GASPING FOR CLEAN AIR

background reading | air pollution unit

EARTH matters
Studies For Our Global Future

The sky's the limit for the billions of tons of pollutants that people pump out of factories, homes and cars each year. Increased global industrialization and rapid population growth are combining to create more of these pollutants, which create problems such as urban smog, acid rain and unbreathable air. The health of humans and our ecosystems suffer as a result of the largely preventable amounts of pollution with which we foul our air.

The state of your air quality depends on where you live. For the most part, countries that have long been industrialized and developed (e.g. U.S., Canada, western European countries, Japan) have had more time and money to implement measures to control air pollution, and now enjoy cleaner air than in previous decades. Today's rapidly industrializing economies, such as China and India, are just now coming to terms with the effects of worsening air quality, especially the impacts on public health. Even cities in less industrialized countries suffer from an increase in respiratory illnesses due to vehicle emissions and indoor air pollution.

Air pollution basics – what's in the air?

Particulate matter

Much of the world's air pollution is found in urban areas in low and middle-income countries, places where rapid urbanization is only expected to increase in the coming decades. According to the **World Health Organization (WHO)**, 90 percent of the world's population breathes toxic air, where the level of particulate matter (PM), exceeds WHO limits.[1]

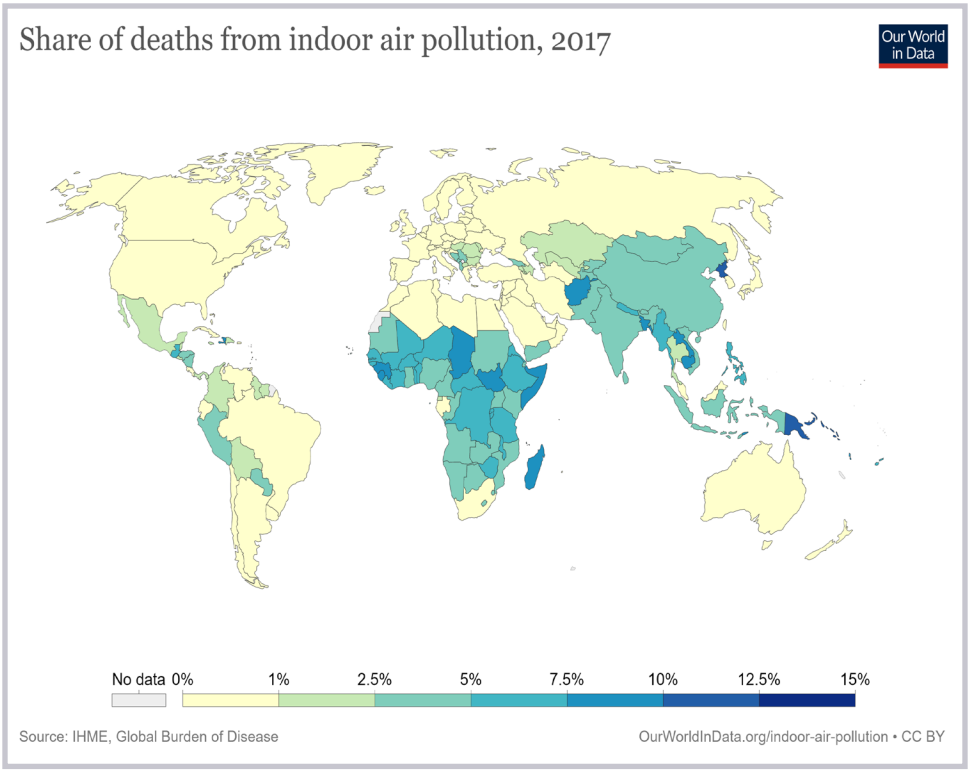
Photo Credit: Ssuaphoto/iStockphoto.com

A growing health concern for many countries is particulate matter, suspended particles of soot, ash, dust, acids, metals and chemicals. PM includes two different types of particles: PM10 or "inhalable coarse particles," with diameters over 2.5 micrometers (but less than 10 micrometers), often found near roadways and dusty industries, and PM2.5 or "fine particles," with diameters under 2.5 micrometers, often found in smoke or haze. Once inhaled, both types of particles – though especially fine particles – can go deep into the lungs and cause serious health risks.

