Role of Plants in Controlling Environment Pollution

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ABSTRACT

Plants improve the air quality by absorbing the carbon dioxide from the atmosphere which they use in the process of photosynthesis (formation of food with the help of sunlight).They absorb CO_2 and in turn release oxygen into the atmosphere. They increase humidity by transpiring water vapour through stomata and they can also absorb pollutants on the external surfaces of the leaves. Thus, growing plants will help in the control of air pollution.

KEYWORDS-plants, control, pollution, atmosphere, oxygen

INTRODUCTION

Plants absorb carbon dioxide and produce oxygen through photosynthesis which helps in reducing the carbon dioxide content in the environment which is a very harmful pollutant. The plants can absorb minute pollutants through their leaves and plants are also responsible for increasing the humidity in the environment by transpiration of water vapors thus improving the air quality and leads to a clean and green environment.

Usually, urban areas have very high pollution due to modern technologies and industrialization but these areas have very few plants that lead to rising pollution day by day.

According to research, the pollution around industries and urban areas can be controlled easily by planting more trees in such areas.

Soil erosion is one of the biggest problems that reduce the organic content and quality of the soil. The soil erosion can be controlled by planting more trees as the root of plants prevents washing away of soil by keeping the soil undamaged by making the soil harder by absorbing some water from the soil.[1,2,3]

Burning of fossil fuels, urbanization, etc has resulted in so much pollution, it is very necessary to control this pollution which is already causing harm to the health of plants and animals. One of the most effective methods to control pollution is to plant more trees and encourage other people to do the same.

Air pollution is air contaminated by anthropogenic or naturally occurring substances in high concentrations for a prolonged time, resulting in adverse effects on human comfort and health as well as on ecosystems. Major air pollutants include particulate matters (PMs), ground-level ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxides (NO_2), and volatile organic compounds (VOCs). During the last three decades, air has become increasingly polluted in countries like China and India due to rapid economic growth accompanied by increased energy consumption. Various policies, regulations, and technologies have been brought together for remediation of air pollution, but the air still remains polluted. In this review, we direct attention to bioremediation of air pollutants by exploiting the potentials of plant leaves and leaf-associated microbes. The aerial surfaces of plants, particularly leaves, are estimated to sum up to 4×10^8 km^2 on the earth and are also home for up to 10^{26} bacterial cells. Plant leaves are able to adsorb or absorb air pollutants, and habituated microbes on leaf surface and in leaves (endophytes) are reported to be able to biodegrade or transform pollutants into less or nontoxic molecules, but their potentials for air remediation has been largely unexplored. With advances in omics technologies, molecular mechanisms underlying plant leaves and leaf associated microbes in reduction of air pollutants will be deeply examined, which will provide theoretical bases for developing leaf-based remediation technologies or phylloremediation for mitigating pollutants in the air.

To reduce air pollution, the first step is to eliminate or reduce anthropogenic-caused emissions. The second step is to remediate existing pollutants. Different strategies, policies, and models for air pollution abatement have been proposed or implemented (Macpherson et al., 2017). For example, the Chinese government has imposed restrictions on major pollution sources including vehicles, power plants, transport, and industry sectors (Liu et al., 2016) and promulgated the "Atmospheric Pollution Prevention and Control Action Plan" in September 2013, which was intended to reduce $PM_{2.5}$ by 25% by 2017 relative to 2012 levels (Huang et al., 2014). Science-based technologies have been developed for control of air pollutants, such as diesel particulate filters (Tsai et al., 2011) and activated carbon filtering as adsorbent for xylene and NO_2 (Guo et al., 2001). Catalytic oxidization and chemisorption methods have been used for indoor formaldehyde removal (Pei and Zhang, 2011; Wang et al., 2013). Photocatalysis as one of the most promising technologies has been used for eliminating VOCs (Huang et al., 2016).

