PLASTIC ATLAS

Facts and figures about the world of synthetic polymers

2019

HEINRICH BÖLL STIFTUNG

#breakfreefromplastic

IMPRINT

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Executive editors:
Lili Fuhr, Heinrich Böll Foundation
Matthew Franklin, Break Free From Plastic

Managing editor: Kai Schächtele
Art direction and infographics: Janine Sack, Sabine Hecher, Lena Appenzeller
Project management: Kristin Funke, Annette Kraus
English editor: Paul Mundy
Proofreader: Maria Lanman
Research editor: Alice Boit

Contributors: Claire Arkin, David Azoulay, Alexandra Caterbow, Christine Chemnitz, Camille Duran, Marcus Eriksen, Steven Feit, Manuel Fernandez, Chris Flood, Lili Fuhr, Elisabeth Grimberg, Stephan Gürtler, Lea Guerrero, Johanna Hausmann, Von Hernandez, Ulrike Kallee, Christie Keith, Doris Knoblauch, Christoph Lauwigi, Linda Mederake, Doun Moun, Carroll Muffett, Jane Patton, Christian Rehmer, Kai Schächtele, Dorothea Seeger, Olga Speranskaya, Esra Tat, Nadja Ziebarth

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Editorial responsibility (V. i. S. d. P.): Annette Maennel, Heinrich Böll Foundation

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INTRODUCTION

At this point in modern life, we touch plastic more than we touch our loved ones. Plastic is everywhere; it is in our air, our water, and in our soils. It is the vehicle for globalization, and the epitome of unregulated late stage capitalism—a system that externalizes costs to people and the environment for the sake of profit. Even for the conscious citizen, plastic is almost unavoidable and successfully living plastic-free requires a certain amount of access and privilege enjoyed by very few in the world.

We are only just beginning to understand the effects of our global reliance on this material. What makes plastic useful is exactly what makes it harmful: it persists. It is designed to fool nature itself, made from molecular chains that are too resilient to biodegrade in a meaningful timeframe. Indeed, plastic degradation has adverse effects on nature itself and mankind. No matter where scientists go looking for plastic, they find it—at the farthest reaches of the earth. It is not just ubiquitous in the environment but also in our own bodies.

We as a species are contaminated with plastic, and not just indirectly by eating fish that have ingested plastic. Plastic pollutes at every stage of its lifecycle from when the oil and gas is extracted to produce it, all the way to the end-of-life where plastic waste is littered, landfilled, downcycled, burned.

Plastic use and production has accelerated at breakneck speed, with more than half of all plastics having been manufactured after 2005. The market is controlled by a few major multi-national corporations that are collectively investing over 200 billion US dollars in additional capacity to produce even more petrochemicals, the majority of which will become plastic. Capitalizing on shale gas from the United States, their plan is to build out more than 300 new production facilities or expansions, in hopes of adding 40 percent more plastic to commerce by 2025. The supply for plastic far outweighs the demand.

However, plastics and petrochemical companies are increasingly nervous about the growing war on plastics. And although some

companies are beginning to at least acknowledge their responsibility for this pollution, they still maintain, aggressively and publicly that the consumer is at fault for plastic pollution.

This is at odds with reality. Fact is, consumer brands are aggressively opening markets in new regions—Asia, Africa, South America fully aware that in most regions the waste infrastructure and recycling systems lag far behind most countries in the global north. Now a movement of 1,500 civil society groups is working together under the banner of Break Free From Plastic across all geographies to stop plastic pollution for good.

Break Free From Plastic and the Heinrich Böll Foundation are proud to be launching this first international English version of the Plastic Atlas together. The Plastic Atlas has the hard facts, data and figures to prove that the story of plastic that industry is telling us is a myth. We need urgent and drastic reductions in plastic production and consumption and regulation at the local, national and global level that tackle plastic pollution at the source. Solutions to the plastic crisis need to focus on preventing more plastic from entering the market and on implementing and supporting zero waste communities and cities, alternative delivery systems and reusable products. Governments need to hold companies accountable that are currently contributing to and profiting from the plastic crisis. And citizens need to demand real action and solutions from their policy makers to keep our ecosystems and bodies free from plastics and their toxic additives.

