Land pollution

What's beneath your feet? Maybe a wooden floor or a stone one... and, beneath that? Brick foundations, water pipes, power cables... and who knows what else. Keep going down and you'll come to soil, rocks, and the raw stuff of Earth. We imagine these basic foundations of our planet to be a kind of pristine, internal wilderness—but often that's far from the case. While we can see many of the changes we've made to the world, some of our impacts are virtually invisible, and land pollution is a good example. You might see factory smoke rising through the air or oil slicks drifting over the ocean, but you can't easily see the poisons that seep from underground mines, the garbage we tip into landfills by the truckload, or the way the very soil that feeds us is turning slowing to dust. Land pollution, in short, is a much bigger and more subtle problem than it might appear. How does it occur and what can we do about it? Let's take a closer look!

# What is land pollution?

If you've read our articles on water pollution and air pollution, you'll know that pollution can be defined generally along these lines: it's the introduction into the environment of substances that don't normally belong there, which, in great enough concentrations, can have harmful effects on plants, animals, and humans. We can define land pollution either narrowly or broadly. Narrowly defined, it's another term for soil contamination (for example, by factory chemicals or sewage and other wastewater). In this article, we'll define it more widely to include garbage and industrial waste, agricultural pesticides and fertilizers, impacts from mining and other forms of industry, the unwanted consequences of urbanization, and the systematic destruction of soil through over-intensive agriculture; we'll take land pollution to mean any kind of long-term land damage, destruction, degradation, or loss.

# Causes of land pollution

There are many different ways of permanently changing the land, from soil contamination (poisoning by chemicals or waste) to general urbanization (the systematic creation of cities and other human settlements from greenfield, virgin land). Some, such as huge landfills or quarries, are very obvious; others, such as atmospheric deposition (where land becomes contaminated when air pollution falls onto it) are much less apparent. Let's consider the main causes and types of land pollution in turn.

## Waste disposal

Humans produce vast quantities of waste—in factories and offices, in our homes and schools, and in such unlikely places as hospitals. Even the most sophisticated waste processing plants, which use plasma torches (electrically controlled "flames" at temperatures of thousands of degrees) to turn waste into gas, produce solid waste products that have to be disposed of somehow. There's simply no getting away from waste: our ultimate fate as humans is to die and become waste products that have to be burned or buried!



Figure 1

Waste disposal didn't always mean land pollution. Before the 20th century, most of the materials people used were completely natural (produced from either plants, animals, or minerals found in the Earth) so, when they were disposed of, the waste products they generated were natural and harmless too: mostly organic (carbon-based) materials that would simply biodegrade (break down eventually into soil-like compost). There was really nothing we could put into the Earth that was more harmful than anything we'd taken from it in the first place. But during the 20th century, the development of plastics (polymers generally made in chemical plants from petroleum and other chemicals), composites (made by combining two or more other materials), and other synthetic (human-created) materials has produced a new generation of unnatural materials that the natural environment has no idea how to break down. It can take 500 years for a plastic bottle to biodegrade, for example. And while it's easy enough to recycle simple things such as cardboard boxes or steel cans, it's much harder to do the same thing with computer circuit boards made from dozens of different electronic components, themselves made from countless metals and other chemicals, all tightly bonded together and almost impossible to dismantle.

Nothing illustrates the problem of waste disposal more clearly than radioactive waste. When scientists discovered how to create energy by splitting atoms in nuclear power plants, they also created the world's hardest waste disposal problem. Nuclear plants produce toxic waste that can remain dangerously radioactive for thousands of years and, what's worse, will contaminate anything or anyone that comes into contact with it. Nuclear plants that have suffered catastrophic accidents (including the Chernobyl plant in the Ukraine, which exploded in 1986, and the Fukushima plant in Japan, which was damaged by an earthquake in 2011) are generally sealed with concrete and abandoned indefinitely. Not surprisingly, local communities object vociferously to having nuclear waste stored anywhere near them.

## Mining

Although there are many responsible mining companies, and environmental laws now tightly restrict mining in some countries, mines remain among the most obvious scars on (and under) the landscape. Surface mining (sometimes called quarrying or opencast mining) requires the removal of topsoil (the fertile layer of soil and organic matter that is particularly valuable for agriculture) to get at the valuable rocks below. Even if the destruction of topsoil is the worst that happens, it can turn a productive landscape into a barren one, which is a kind of pollution. You might think a mine would only remove things from the land, causing little or no pollution, but mining isn't so simple. Most metals, for example, occur in rocky mixtures called ores, from which the valuable elements have to be extracted by chemical, electrical, or other processes. That leaves behind waste products and the chemicals used to process them, which historically were simply dumped back on the land. Since all the waste was left in one place, the concentration of pollution often became dangerously high. When mines were completely worked out, all that was left behind was contaminated land that couldn't be used for any other purpose. Often old mines have been used as landfills, adding the insult of an inverted garbage mountain to the injury of the original damage. But at least it saved damaging more land elsewhere.