According to WHO, ambient (outdoor) air pollution, made of high concentrations of coarse and fine particulate matter, cause 4.2 million premature deaths worldwide every year.[2] Problems from particle pollution include difficulty breathing, irregular heartbeat, aggravated asthma, and chronic bronchitis. Delhi, India's capital, currently holds the infamous title of most polluted megacity, which often worsens in the winter months. WHO's threshold for a healthy level of fine particulate matter is 10 micrograms per cubic meter (10 µg/m^3), for an annual mean, and 25µg/m3 for a 24-hour period mean. The most polluted day recorded in Delhi's history was November 6, 2016 when the PM2.5 concentration got to 933 µg/m3.[3] November 2021 broke the record for most days with air quality at severe levels, forcing schools to close and prompting a city-wide

lockdown.[4] The city's fumes from over 10 million cars, small-scale diesel electricity generators, coal plants, and crop burning by farmers are all causes of hazardous pollution. Children and teens in Delhi have been the most affected, with the toxic air causing cancer and pneumonia-related deaths in small children.[5]

Responsible for 3.8 million deaths a year, according to WHO, **indoor air pollution** is one of the leading causes of disease and premature death in low and middle-income countries.[6] The vast majority of these deaths occur in developing countries where indoor air pollution results from burning **biofuel.** Almost 3 billion people, in low- and middle-income countries mostly, still rely on solid fuels (wood, animal dung, charcoal, crop wastes and coal) burned in inefficient and highly polluting stoves for cooking and heating.



Nitrogen dioxide

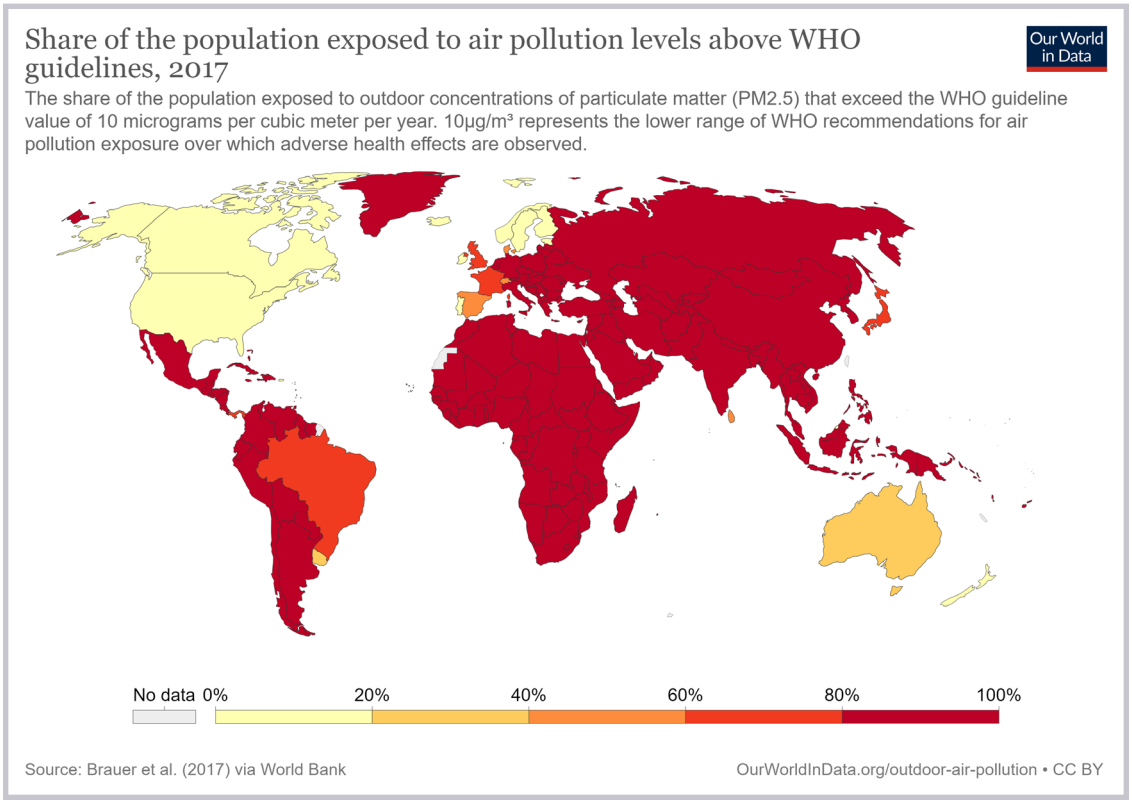
Another pollutant on the rise in industrial cities is **nitrogen dioxide (NO_2)**. NO_2 primarily gets into the air from burning fuel in vehicles and power plants. Exposure to NO_2 is linked to respiratory symptoms, especially for asthma sufferers. NO_2 also interacts with water, oxygen and other chemicals in the atmosphere to form acid rain.