Air pollutants can also be mitigated through biological means, commonly referred to as biological remediation or bioremediation. It is the use of organisms to assimilate, degrade or transform hazardous substances into less toxic or non toxic ones (Mueller et al., 1996). Plants have been used for remediation of pollutants from air, soils, and water, which has been termed as phytoremediation (Cunningham et al., 1995; Salt et al., 1995; Huang et al., 1997). Microbes such as bacteria and fungi are also capable of biodegrading or biotransforming pollutants into non toxic and less toxic substances, which is known as microbial biodegradation (Ward et al., 1980; Ma et al., 2016). Microbes as heterotrophs occur nearly everywhere, including plant roots and shoots. Both roots and shoots have been reported to be able to remediate air pollutants (Weyens et al., 2015; Gawronski et al., 2017), but little credit has been given to microbe activity.[4,5,6]

Plant shoots or the above-ground organs of plants colonized by a variety of bacteria, yeasts, and fungi are known as phyllosphere (Last, 1955). However, most scientific work on phyllosphere microbiology has been focused on leaves (Lindow and Brandl, 2003). This review is intended to explore the potential of plant leaves and leaf-associated microbes in bioremediation of air pollutants, or simply known as phylloremediation. Phylloremediation was first coined by Sandhu et al. (2007), who demonstrated that surface-sterilized leaves took up phenol, and leaves with habiated microbes or a inoculated bacterium were able to biodegrade signficantly more phenol than leaves alone. Previous reports also documented that both plant leaves and leaf-associated microbes mitiagted air pollutants, such as azalea leaves and the leaf-associated Pseudomonas putida in reducing VOCs (De Kempeneer et al., 2004), leaves of yellow lupine plants along with endophytic Burkholderiacepacia for toluene reduction (Barac et al., 2004), and poplar leaves and the leaf-associated Methylobacterium sp. decreased xenobiotic compounds (Van Aken et al., 2004). Phyllo originated from Greek word of phullon, meaning leaf. Thus, phylloremediation should be defined as a natural process of bioremediation of air pollutants through leaves and leaf-associated microbes, not the microbes alone.

Plant Leaves and Phyllosphere

Leaves are the primary photosynthetic organs with distinctive upper surface (adaxial) and lower surface (abaxial) . The upper surface has a layer (<0.1–10 μm) of waxy cover called cuticle (Kirkwood, 1999). Wax contents and compositions frequently differ among plant species. The primary function of cuticle is to prevent evaporation of water from leaf surfaces, and it is also the first barrier for the penetration of xenobiotics. The leaf surface is filled with trichomes, which are epidermal outgrowths in various forms. Trichomes play roles in mechanical defense because of their physical properties and also in biochemical defense due to the secretion of secondary metabolites (Tian et al., 2017). Epidermis cells are directly underneath the cuticle layer in which stomata often occur. Xylem and phloem are situated within the veins of leaves as the plant vascular system, which are connected from root tips to leaf edges. There is a layer of compactly arranged cells around the vein called bundle sheath regulating substance circle around the xylem and the phloem. Xylem transports water and nutrients from roots to shoots, and phloem transports assimilated products from source and sink tissues. Under the epidermis, there are mesophyll cells in two layers: column-like palisade cells and loosely packed spongy cells. The air spaces among the spongy cells promote gas exchange, and photosynthesis takes place in chloroplasts packed in the mesophyll cells. The underside of leaves also has a layer of epidermal cells where most stomata are located. There are two guard cells surround the stomata, and stomatal pore opening and closure is regulated by changes in the turgor pressure of the guard cells. Stomata regulate the flow of gases in and out of leaves and also able to adsorb or absorb other chemicals.[7,8,9]

