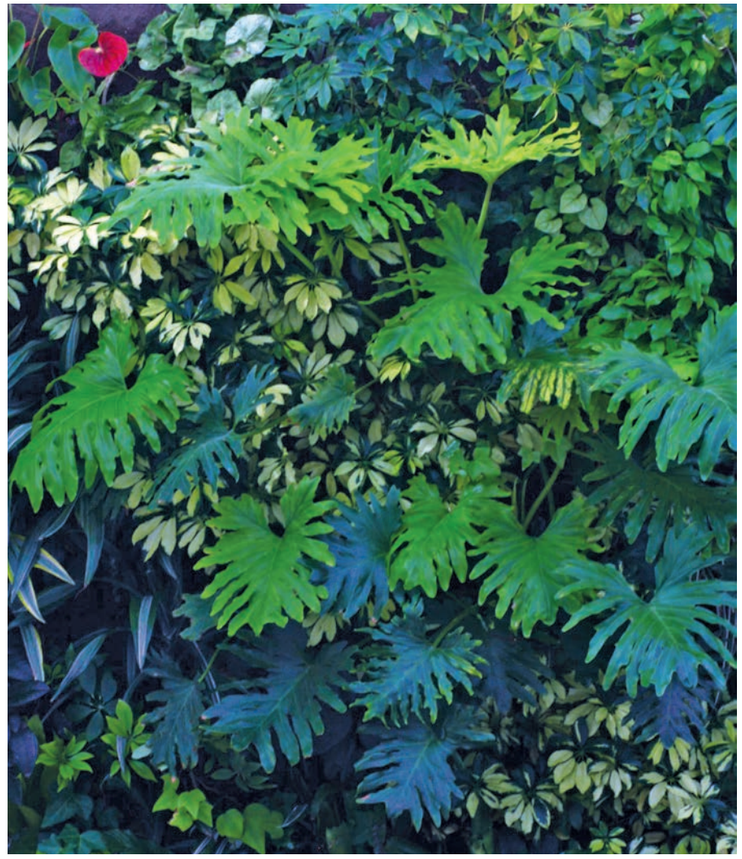
PLANTS VERSUS MICROBES

Even from the earliest experiments, researchers knew plants weren't alone in those chamber studies; they were rooted in potting soil that was rich in bacteria, fungi, and other microscopic organisms. Scientists saw air pollutant levels dropping, but they didn't know for sure how much could be attributed to the plants and how much to the microorganisms.

So research groups began probing the question directly. In one 2006 study, for instance, scientists found that soil could keep cleaning the air in a Plexiglas chamber even after a plant had been uprooted and removed. Curiously, virgin potting mix didn't have the same effect.

Because of these results and those from similar studies, Margaret Burchett, an adjunct professor at the University of Technology in Sydney, Australia, believes that "the microorganisms of the potting mix are the primary agents of [pollutant] removal." The plants "exude goodies to attract and multiply the bacteria," she explains. "The microbes are capable of utilizing [pollutants] as food, even down to amazingly low concentrations."

However, there's still no consensus among researchers on whether plants are primarily responsible for removing pollutants, or whether bacteria, fungi, and other decomposers are doing most of the work. —A.G.M.



ALEKSANDRA SZYWALA

More research is needed to determine how much of a difference indoor plants make to air quality, but growing a diverse array like in this living wall most likely has some positive effects.

THE BOTTOM LINE

So now what? Should you compost your good-for-nothing spider plant? Are your palms and philodendrons a waste of space? Definitely not! It's likely that indoor plants (in sufficient numbers) do have a positive effect on the air you breathe. We just don't yet know to what extent.

Regardless, you can be sure that indoor plants offer other positive benefits. More and more research indicates that indoor greenery can improve mood and boost performance of creative tasks, and even accelerate the recovery of hospital patients. While these studies are ultimately just as limited as the air quality research, they do dovetail with a larger sensibility that anyone who gardens will agree on: plants just make us happy.

So enjoy your indoor plants, and maybe even find room to grow a few more. As Wolverton advises, "I always recommend a variety of plants and as many as one can reasonably maintain." Appreciate them for the beauty and sense of well-being they bring to your space. And if you want to capitalize on their tentative potential to filter your air, don't limit yourself to the top species on those popular lists because it's simply too soon to judge.

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