The United States and Europe are among the largest emitters of nitrogen dioxide. In fact, Oxford Street in London was named the most polluted street on Earth in 2014, due to the NO_2 emitted from diesel vehicles.[7] Fortunately, the city implemented a series of cleaner air policies that reduced NO_2 emissions by 40 percent by 2021.[8] China is the largest emitter of **greenhouse gases** and progress has been slow in reducing the country's NO_2 emissions. From 2015-2019, NO_2 reductions totaled 9 percent.[9]

Ozone

High in the atmosphere, ozone forms a layer that filters out harmful **ultraviolet radiation**, thus protecting life on Earth. But ozone is also formed at the Earth's surface under certain conditions when sunlight reacts with high concentrations of **nitrogen oxides (NOx)** and volatile organic compounds in the air. The result we see is smog, that hazy air that blankets many cities. There are thousands of sources of these gases; the two most common are power plants that burn **fossil fuels** and combustion of gasoline in the engines of cars, buses and trucks. Other sources include paint solvents, wood fires like those we have in our fireplaces and coal-fired boilers; some emissions even come from trees.

Adverse health effects of ozone pollution include shortness of breath, chest pain when inhaling deeply, wheezing and coughing. Long-term exposure may lead to permanent lung tissue damage.[10] Ozone can affect the health of trees, crops and other plants at concentrations even lower than those that harm humans. Ozone has been shown to reduce plant growth by interfering with the plant's ability to produce and store food, and it can make plants more susceptible to disease, insect attacks and harsh weather. Forest declines in several parts of the U.S. have been attributed to ozone and other pollutants.



Carbon monoxide

Carbon monoxide (CO) is another common vehicle-related pollutant. Motor vehicle exhaust is responsible for 60 percent of CO emissions in the U.S. In 2020, carbon monoxide levels for the U.S. were 81 percent lower than in 1980, largely due to the addition of car pollution control devices called **catalytic converters** which help remove CO from car exhaust.[11]

Carbon monoxide is absorbed into the bloodstream more quickly than oxygen, creating numerous health risks. Exposure to even low levels of CO reduces the body's delivery of oxygen to its organs and tissues, producing impaired perception and thinking, slowed reflexes and drowsiness. Long-term exposure to CO is believed to aggravate cardiovascular disease. Since carbon monoxide is odorless and colorless, many people choose to put CO detectors in their homes, to alert them to leaks and potentially save lives.

Protesting air pollution on the first Earth Day, 1970.