DISCUSSION

Air pollution poses a great threat to human health, and it has become a worldwide problem that needs to be urgently dealt with. Many measures have been taken to reduce air pollution and improve air quality. These methods are generally costly and require special equipment. Some plants have the ability to assimilate, degrade, or modify toxic pollutants in air into less toxic ones. It is proposed here to develop plant-based technology to clean polluted air at low cost. This air phytoremediation technology has many potential advantages in contrast with traditional air pollution treatment methods. It is simple, potentially cheap, and easily implemented. Plants to be used for air phytoremediation have the potential to reduce pollutants in air and improve air quality; they also fix carbon dioxide through photosynthesis and help to decrease greenhouse gases in the atmosphere. The selected plants can also be used as raw materials for production of energy and bio-based chemicals. However, little research has been carried out on air phytoremediation technology, especially in the basic research area. This editorial gives a brief discussion about air phytoremediation to stimulate more research on this technology and further improve its effectiveness in practical use.

With the increase of population and the development of modern industry, more pollutants are entering the atmosphere, contributing to air pollution (Burns et al. 2020). Vehicles and traditional power factories are among the main sources of air pollution (Chen et al. 2014; Zhu et al. 2018; Zeng et al. 2019). The exhausts from automobile engines contain many kinds of pollutants, notably particulates (soot of various sizes), carbon monoxide, nitrogen oxides (NOx), volatile organic compounds (VOCs), and small amounts of heavy metals. Traditional power factories, which produce electricity by burning fossil fuels such as coal, gas, and oil, discharge a range of air pollutants, notably sulfur dioxide (SOx), NOx, and particulates. Besides the toxic pollutants, these vehicles and factories also release huge amounts of carbon dioxide, a key cause of global warming and climate change when it rises and accumulates in the atmosphere (Zhu et al. 2013a,b; Woodford 2018). Air pollution has become a trigger for headache problems worldwide. According to a recent WHO report, nearly 91% of the world's population lives in areas where the level of airborne pollutants exceeds WHO permissible limits (Health Effects Institute 2018). Pollutants, including carbon monoxide, SOx, NOx, VOCs, and particulates with toxic metals, can cause dozens of diseases and threaten human health (Burns et al. 2020). Many efforts have been made to prevent air pollution (Kelly and Zhu 2016; Zhu et al. 2016; Zeng et al. 2019). One route to reducing the harm of air pollution to human health is to reduce the emission of air pollutants. For example, high standard gasoline and a highly efficient auto-exhaust catalysts are used to reduce the emission of pollutants from vehicles. The wet, dry, and semi-dry desulfurization systems for flue gas, selective catalytic reduction of NOx, activated carbon adsorption of VOCs, and electric precipitation of particulates are used to decrease the emission of pollutants in flue gas from the traditional power factories. The reduction of the emission of pollutants is often carried out via the complicated physical and chemical process, such as adsorption and catalysis. Such procedures are generally expensive because of high equipment investment and operational costs (Cao et al. 2019; Burns et al. 2020).

Another route is to remove the pollutants from the polluted air. Photo-catalysis, activated carbon adsorption, and pot-plants are useful methods to remove indoor air pollutants (Pettit et al. 2018; Bhave and Yeleswarapu 2020; Dhanabalan et al. 2020). However, little research has been carried out on the removal of ambient air pollutants. Removal of these pollutants often depends on slow natural degradation processes. When their removal rate is less than their emission, serious air pollution will occur. Therefore, there is an urgent need to develop simple, cheap, and effective methods to remove pollutants from ambient air.[10,11,12]

Air Phytoremediation: An Effective Way to Clean Polluted Air at Low Cost

Air phytoremediation (AP) is an environmental remediation technology that uses green plants to remove the pollutants from polluted air (Gawronski et al. 2017). Some plants have the ability to assimilate, degrade, or modify toxic pollutants in air into less toxic ones, which makes it possible to remove the airborne pollutants via the AP technology (Omasa et al. 2012). Some reports indicate that air pollutants can be effectively removed by plants. For example, Brassica species absorb SO_2 and NO_2 from polluted air and utilize it as a nutrient for their growth, Spinaciaoleracea and Brassica oleracea uptake Cd, Sn, Zn, and Pb from air particulates through their leaves; Chenopodiummurale removes volatile hydrocarbons; Zea mays removes phenolic compounds; and Zamioculcaszamiifolia removes formaldehyde (Gawronski et al. 2017; Pettit et al. 2018; Kumar et al. 2019).