Citizens need to demand real action from policy makers to keep our ecosystems and bodies free from plastic.

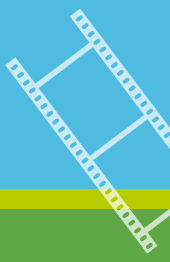
Barbara Unmüßig
President, Heinrich Böll Foundation

Stiv Wilson
Executive Producer, The Story of Plastic, Member of the international Steering Committee of Break Free From Plastic

12 BRIEF LESSONS

ON PLASTIC AND THE PLANET

1 The massive expansion of plastic began in the second half of the 20th century, with the discovery that a **WASTE PRODUCT FROM THE PETROCHEMICAL INDUSTRY** could be used to make PVC.



2 Between 1950 and 2017 a total of **9.2 BILLION TONNES OF PLASTIC** were produced. That is more than one tonne for each person now living on Earth. The biggest share consists of single-use products and packaging. Less than ten percent of all plastic ever produced has been recycled.

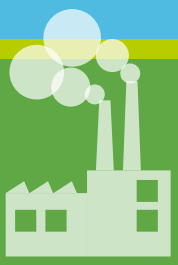
3 In 1978, Coca-Cola first decided to replace its iconic glass bottles with plastic ones. Now, **DISPOSABLE CUPS, PLASTIC PLATES AND OTHER UTENSILS** have become an indispensable part of our fast-paced daily lives.

4 Plastic generates many **HEALTH RISKS**. An array of chemicals is added to the base plastic to give it desirable characteristics. But these chemicals are hazardous to health, and they accumulate in indoor air and house dust.

5 Plastic waste and microplastics floating in the world's oceans are a much-discussed problem. But few realize that **PLASTIC POLLUTION OF THE SOIL** can be between 4 and 23 times higher than in the seas.

6 In 2018, over **1.13 TRILLION ITEMS OF PACKAGING** —most of them plastic—were used for food and drinks in the EU alone. Packaging is not the only problem: agriculture uses around 6.5 million tonnes of plastic worldwide each year.

7 We wear plastic. Polyester and other synthetic fibers are made from petroleum or natural gas. Making a **POLYESTER SHIRT** may emit between **3.8 AND 7.1 KILOGRAMS OF CO_2**.



8 Plastic fuels climate change. If current trends continue, plastics will have caused around 56 gigatonnes of CO_2 emissions by 2050. In other words: making plastic could cost **10 TO 13 PERCENT OF THE REMAINING CARBON BUDGET** to keep global warming below 1.5 degrees Celsius.

9 A handful of multinationals control the global market for plastic, which is flooded by **CHEAP FRACKED GAS** from the USA. Ineos, Europe's biggest plastics producer, is investing billions to import feedstock from the USA to make plastics in Europe.

10 For decades, the plastics industry has resisted efforts to limit plastic production and the damage it causes. It invests billions of dollars and pays armies of lobbyists to win subsidies, prevent regulation and **SHIFT THE BLAME** to consumers and poor countries in Asia.

11 In 2018, China banned the import of plastic waste. Other countries also refusing to act as the world's garbage bin and are sending waste back. The four **BIGGEST EXPORTERS** are the USA, Japan, Germany and the UK.

12 The global **BREAK FREE FROM PLASTIC** movement holds consumer-goods companies and plastic producers accountable for the waste they generate and champions zero waste communities and lifestyles. Over 1,500 organizations and thousands of individuals have joined this movement.

BREAKTHROUGH IN THREE LETTERS

The first plastics imitated ivory and silk and attracted just a limited market. Things took off after World War II with the rise of PVC. Cheap plastics soon conquered the world.

Plastics are part of the everyday life of billions of people and are used extensively in industry. Over 400 million tonnes are produced globally every year. But what exactly is plastic? The word refers to a group of synthetic materials made from hydrocarbons. They are formed by polymerization: a series of chemical reactions on organic (carbon-containing) raw materials, mainly natural gas and crude oil. Various types of polymerization make it possible to produce plastics with particular properties: hard or soft, opaque or transparent, flexible or stiff.