Sulfur dioxide

The compound **sulfur dioxide (SO_2)**, a byproduct of fossil fuel combustion at power plants and other industrial facilities, also pollutes our air and threatens our health. Emissions of SO_2 have been greatly reduced in many industrialized countries with the aid of pollution control equipment and improvements in energy efficiency. In much of the world, however, these elements pose dire threats to human and environmental health. In Eastern Europe and the former Soviet republics, hasty industrialization after World War II powered by high-sulfur, brown coal led to widespread environmental degradation and human illness. India, one of the largest consumers of coal, leads the world in sulfur dioxide emissions and saw its SO_2 emissions double between 2007 and 2017.[12]

Acid rain

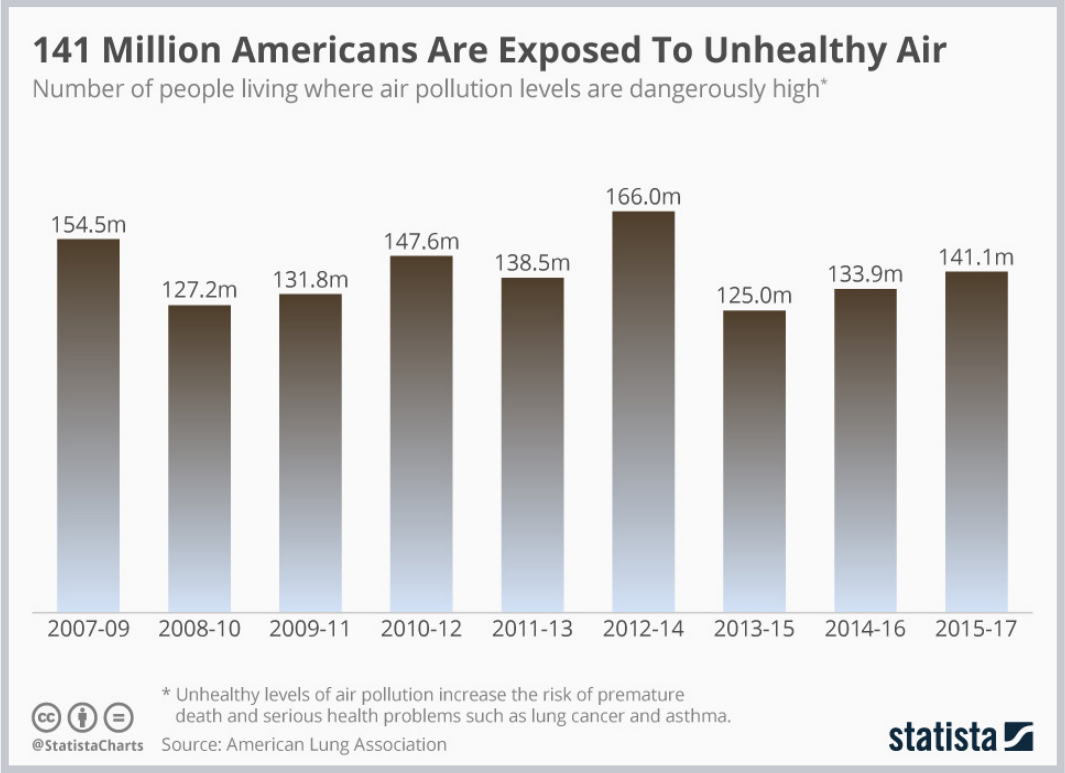
Excessive levels of pollutants are just as damaging to the planet's health as they are to its inhabitants, especially in the form of **acid rain**. When sulfur and nitrogen oxides combine with oxygen and moisture in the atmosphere, they become sulfuric and nitric acids. These acidic pollutants fall to the ground, often hundreds of miles from their origins, as dry particles or in rain, snow, frost, fog and dew. Acid rain damages wildlife through direct contact – it can leach or dissolve minerals in the soil, and also extract nutrients. At the same time, acid rain releases toxic elements such as aluminum into to the soil where they can be harmful to plants and animals. In areas severely affected by acid rain, trees decline in growth and die prematurely, plants and microorganisms crucial to the wildlife food chain die, and lakes become too acidic to support fish and birds. Acid precipitation is believed to be responsible for dieback and deterioration of white birch trees in southeastern New Brunswick, Canada, and of red spruce in higher-elevation areas of the United States.[13]