Compared with the traditional air pollution treatment methods, AP technology has many advantages:

1. It is a green technology and will not cause secondary pollution (Brilli et al. 2018);
2. It can be simple, cheap, and easily implemented (Gawronski et al. 2017);
3. The AP plants not only can remove air pollutants, but they also fix carbon dioxide through photosynthesis;
4. The AP plants can be used as raw materials for energy and bio-based chemicals production (Zhu et al. 2015a,b, 2017);
5. The AP plants can beautify the environment via urban greening.

At present, AP technology is mainly used to remove indoor air pollutants (Brilli et al. 2018). Because of the lack of basic research, the treatment of ambient air pollutants is rarely carried out via the AP technology, although it presents many potential advantages. The AP is basically a biochemical process in plant cells of leaves (Kumar et al. 2019). The plant leaves act as a sink for air pollutants and particulates. The AP process is closely related with the plant species and the microbial association on their leaves (Weyens et al. 2015; Wei et al. 2017). For AP technology to become a powerful weapon to fight against air pollution, more studies should be carried out in the following aspects:

1. Identification of the microbial associations on plant leaves and their role in the air pollutants' degradation process;
2. Investigation of the biochemical process including the uptake of air pollutants and their metabolism in plants;
3. Investigation of the physiological processes and mechanisms of air pollutants on the physiological, anatomical, and genetic changes of plant leaves;
4. Selection or construction of more efficient plant species that degrade air-pollutants via modern biotechnology;

5. Development of new technology for comprehensive utilization of the AP plants; for example, using AP plants as raw materials for energy and bio-based chemicals production.
6. Determination of which types of air pollution, e.g. volatile organic compounds, particulates, nitrogen oxide gases, etc., can be effectively decreased by application of AP technology, and whether the benefits are large enough to justify further research and/or plantings.[13,14,15]

With the deepening understanding of the physiological processes and mechanisms involved in phytoremediation, AP technology has potential to become a mainstream air pollution treatment method and play an important role in improving air quality.

RESULTS

Development of the human society has a conspicuous negative influence on water resources and causes serious environmental contamination that is nowadays reaching a critical level. The quality of water is one of the vital components of the overall environment. Thus, water pollution can lead to human health issues, poisoned wildlife, and to long-term ecosystem damages. Plants are the first organisms that react to negative environmental changes and they are often used as bioindicators of water and air pollution. In addition, a significant number of plant species have the ability to accumulate harmful pollutants from soils and water. Recently, special attention has been paid to investigating the potential of plants to absorb toxic substances and reduce their negative impact on water resources. Besides, proper management of water resources depends upon understanding how plants regulate the use and retention of water. Environmental pollutants such as heavy metals can cause disturbance in root structure and function, thus having a negative effect on the water uptake. This chapter will review and discuss the role of the plants in water regulation and the control of water pollution in urban and mining areas. Information presented will provide better insights into the plant-based technologies aimed at contributing to the purification and remediation of polluted water resources.

Cities usually come at the price of green space. Since prehistoric times, humans have busily cleared forests to make way for settlements. But increasingly, greenery has been edging its way back into modern urban landscapes, and for good reason. Vegetation helps cities become better habitats for wildlife and for people, and it helps to make city air safer.

Trees have a remarkable range of traits that can help reduce urban air pollution, and cities around the world are looking to harness them. In January 2019, the mayor of London announced that 7,000 trees would be planted before the end of the following year. Meanwhile, China's Hebei Province, home to Beijing, has been working on a "green necklace" of plants that could help reduce pollution from factories that surround the capital. And Paris is planning an urban forest that will encompass its most iconic landmarks in an effort to adapt to climate change, and also improve the city's air quality.

