Plastic's Toxic Lifecycle

From well to ocean, plastic has harmful health, environmental, and climate impacts. Not only does plastic fuel the demand for increased fossil fuel production, but the glut of plastic from fracking feedstocks is creating yet more long-lasting plastic in our lives. The full toll of this process is immense, creating a legacy of toxic pollution for future generations.

The Plastic Lifecycle

Fracking produces raw feedstock and energy for plastic

More than 90 percent of plastic worldwide comes from fossil fuels.[1] In the United States, natural gas and natural gas processing are the primary sources of plastic feedstock, although oil is a raw material for some plastic.[2] Plastic production also uses fossil fuels directly for process heat and indirectly to produce electricity that powers its manufacturing.[3] Plastic accounted for around 8 to 9 percent of global oil and gas demand in 2019,[4] and is projected to account for up to 20 percent of oil demand by 2050.[5]

In the U.S., around two-thirds of oil[6] and 80 percent of natural gas are produced using hydraulic fracturing, or fracking.[7] The entire fracking process is toxic, dangerous, and poorly regulated. Fracking is linked to a range of health issues including lung disease, respiratory illness, and reproductive harms. Increasingly, fracking is linked to cancer.[8] People who live closest to oil and gas operations are at a higher risk of experiencing negative health outcomes.[9]

Since the fracking boom began, drinking water contamination has popped up across the country. One study found higher concentrations of combustible methane in areas close to active fracking sites.[10] Other studies confirm that foam, brine, natural gas, and other chemicals can migrate through layers of rock and leach into groundwater sources.[11] Contaminated groundwater not only puts communities' health in jeopardy, but also impacts their livelihoods. There have been many instances where groundwater contaminated by fracking poisoned livestock, causing illness, reproductive issues, and death.[12]

Refining crude oil and natural gas creates intermediate products

Crude oil is composed of hundreds of different hydrocarbons that are separated at refineries into the range of products that become asphalt, jet fuel, and automotive gasoline. Among the products separated from crude oil at this stage is naphtha, a feedstock that can be "cracked" to produce ethylene.[13] The amount of naphtha extracted from crude oil depends on the method of distillation — at some process temperatures, refineries will produce more feedstock but less diesel, or vice versa.[14] Refining naphtha emits significant quantities of carbon dioxide (CO_2), nitrogen oxides (NOx), and volatile organic compounds (VOCs).[15]

Natural gas contains a number of hydrocarbons that can be used to produce petrochemicals. Wet natural gas specifically, found in some shale plays, has higher concentrations of natural gas liquids (NGLs), predominantly ethane.[16] NGLs are the raw materials for manufacturing a range of petrochemicals including plastics. Natural gas processing plants separate dry gas (methane) from NGLs (ethane, etc.) so that each can be used for different purposes.[17]

Plants that convert fossil fuels into petrochemicals are known to emit massive amounts of air and climate pollutants, including polycyclic aromatic hydrocarbons, CO_2, ozone-creating VOCs (such as benzene and toluene), and NOx.[18] These plants pump out mountains of toxic plastics.[19]

Toxic mega-plants convert refined products into plastic

First, ethane is transported to a type of petrochemical facility known as a cracker plant, where a series of processes involving steam (or just heat) "crack" ethane into ethylene.[20] Steam cracking of feedstocks like ethane and naphtha is the primary source of ethylene.[21] Steam cracking of naphtha occurs at temperatures between 750 to 900 Celsius and requires significant energy inputs (from fossil fuels) to generate heat.[22] Ethylene is the most frequently produced petrochemical and creates the most common type of plastic.[23] Cracking produces a wide variety of other plastic building blocks like propylene.[24]

Next, polymer plants convert ethylene and other molecules into plastic polymers. This is done through a process called polymerization, which combines molecules into long chains to produce much larger molecules.[25] For example, ethylene can be polymerized to convert it into small plastic pellets (called polyethylene resin). This resin is used to manufacture plastic products.[26] The U.S. produces around 90 billion pounds of plastic resin every year.[27]

Finally, manufacturing plants shape resin and pellets into products through extrusion, which melts plastic resin and pushes it through specialized shapes.[28] This is also the stage that adds fillers and additives, which can make up as much as 85 percent of the product by volume.[29] Many plastics contain hazardous chemical additives, which may leach out as the plastic ages.[30] Some are extremely noxious, many have been linked to chemical toxicity, and some are classified as endocrine disruptors, which can alter hormone function.[31] These additives can seep from plastics into food and the environment, accumulating over time.[32]