Since 1990, sulphate ions in the atmosphere have steeply dropped, as action from the U.S. and Canadian governments helped curb acid rain in these regions. However, even as lakes and wildlife recover, nitrates from livestock feed and fertilizers continue to contribute to nitric acid precipitation.[14]

Acid rain can also take its toll on the human body. Sulfuric and nitrogen oxide emissions have been linked to increased frequency of asthma, heart disease and lung disease, especially among children and the elderly. Even the water you drink may be tainted. Acid rain can cause a leaching of toxic substances both out of the soil and out of pipes that carry drinking water to millions of people.

Clearing the U.S. skies

Countries that have made the most progress in reducing air pollution levels have set strict standards for acceptable levels of pollutants and enforce these air regulations. In response to a worsening air crisis, the U.S. Congress enacted the **Clean Air Act of 1970** and directed the newly formed **Environmental Protection Agency (EPA)** to establish air quality standards for most common and widespread air pollutants (CO, NOx, SO_2, PM, volatile organic compounds and lead.) Under the Act, state governments were directed to develop and implement strategies to meet and maintain these air quality standards. Amendments to the Act in 1990 were specifically designed to combat acid rain, urban air pollution and toxic air emissions. One of these amendments called for enhanced car inspection and maintenance programs, tougher regulations on vehicle exhaust, and development of cleaner-burning fuels.



To combat sulfur dioxide emissions which leads to acid rain, Congress established an **emissions trading** system in 1990 which assigns allowances (one allowance = one ton of sulfur dioxide per year) to electric utilities and other industries that produce sulfur dioxide. The system lets each utility or factory decide the most cost-effective way to reduce its emissions; then it may sell the allowances it no longer needs after the reductions. This cap on emissions plus the greater competition for allowances provides an incentive for further reductions and ensures that the level of sulfur dioxide from industry sources will not increase. Since the start of its Acid Rain Program

in 1995, sulfur dioxide emissions have dropped over 90 percent from 1990 levels; nitrogen oxide emissions have dropped 57 percent since 1990.[15] Reductions in these emissions have led to a significant decrease in acid deposition, which improves water quality in U.S. lakes and streams.[16] The EPA reports that because of the Clean Air Act, air quality in the United States is better today than it was in 1970. From 1970 to 2020, the combined emissions of the six common air pollutants dropped by 78 percent, even as the U.S. economy continued to grow.[17]

The Ponina Fire in Oregon, April 2021. Oregon Department of Forestry.

While overall progress has been positive, fine particulate pollution (PM2.5) has increased in recent years, especially due to wildfires in the West and Northwest regions of the U.S. Scientists estimate that wildfires, whose frequency has grown due to climate change, account for up to 25 percent of PM2.5 nationwide, and up to half in some western regions.[18]

Although Clean Air regulations have facilitated the decrease in concentration of many air pollutants, elevated ozone levels have continued to be a pervasive and damaging problem in cities of various sizes, as well as in some rural areas. To counter this, the EPA has set more stringent national air quality standards. In 1997, the EPA established **ozone standards**, at 80 parts per billion, when averaged over 8 hours. In October 2015, the EPA further strengthened that standard by establishing new health-protective levels of 70 parts per billion. Meeting the criteria over a three-year period is known as **8-hour ozone attainment**. Despite these protections, a 2021 "State of the Air" report found that about 41 percent of the U.S. population lives in counties with unhealthy levels of ozone or particle pollution.[19]

Environmental justice

In the United States, people of color are more often exposed to toxic air pollution. They are more likely to live in neighborhoods close to highways and industrial pollution sites due to decades of discriminatory housing and **redlining policies**.[20] A study by the EPA found that Black communities in the U.S. face the highest impact of all populations, with a 54 percent higher health burden than the overall population. People living below the poverty line face a 35 percent higher burden. Historic racism and economic inequalities are two reasons why pollution sources are more likely to be placed near or within low income communities, as well as Black and other communities of color, the study cited.[21]

To address these problems, the EPA created the Office of Environmental Justice, a new branch within its agency in 1990. The EPA defines environmental justice as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies."[22] Fair treatment means that no community should bear a disproportionate burden of negative environmental impacts.