While trees are generally effective at reducing air pollution, it isn't as simple as the more trees you have in an urban space, the better the air will be. Some trees are markedly more effective at filtering pollutants from the air than others. To make the most difference in air quality in a street or city, it has to be the right tree for the job.[16,17,18]

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And, of course, trees are only a way to filter pollution; better is to reduce emissions of pollutants in the first place, notes David Nowak, a senior scientist at the US Forest Service who has been studying plants' contribution to air quality for 30 years. "But trees can be of great help," he says.

Trees can improve air quality in direct and indirect ways. Indirectly, they can help by shading surfaces and reducing temperatures. If buildings are shaded by trees, it reduces the need for conventional air conditioning, and the emissions of greenhouse gases that come with it. Plus, lower temperatures decrease risk of harmful pollutants like ground level ozone that commonly spike on hot days in urban areas.

But trees also play a vital role in directly removing pollutants from the air. Plants are often seen as the "lungs" of an ecosystem because they absorb carbon dioxide and emit oxygen, says Rita Baraldi, a plant physiologist at the Institute of Bioeconomy of the Italian National Research Council. But they also act as an ecosystems "liver" too, filtering atmospheric pollutants like sulphur dioxide and nitrogen dioxide through their leaves.

Trees are particularly effective at removing particulate matter (PM), Nowak adds. PM comes in the form of tiny particles of organic chemicals, acids, metals and dust, emitted from fossil-fuel-burning vehicles and factories, as well as construction sites. The largest of these particles measure up to 10 micrometers across (known as PM10s), which is around a fifth of the width of a human hair. Then there are PM2.5s, measuring 2.5 micrometres across, and even smaller nanoparticle pollution.

Fine particulate matter can easily penetrate into human respiratory system, causing lung and cardiovascular diseases or exacerbating respiratory illness. It has also been linked to inflammation and heart disease. By one estimate, 8.9 million deaths a year globally could be attributable to exposure to outdoor fine particulate matter.

Clearing the air

From an urban planning perspective, plants act as a readily available set of PM purifiers. "Trees can help reduce PM in two main ways," says Prashant Kumar, the founding director of the Global Centre for Clean Air Research at the University of Surrey.

Conifers offer the best PM reduction because they are an evergreen species. But that does not automatically make them fit for any context – David Nowak

The first one is dispersion – by crashing into trees and plants, concentrated clouds of minuscule particles get dispersed and so diluted by the air, decreasing the risk of inhalation by humans. The second one is deposition. PM can easily get trapped in the waxy, hairy leaves of trees and shrubs. When it rains, most of these particles are washed away by water into drains.

"The extent to which each species performs such filtering activity depends mostly on canopy size, leaf size and leaf structure," says Baraldi. Bigger canopies can trap more particles than smaller ones, and larger leaves can trap more pollutants than small ones. When it comes to leaf type, it is those with rough, rugged and hairy surfaces that act as the "best filters" for PM.

Recent research suggests that tiny hairs on plant leaves in particular may play a big role in trapping the solid and liquid particles that make up PM. In one recent study, Barbara Maher and colleagues at the University of Lancaster tested the ability of nine tree species to capture PM in wind-tunnel experiments. Silver birch, yew and elder trees were the most effective at capturing particles, and it was the hairs of their leaves that contributed to reduction rates of 79%, 71% and 70% respectively. In contrast, nettles emerged as the least useful of the species studied, though they still captured a respectable 32%.