The first plastic was presented at the Great London Exposition in 1862. Called "Parkesine" after its inventor, Alexander Parkes, who made it from cellulose, this organic material could be shaped when it was heated and retained its shape on cooling. A few years later, John Wesley Hyatt developed celluloid, transforming nitrocellulose into a deformable plastic by treating it with heat and pressure and adding camphor and alcohol. It replaced ivory and tortoiseshell in billiard balls and combs, and was destined for a bright future in the film industry and photography. In 1884, the chemist Hilaire de Chardonnet patented a synthetic fiber known as "Chardonnet silk." Its successor, rayon or viscose, is a semisynthetic plastic made from chemically treated cellulose—which is cheaper than natural fibers such as silk.

This and other early plastics were made from natural raw materials. It would take another 40 years before a completely synthetic plastic was developed. In 1907, Leo Hendrik Baekeland improved on phenol-formaldehyde reaction techniques and invented Bakelite, the first plastic that contained no naturally occurring molecules. Bakelite was marketed as a good insulator and a durable and heat-resistant material.

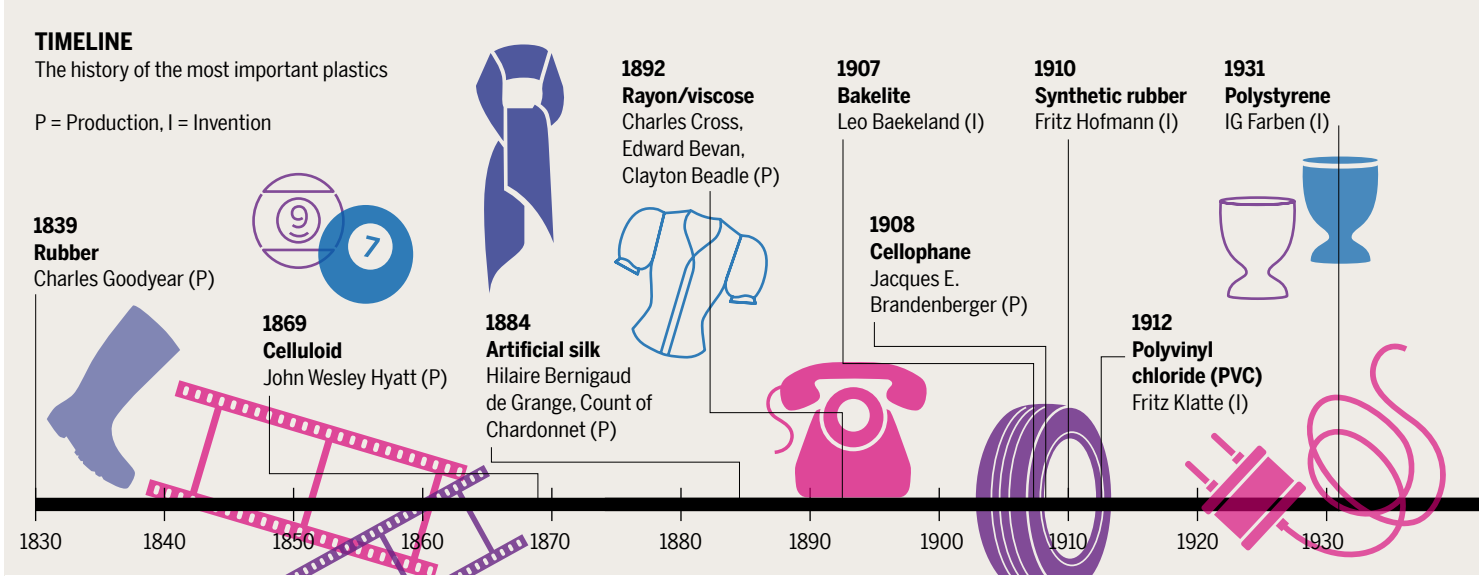
Five years later, Fritz Klatte patented a material known as polyvinyl chloride, better known as PVC, or vinyl. Until the middle of the 20th century, plastics occupied a relatively small market niche. The trigger for the mass spread of PVC was the discovery that it could be made from a waste product of the petrochemicals industry. The chlorine resulting from the production of sodium hydroxide (caustic soda) could be used as a cheap feedstock.