The COVID-19 pandemic has further impacted the health of many communities who live in areas with high pollution. A national study from Harvard University found that a small increase in long-term exposure to PM2.5 pollution leads to a larger death rate for COVID-19.[23] In spring 2020, the EPA began offering grants to fund community projects that address the impacts of COVID-19.

A global air crisis


Photo Credit: BD Photo/iStockphoto.com

Polluted city street in New Delhi, India.

The greatest challenges ahead for combating air pollution appear to be in some of the most populated, rapidly industrializing cities in developing countries. Globally, about 55 percent of the world's population were exposed to increased levels of fine particulate matter (PM2.5) between 2010 and 2016, with the largest increase coming from Central and Southern Asia.[24] WHO data shows that nearly the entire global population (99 percent) breathe air that exceeds their guidelines for safe levels of pollutants, with low and middle-income countries facing the most exposure.[25] India, alone, has 22 of the top 30 most polluted cities in the world, with Ghaziabad ranking first.[26] Indoors, more than one-third of the world population does not have access to clean cooking fuels, the main source of household air pollution, which claims 3.8 million lives a year.[27]

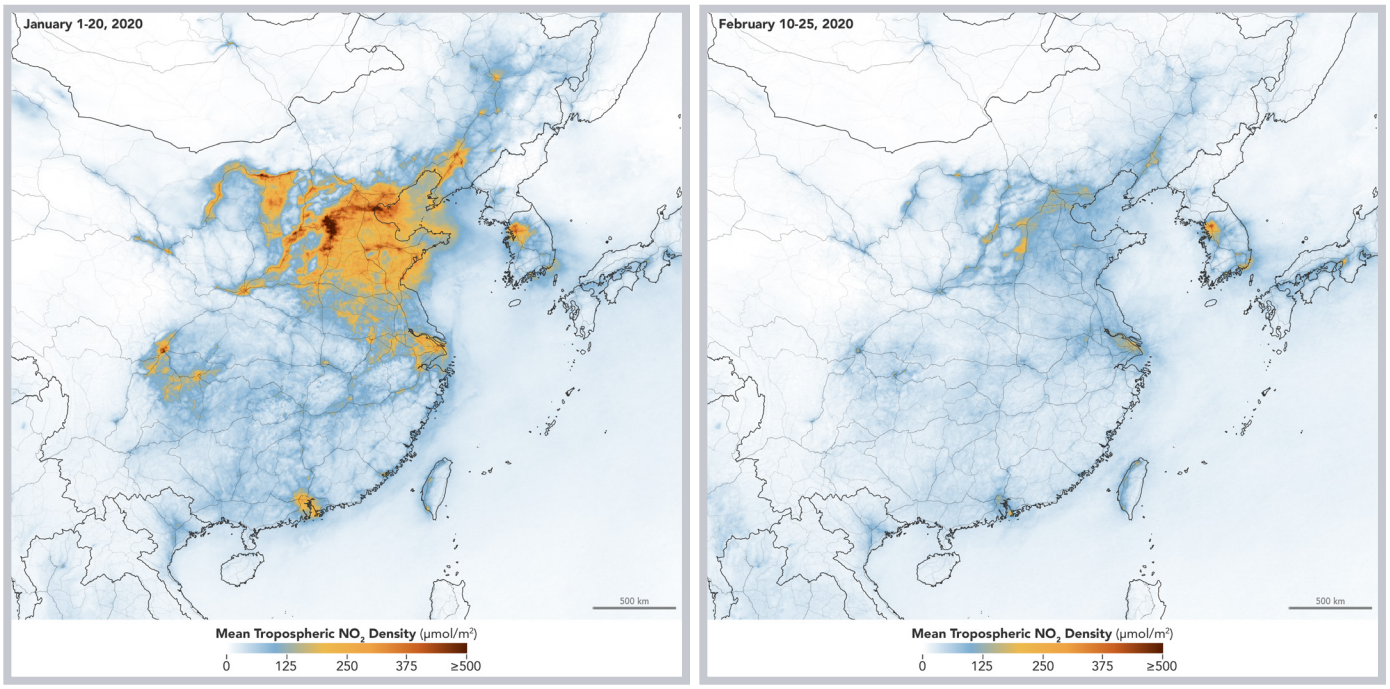
Without new air pollution policies, urban air quality will continue to deteriorate globally. By 2050, outdoor air pollution (particulate matter and **ground-level ozone**) is projected to become the top cause of environmentally-related deaths worldwide.[28]