Alpine air

Conifers, like pines and cypresses, are also good natural purifiers. In 2015, Jun Yang, an urban ecologist at the Center for Earth System Science, Tsinghua University, in Beijing, ranked the most frequently occurring species in cities based on their PM 2.5 absorption capacity. The ranking also took into account species' ability to survive in urban contexts, and any negative impact on air quality, such as the production of allergens, and of volatile organic compounds (VOCs) – a set of substances that can interact with gases emitted by vehicles, like nitrogen dioxide. In the presence of sunlight, these reactions can contribute to ground-level ozone, which is harmful to human health. The effects can be considerable; when a heatwave hit Berlin in 2006, the ozone created by the interaction of plants' VOCs and vehicles' pollutants resulted in sudden decreases in air quality.[19,20,21]

To Yang's surprise, his ranking system showed that the most widespread species of trees were not the best pollution filters. "Of the 10 most recurring species, only the London plane, silver maple and honey locust ranked above average," he says. It was conifers, such as pines and cypresses, that were the best pollution filters. Planting conifers, Yang concluded, would make most sense in polluted cities like Beijing to reduce PM2.5s. The Chinese capital routinely reports PM levels above 125 micrograms per cubic meter, more than 10 times greater than World Health Organization recommended threshold of 10 micrograms per cubic meter.

There is a lot of conflicting advice and wishful thinking on the benefits of urban trees to mitigate air pollution – Stephanie Carlisle

The reason for conifers' success in reducing PM is partly down to their canopy structure – the dense canopy of needle-like leaves typical of conifers is very effective at trapping pollutants. And their seasonal biology helps too. "Conifers offer the best PM reduction because they are an evergreen species," Nowak says. Unlike deciduous trees, who lose their leaves during winter, evergreen species act as year-round filters. "But that does not automatically make them fit for any context."

The issue with conifers, Nowak says, is that many species can be very sensitive to salt levels in soils, which tend to be high in urban areas especially where salt is used to de-ice roads. Compounding the issue, conifers' year-round canopy can block sunlight from melting snow and ice, which can lead to road traffic problems in cities subject to cold temperatures, Nowak notes. These two drawbacks to conifers were also cited by Yang as caveats to be considered in his recommendations.

Troubling trees

Some deciduous species can also come with side-effects, Nowak says. For example, trees commonly found in cities of the northern hemisphere – such as poplars or black gum trees – can emit high levels of VOCs.

"Ideally, you want to be able to identify species that can maximise PM absorption but minimise ozone-precursor production," says Margarita Préndez, an organic chemist at the University of Chile, who has studied how different species affect air quality in Santiago. Nowak cites conifers like hemlocks, junipers and deciduous trees like elms, horse chestnuts and basswood as examples of low-VOC plants.

"Based on data from Santiago and other Chilean cities, native trees emit fewer VOCs than non-native trees," Préndez adds. In Santiago, non-native species like the Prunus and the London plane tree can produce up to 30 times more VOCs than native species.

But this rule might not apply everywhere, and Yang says that you can't generalise when it comes to endemic versus introduced trees. "Some of the best species for air pollution reduction are non-native," he says. "We should not rule them out for ideological reasons."

It's a finely balanced business to find the right trees for a city. But that's just the start, says Nowak. The next question is where to plant them.[22,23,24]

Many well-meaning schemes have suffered because of poorly planned planting. "Some cities like Beijing and Mexico City have planted trees pretty far from the city centers," says Rob McDonald, lead scientist at The Nature Conservancy. "That may not be that beneficial."

McDonald, who works with municipal governments to manage urban forests, says that as a rule of thumb, trees need to be planted close to where people – and sources of pollution – are.

And as wind direction and landscape structure can affect the way pollution moves, trees need to be planted accordingly, Nowak adds. In narrow streets surrounded by tall buildings, like those of downtown Manhattan, airflow can trap pollutants close to the ground. Planting tall trees with big canopies can make matters worse in this situation by preventing the pollution from dispersing. A recent tree planning scheme in Beijing ended up trapping pollution in certain areas, partly for this reason.