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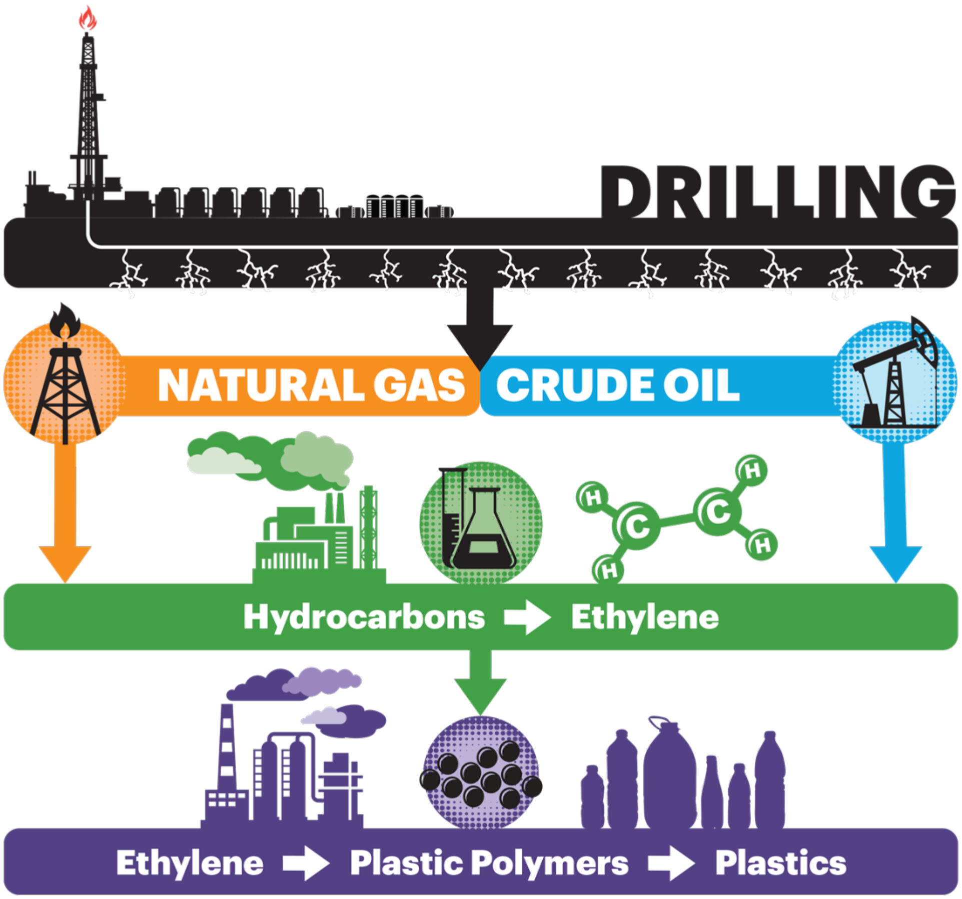
Fig. 1: The Plastic Lifecycle



Much of this plastic is ready to be thrown away just after production

This whole process produces a huge quantity of plastic. According to one industry group, the world produced 390 million metric tons of plastic in 2021.[33] Around 44 percent of this plastic is used for packaging,[34] which creates materials that are immediately thrown away.[35]

Even though most Americans recycle plastic,[36] only around 6 percent of the plastic used in the U.S. is ultimately recycled.[37] Many plastics featuring the recycling triangle cannot actually be recycled, and some plastics can jam recycling machinery.[38] The numerous additives, dyes, and fillers also make it much harder to repurpose plastic.[39] Plastic also degrades with each use, making it undesirable compared to readily available and cheap new plastic.[40] Ultimately, much of the plastic placed in recycling bins ends up in landfills.[41]

Recycling has its own environmental footprint, requiring electricity and toxic solvents to break down and reconstitute products.[42] Recycling facilities are also prone to catching fire, releasing toxic fumes from burning plastic in hard-to-control blazes.[43] According to a "very conservative" report from a fire suppression company, there were 390 fires at recycling facilities in the U.S. and Canada in 2022. Given data limitations, these reported fires were likely only the major incidents, while the total number of fires could be as high as 2,000.[44]

A higher percentage of plastic is burned instead of recycled. The Organisation for Economic Co-operation and Development estimates that the U.S. incinerated 19 percent of its plastic in 2019, often to generate electricity.[45] Incinerating trash produces toxic air emissions and contributes to climate change. In 2011, the New York Department of Environmental Conservation found that incinerators emit nearly 14 times more mercury than coal per megawatt.[46] Garbage incineration may produce more greenhouse gas emissions per megawatt than some fossil fuels.[47]

Plastic's toxic legacy

Plastic lasts for hundreds to thousands of years, and its toxic remains pose serious challenges.[48] The U.S. illegally dumps between 0.14 and 0.41 million metric tons of plastic waste annually.[49] Even legally dumped plastic fills up increasingly limited and expensive landfill space.[50] As water percolates through these landfills, it picks up toxins, generating super-polluted runoff that is harmful to human health and the environment.[51]

We know that at least 9.2 million metric tons of plastic, including 3.0 million metric tons of microplastics[1], enter the environment globally every year.[52] While 40 percent of all plastic waste is unaccounted for, large volumes of plastic waste enter the ocean, where it remains for decades.[53]

Microplastics are ubiquitous, finding their way into our oceans and even into the food we eat and the air we breathe.[54] Even indoor air can have high concentrations of microplastics from household products and synthetic textiles, which accumulate in people's lungs after being inhaled.[55] Plastic particles have been found in tap water, beer, and sea salt, and one study even found them in 93 percent of bottled water.[56]

1 Microplastics are plastic particles that are smaller than 5 millimeters across. Microplastics are present in commercial products or form from the natural fragmentation and use of larger plastics.

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Conclusion and Recommendations

We must stop the exponential growth of plastic production. There is no solution to plastic pollution that involves the continued production of new plastic and relies on disposal strategies that have proven inadequate and harmful. Instead, it is time to take real steps to curtail the supply of plastic by banning fracking and shutting down dangerous petrochemical plants.

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