Figure 2

## Urbanization

Humans have been making permanent settlements for at least 10,000 years and, short of some major accident or natural disaster, most of the cities and towns we've created, and the infrastructure that keeps them running, will remain with us for thousands more years into the future. Not many of us would automatically classify cities and other human settlements as "land pollution"; people obviously need to live and work somewhere. Even so, urbanization marks a hugely important change to the landscape that can cause land pollution in a variety of subtle and not-so-subtle ways.

With over 7.7 billion people on the planet, it might come as a surprise to find that humans have urbanized only about 3 percent of Earth's total land surface [1], though about 30–40 percent of the total land area has been transformed if we include agriculture [2]. Our impact on the planet extends much further than urbanization might suggest. Way back in 1996, Herbert Girardet estimated that London, England has an ecological footprint (area of land needed to support it) some 125 times bigger than the city itself [3]. Add up that effect for every major city in the world and you get an idea of how big an impact urbanization has had. Today's figures are staggering. According to the Global Footprint Network, the ecological footprint of most countries (what they use) hugely exceeds their biocapacity (what they can produce): in the United States, the ecological footprint per person is 2.3 times bigger than the biocapacity; in Germany it's 2.8 times bigger; in China, 3.7 times bigger; and in India, 2.2 times bigger.



Figure 3

One of the problems of urbanization is that, by concentrating people, it concentrates their waste products at the same time. So, for example, crudely disposing of sewage from a big city automatically creates water or land pollution, where the same number of people and the same volume of sewage might not create a problem if it were created in 10 smaller cities or 100 small towns. Concentration is always a key factor when we talk about pollution. Having said that, it's important to remember that urbanization, when it works, can also help people to live very efficiently. Thus, New York has the lowest ecological footprint of any state in the USA, largely because people there have smaller homes and make greater use of public transportation.

## Agricultural chemicals

Those of us who are lucky enough to live in rich countries take our basic survival for granted: aside from trips to the grocery store, we don't worry about where our food comes from or how it gets to us. The reality is that seven billion hungry people consume a vast amount of food. Feeding the world on such a scale is only possible because agriculture now works in an industrial way, with giant machines such as tractors and combine harvesters doing the work that hundreds of people would have done in the past, and chemicals such as fertilizers and pesticides (herbicides that kill weeds and insecticides that kill bugs) increasing the amount of food that can be grown on each piece of land. Unfortunately, most pesticides are by definition poisons, and many remain in the soil or accumulate there for years. One infamous and now widely banned pesticide, DDT, is not ordinarily biodegradable so it has remained in the environment ever since it was first used in the mid-20th century and even spread to such places as Antarctica [5]. DDT is just one of many organic (carbon-based) chemicals that remain in the environment for years or decades, known as persistent organic pollutants.



Figure 4

## Atmospheric deposition

Air pollution doesn't remain air pollution forever. Ideally it disperses, so the concentration of problematic chemicals becomes so low that it no longer constitutes pollution. Sometimes, though, it falls back to the ground and becomes either water pollution (if it enters the oceans, rivers, and lakes) or land pollution. Pollution created ("deposited") in water or land from existing pollution in the air (atmosphere) is known as atmospheric deposition. Land can become polluted by deposition in some very unexpected ways. For example, a corridor of land either side of a highway or freeway becomes systematically polluted over time with all kinds of harmful byproducts of road travel—everything from fuel spills and brake linings to dust worn from the pavement and heavy metal deposits (such as lead) washed from the engines. These chemicals accumulate in the soil where they can undergo reactions with one another and form substances that are even more toxic.



Two important things are worth noting about atmospheric deposition. First, it means no land on Earth—not even the most isolated island—can be considered completely safe from pollution: even if it's hundreds or thousand miles from the nearest factory or human settlement, even if no human has ever lived there, it could still be polluted from the air. Second, if you're doing something that causes pollution (maybe spreading weed killer on your garden or perhaps running a factory where ash is discharged from a smokestack), the effects are not necessarily going to be confined to the place where the pollution is first produced. It's important to remember that pollution knows no boundaries.