In Spring 2020, the COVID-19 crisis spurred lockdowns across the world. As people stopped flying, commuting to work in cars and as factories reduced output, the skies cleared in many places, drastically reducing air pollution in cities across the world. In New Delhi, PM2.5 pollution dropped by 60 percent from March 23 to April 13, compared to a year prior.[29]

In China, CO_2 emissions dropped by 25 percent in the six weeks following the lockdowns. However, once the lockdowns ended, pollution levels quickly rebounded in May 2020, surging to 4-5 percent higher than the previous year's levels at the same time.[30]

Pollution solutions

Combating air pollution will require an investment in infrastructure and new, cleaner technologies. It will also be important to raise awareness of worsening air, so that communities and governments can take precautions to safeguard public health and track progress.



Before/after satellite images of China's air pollution during COVID lockdowns.

Source: NASA

Having reliable and quality data is important in spreading awareness, designing solutions, and measuring progress. Some social entrepreneurs, people who find innovative solutions to society's most urgent challenges, are doing just that. Scientist Christa Hasenkopf co-founded a tech non-profit with Joe Flasher, a software developer, that gives people access to an open-source directory of air quality data throughout the world. She launched the project, OpenAQ, on social media, with a mission to empower the public to fight air pollution through real-time, open data that can help enable science and government policy.

Citizen scientists, people from the general public who collect data to provide to scientists, are also helping governments and scientists monitor air quality. Using apps or small, handheld devices, people can report the pollution levels in their neighborhood. The EPA has an online Air Sensor Citizen Science Toolbox people can use to support citizen science air monitoring initiatives in their communities.

With so much of pollution coming out of our tailpipes, it will also be critical to find ways to reduce motor vehicle emissions. This might involve creating more energy-efficient public transportation options, investing in cleaner fuels and electric vehicles, and encouraging walking, bicycling and teleworking.

Reducing industrial smokestack emission will require increased use of renewable power sources, like solar and wind, to replace coal in manufacturing and power generation. Developing ways to disseminate air quality information to the public is also important. In 2013, China instituted a mass monitoring and warning system in its cities to alert residents on poor air quality days. Red and orange alert days have led to pedestrians wearing masks and people staying indoors to avoid breathing toxic air. As more residents have become aware of their air quality, there is more pressure on national leaders to address the problem.

Government policies are also crucial, as the decades of progress with the U.S. Clean Air Act have shown. While India has the most polluted air in the world, its government's National Clean Air Programme (NCAP) hopes to change that by reducing pollution in over 100 cities by 20 to 30 percent compared to 2017 levels, by 2024.

Even within countries, local action matters. In a landmark decision in June 2020, California adopted a rule that more than half of all trucks sold in the state must be zero-emission by 2030, and 100 percent electric by 2045. Transportation makes up 40 percent of California's greenhouse gas emissions, and policies like this are important in curbing harmful pollution.[31]

Finally, public-private partnerships, meaning collaborations between governments and business, can also help clean the air and save lives. One example of this kind of partnership is the Global Alliance for Clean Cookstoves, which seeks to address indoor air pollution by promoting the use of more efficient cookstoves that use cleaner fuels throughout the developing world. All of these measures would serve not only to save millions of lives each year, but also to reduce our impact on the environment and global climate.

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