Kumar and his team recently issued specific recommendations for urban planners on this point. Hedges or green walls are generally to be preferred to trees in narrow streets flanked by tall buildings. While on broad roads surrounded by low-rise buildings, like those typical of the American suburbs, air can flow more freely so there is less risk of trapping pollutants, making both trees and hedges viable options. Examples of roadside hedges that work well include viburnum, red tip photinia, privet and bay laurel, Baraldi adds.

Ensuring biodiversity is also essential, even if one tree species is a standout winner in terms of its pollutant-trapping abilities. Kumar recommends that no more than 5-10% of an urban forest should be made of the same species or family. And a final factor that Nowak notes is that one should be realistic about maintenance and lifespan – plants that require little attention and that will last several decades are to be preferred.

Through the maze

With such a breadth of variables to keep in mind, knowing which species will work best in a particular place can be challenging. “There is a lot of conflicting advice and wishful thinking on the benefits of urban trees to mitigate air pollution,” says Stephanie Carlisle, an urban ecologist at the University of Pennsylvania who studies the interaction of natural and built environments. “Plus, it is really difficult to measure it.” Indeed, some studies report that plants can reduce PM that reaches indoor spaces by as little as 1% while others claim reduction rates of 60%.

But scientists are building tools intended to help urban designers identify the most suited species to a particular location. For example, a free software provided by the US Forest Service, iTree species, ranks species based on a set of variables including air-pollution removal abilities, carbon storage and VOC emissions.

CONCLUSION

The town of Oakville in Ontario, Canada, was one of the earliest adopters of iTree, and is a good example of just how difficult it is to get the balance right. The municipality found that, according to iTree, the Norway maple provides more benefits to air quality than any other tree. But because Norway maples already accounted for more than 10% of urban canopy, the city refrained from planting more of them, to preserve biodiversity. However, municipality also stopped planting hawthorn after iTree revealed it was of little help for air quality. Hawthorn was gradually replaced with American elms – but then they turned out to be sensitive to Dutch elm disease.

As Nowak explains, the species ranking in the iTree tool gives a general indication of the best species, without taking much local context into account. “Species that come out on top may be invasive or not well suited for that particular ecosystem,” he says. “So it’s always best to check with local experts to determine which species will perform well based on local conditions.” Next, Nowak and his team plan to go further to study how local ecosystems affect how suitable a tree is for planting, and how best to harness its natural characteristics.

The importance of local context is a point echoed by Kumar. Earlier this year, he co-authored a guide to help urban planners select species that can help to mitigate roadside pollution. He listed 61 species that have 12 traits suited for air-pollution reduction, such as rugged leaves. The guide also accounts for "undesirable" variables, such as pollen, VOCs, and high-maintenance species. "Evergreen oaks, pine species, and common yew were selected as potentially most effective," Kumar says. "Because they are relatively tolerant of pollution, evergreen and include a suite of beneficial leaf traits."

Such advice is not just for urban planners. Citizens can now count on an expanding range of toolkits to help them with planting choices. Jennifer Gabrys, a sociologist at the University of Cambridge, developed a digital tool that can let anyone play a role in reducing air pollution. Called Phyto-sensor, and developed while Gabrys was previously at Goldsmiths University, the tool lists plants that have proved effective at PM reduction, like wallflowers and ivy, and provides suggestions on planting locations.

But ultimately, it is context that determines if a species is beneficial or detrimental. "Even 'best-performing trees' may not work in some cases," Kumar says. "For example, we would not recommend planting yew near school playgrounds because it is poisonous."

If all this proves anything, it is that clutching to one tree as a fix-all is not going to get you very far. "Some designers have a tendency to think in terms of objects rather than a complex ecological system," says Carlisle. "But without an holistic understanding of urban ecosystems, the risk is to do more harm than good."

In that sense, tree-planting to tackle pollution is like many other aspects of urban design – the key to success lies in understanding local and environmental nuances. It's what will determine whether urban trees are a breath of fresh air, or a major headache.[25]

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