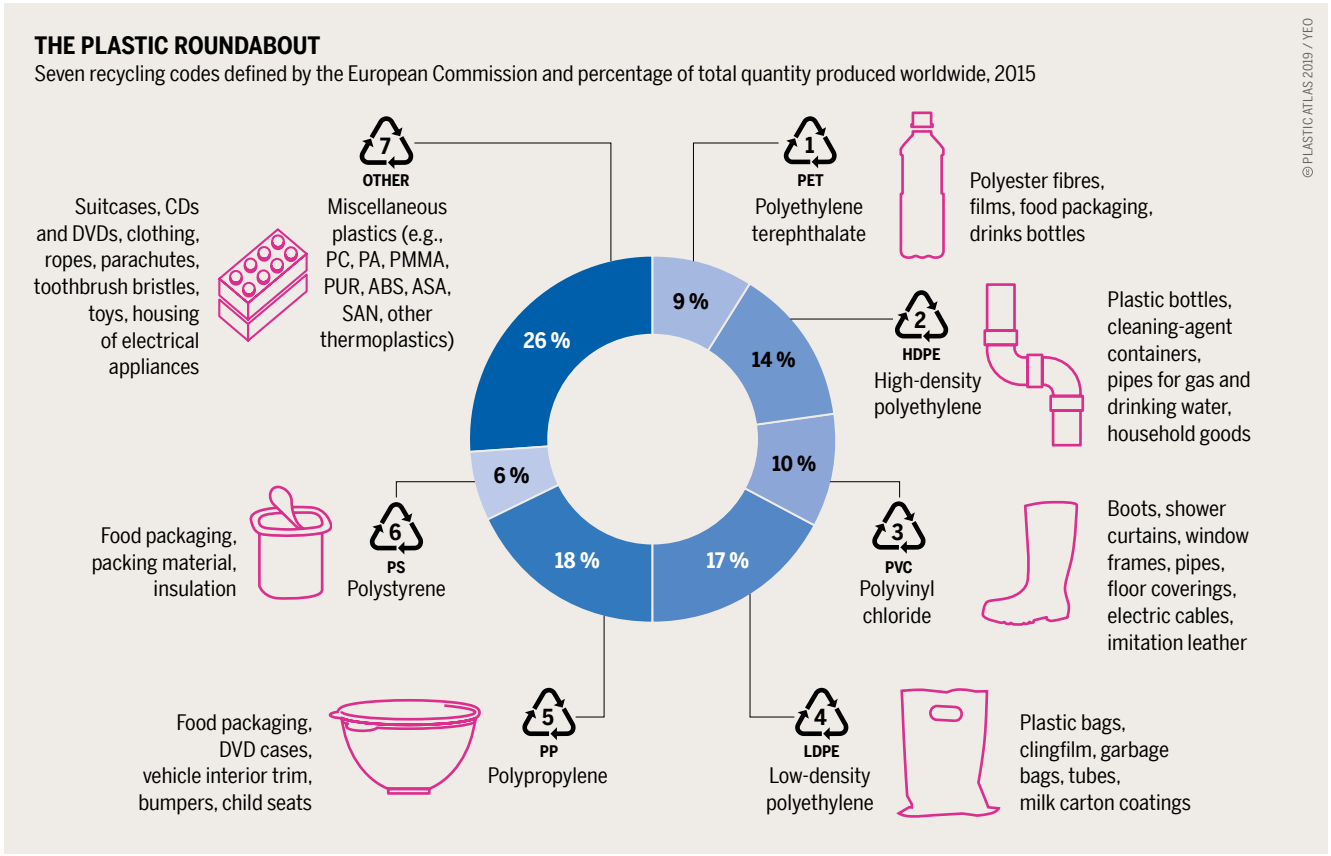
This marked the start of the rapid and uninterrupted rise of PVC. In World War II, demand rose significantly because it was used to insulate cables on navy ships. Although it was increasingly known that PVC production harmed both the environment and human health, the petrochemicals industry took advantage of the new possibilities to turn a waste product into profit. PVC has since become the most important plastic in a wide range of household and industrial products.

