Research Paper
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Author: Dr. Erfan Haghighi, R&D Manager
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Towards sustainable improvement of indoor air quality at workplaces

Indoor air quality – What is the issue?

The quality of air that we breathe is vital for our health, productivity and well-being. Ninety percent of our time is spent indoors and we each consume, on average, 10'800 litters of air each day. Hence, the importance of good indoor air quality (IAQ) is clear. According to the US Environmental Protection Agency, indoor air pollution is often between two and five times greater than outdoors – and can get at its extreme up to 100 times worse the open air. Recent assessments by Health Effects Institute (2018) have placed indoor air pollution as the 8th largest global burden of disease risk, exceeding malaria, violence and HIV/AIDS as a cause of premature death by a factor of 19, 17 and 9, respectively. WHO reported, in 2012 around 7 million people died – one in eight of total global death – as a result of air pollution exposure, including 800'000 people dying worldwide every year due to poor IAQ in their workplace (The Lancet, 2017).

Air-polluting components in an office space are typically airborne pollutants (including CO, CO_2, VOCs, NO, NO_2 and PAHs), toxic gases and particulate matter (PM) released by indoor sources and activities. One of the most common indoor pollutants are volatile organic compounds (VOCs), which can among others be found in everyday objects, such as furnishing, consumer goods and air freshener. If the density of VOCs exceeds a certain threshold, it can not only be classified as carcinogenic, but also lead to headache, nausea, dizziness, fatigue and many other symptoms. Other pollutants like PM are also the most widely used indicators to assess the health effects from exposure to ambient air pollution. Particles with a diameter of 10 microns or less (e.g., PM_{10} and $PM_{2.5}$) can penetrate deep into lung passageways and enter the bloodstream, causing serious cardiovascular and respiratory impacts.

Given the emerging increased level of air pollution and the increased awareness of health issues caused by polluted air, recent advances in the heating, ventilation and air conditioning (HVAC) industry have mainly been focused on enhancing IAQ performance, with no significant energy efficiency improvements. Thus, the application of these commercial HVAC systems integrated with electrofilters, ultraviolet lights, photocatalytic materials, fuel cells, or catalyzers is often limited by the high costs associated with their frequent maintenance and significant energy consumption/CO_2 emission. Particularly in Switzerland, the building sector, which accounts for about 25% of annual Swiss CO_2 emissions, consumes approximately 50% of the Swiss primary energy, with HVAC systems accounting for 60% of this consumption.

Lessons from nature for green science and technology

Natural plants have long been recognized as nature's air purifier, drawing 25% of human-made CO_2 emissions from the atmosphere annually. Plants can absorb and catabolize almost any airborne pollutants, although this phytoremediation capacity has been poorly applied indoors. "Indoor plants are typically selected on the basis of their aesthetic features rather than physiological requirements reflecting their capacity to remove air pollutants" (Cell Press Reviews 2018). Despite their simplistic experimental approach, pioneer studies conducted by NASA during the 1980s and more recently by the University of Technology Sydney in 2009 successfully demonstrated that plants are capable of removing airborne pollutants (in particular, CO2 and VOCs). The capacity of plant leaves to exchange gases, and thus to take up any pollutants from indoor air, is limited by physical processes controlling opening and closing of microscopic leaf pores, namely stomata.

Nevertheless, the VOC-removing ability of potted plants in real indoor environments (rather than laboratory conditions) remains a challenge and a subject of debate. While some researchers concluded that potted plants do not clean the indoor-air fast enough to have an effect on the air quality of their home or office, other studies have demonstrated how leveraging soil and plant microbiome can potentially improve the cleaning capacity of potted plants by 200 times. Evidence suggests that plant-based biofilteration help breakdown VOCs three times faster than the natural decay rate, offering potted plants as a promising alternative biofilteration technology with biophilic productivity and well-being benefits.

Integrating plants with sensor technology: Energy-efficient improvement of IAQ

Using a combination of plants, sensor technology and big data, we, at Oxygen at Work, provide science-driven sustainable office building design solutions, improving IAQ and achieving energy consumption efficiency as well as promoting health and well-being in the workplace. Being at the cutting edge of scientific research and innovative development, our quest is to redefine HVAC technology, as a critical component in shifting building systems towards sustainability, through nature and design innovations. Our design solution enables the engineering of indoor environment through the real-time monitoring of local air quality retrieved from low-cost wireless network sensors communicating with logging stations on our cloud servers. A user-friendly online software (login required) serves as a decision support system to maximize air cleaning according to both pollutant levels and the physical characteristics of the interior space (such as volume, number of occupants, temperature, humidity, etc.).

Do you want to figure out how much CO_2 emission you can offset by bringing nature into your office spaces? Please visit our demo on our website and/or contact us.

Contact details:
remy@oxygenatwork.org
www.oxygenatwork.org