# Effects of land pollution

With luck and the right atmospheric conditions, air and water pollution disperse and disappear. What makes land pollution such a problem is that land is static, so land pollution stays exactly where it is until and unless someone cleans it up. Land that's polluted stays polluted; land that's urbanized almost invariably stays urbanized. As we've already see, plastics take hundreds of years to disappear while radiation can contaminate land for ten times longer. That means landfill sites and radioactive waste dumps remain that way pretty much indefinitely.

The simplest effect of land pollution is that it takes land out of circulation. The more land we use up, the less we have remaining. That might not sound a problem where there's plenty of land in rural areas, but it's certainly a concern where productive agricultural land is concerned, especially as the world's population continues to increase. The biggest problem comes when contaminated land is returned to use, either as building or agricultural land. Houses might be built on brownfield (former industrial) sites that haven't been cleaned up properly, putting future owners and their families at risk. Or people might get their water from rivers supplied by groundwater contaminated by landfill sites, mine workings, or otherwise polluted land some distance away. Illnesses such as cancer develop over years or decades for a variety of reasons and it's extremely difficult to prove that they've been caused by something like local environmental pollution, especially when people move homes during their lifetime. No-one knows how much land is contaminated, how contamination varies from one place to another, or how land contaminants react with one another once they enter watercourses and become water pollution. So the scale of the problem and its ultimate effects are impossible to determine.

However, we do know what effect individual pollutants have. We know, for example, that lead is a toxic heavy metal that has all kinds of unpleasant effects on human health; it's been implicated in developmental deficits (such as reductions in intelligence) in children. We know that some chemicals are carcinogenic (cancer-causing) while others cause congenital defects such as heart disease. At the very least, it seems prudent not to introduce dangerous chemicals, such as persistent organic pollutants, into the environment where they may mat harm people's health for many years into the future.

# Solutions

“When you choose what to eat, what to wear or what to drive, think about how your choice impacts the land—for better or for worse.”

Why does land pollution matter? Although Earth might seem a pretty big place, only about a third of its surface is covered in land, and there are now over seven billion people trying to survive here. Most of our energy (around 85 percent worldwide) still comes from fossil fuels buried under the ground and, since we haven't yet figured out how to mine in space, so do all our minerals. Much of our food is grown on the surface of the planet; the water we need comes from the planet's surface too or from rocks buried just underground. In short, our lives are as intimately tied to the surface of Earth as the plants that grow from the ground. Anything that degrades, damages, or destroys the land ultimately has an impact on human life and may threaten our very ability to survive. That's why we need solutions to the problem.

What kind of solutions? Ideally, we'd look at every aspect of land pollution in turn and try to find a way of either stopping it or reducing it. With problems like waste disposal, solutions are relatively simple. We know that recycling that can dramatically reduce the need for sending waste to landfills; it also reduces the need for incineration, which can produce "fly ash" (toxic airborne dust) that blows may miles until it falls back to land or water. We'll always need mines but, again, recycling of old materials can reduce our need for new ones. In some countries, it's now commonplace to require mine operators to clean-up mines and restore the landscape after they've finished working them; sometimes mine owners even have to file financial bonds to ensure they have the money in place to do this. Greater interest in organic food and farming might, one day, lead to a reduction in the use of harmful agricultural chemicals, but that's unlikely to happen anytime soon. Even so, public concerns about food and chemical safety have led to the withdrawal of the more harmful pesticides—in some countries, at least. Meanwhile, international efforts, such as the United Nations Convention to Combat Desertification (UNCCD), are helping to focus attention on major problems like soil erosion.

Ideally, we don't just need to stop polluting land: we also need to clean up the many contaminated sites that already exist. Many former nuclear sites have already been cleaned up as much as possible; in the UK, for example, the Nuclear Decommissioning Authority is currently spending around £117 billion ($146,000 million) to clean up 17 former nuclear sites—and the figure keeps on rising. In the United States, a program called the Superfund has been decontaminating hundreds of polluted sites since 1980. Where sites can't be completely restored, it's possible to "recycle" them and benefit the environment in other ways; for example, a number of contaminated sites and former mines in the United States have now become wind farms or sites for large areas of solar panels.

New technologies will almost certainly make it easier to "recycle" polluted land in future. For example, the relatively new form of waste disposal called plasma gasification makes it possible to "mine" former landfills, converting the old waste into an energy-rich gas and a relatively safe solid waste that can be used as a building material. Bioremediation is another very promising land-cleaning technology, in which microbes of various kinds eat and digest waste and turn it into safer end-products; phytoremediation is a similar concept but involves using plants, such as willow trees, to pull contaminants from the soil.

All these things offer hope for a better future—a future where we value the environment more, damage the land less—and realize, finally, that Earth itself is a limited and precious resource.

# Bibliography

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