

What's in the air you breathe? - Amy Hrdina and Jesse Kroll

Take a deep breath.

In that single intake of air, your lungs swelled with roughly 25 sextillion molecules, ranging from compounds produced days ago, to those formed billions of years in the past. In fact, many of the molecules you're breathing were likely exhaled by members of ancient civilizations and innumerable humans since.

But what exactly are we all breathing? Roughly 78% of Earth's atmosphere is composed of nitrogen generated by volcanic activity deep beneath the planet's crust. The next major ingredient is oxygen, accounting for 21% of Earth's air. While oxygen molecules have been around as long as Earth's oceans, oxygen gas didn't appear until ocean-dwelling microorganisms evolved to produce it. Finally, 0.93% of our air is argon, a molecule formed from the radioactive decay of potassium in Earth's atmosphere, crust, and core. Together, all these dry gases make up 99.93% of each breath you take.

Depending on when and where you are, the air may also contain some water vapor. But even more variable is the remaining 0.07%, which contains a world of possibilities. This small slice of air is composed of numerous small particles including pollen, fungal spores, and liquid droplets, alongside trace gases like methane and carbon dioxide. The specific cocktail of natural and man-made compounds changes dramatically from place to place. But no matter where you are, 0.07% of every breath you take likely contains man-made pollutants—potentially including toxic compounds that can cause lung disease, cancer, and even DNA damage.

There's a wide variety of known pollutants but they all fall into two categories. The first are primary pollutants. These toxic compounds are directly emitted from a man-made or naturally occurring source. However, they don't always come from the places you'd expect. Some large factories mostly generate water vapor, with only small quantities of pollutants mixed in. Conversely, burning wood or dung can create polycyclic aromatic hydrocarbons; dangerous compounds that have been linked to several types of cancer, as well as long-term DNA damage.

In all cases, pollutants interact with regional weather patterns and topography, which can keep compounds local or spread them kilometers away. When these molecules travel through the air, a transformation occurs. Natural compounds called oxidants, formed by

oxygen and sunlight, break down the pollutants. Sometimes, these reactions make pollutants more easily washed out by rain.

But in other cases, they result in even more toxic secondary pollutants. For example, when factories burn coal, they release high concentrations of sulfur oxides. These molecules oxidize to form sulfates, which condense with water vapor in the air to form a blanket of fine particles that impair visibility and cause severe lung damage. This so-called sulfurous smog was well-known in 20th-century London and continues to plague cities like Beijing.

Since the advent of cars, another secondary pollutant has taken center stage. Exhaust from fossil fuel-burning vehicles releases nitrogen oxides and hydrocarbons which react to form ozone. And while some ozone in the upper atmosphere helps shield us from ultraviolet rays, on the ground, this gas can form alongside secondary particles and create photochemical smog.

This brown fog can be found covering densely packed cities, making seeing difficult and breathing hazardous. It also contributes to climate change by trapping heat in the atmosphere.

In recent decades, industrial activity has contributed to a huge spike in various trace gas emissions, fundamentally changing the air we all breathe. Many places have already responded with countermeasures. Most cars produced since the 1980's are equipped with catalytic converters that reduce the emission of carbon monoxide and nitrogen oxides. And today, places like Beijing are battling smog by electrifying their energy infrastructure and limiting automobile emissions altogether.

But while moving away from fossil fuels is essential, there's no universal remedy for air pollution. Different regions need to respond with unique regulations that account for their local pollutants. Because no matter where you live, we all share the same air.