Alongside PVC, polyethylene has also gained acceptance. Invented in the 1930s, it is used to make drink bottles, shopping bags and food containers. The chemist Giulio Natta developed polypropylene, a plastic with similar properties to polyethylene. Gaining popularity in the 1950s, it is today used for a range of everyday products such as packaging, child seats and pipes.

At the time, the positive image of plastics contributed to the boom in their use. Plastics were seen as trendy, clean and modern. They squeezed out existing products and muscled their way into almost all areas of life. Today, PVC,

The most important types of plastics were invented between 1850 and 1950. They have been refined, often by mixing them with toxic additives.



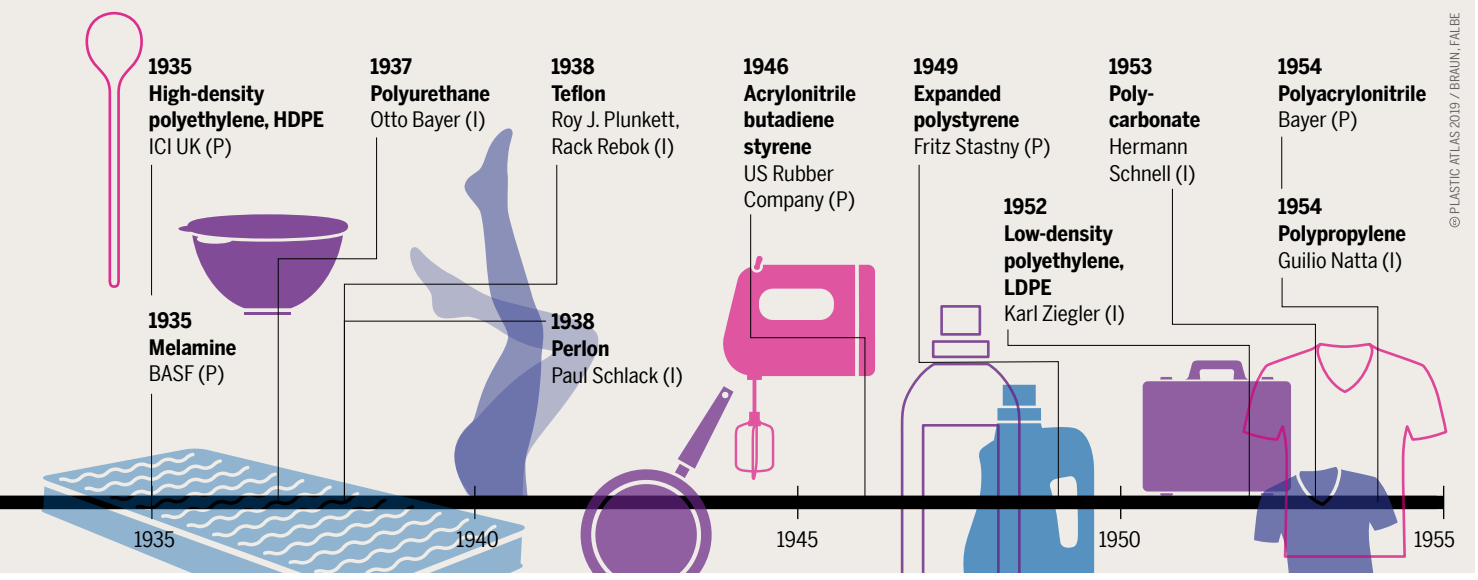


In 2015, 407 million tonnes of plastics were produced worldwide. In theory, all should be recycled. Reality is rather different.

polyethylene and polypropylene are the most widely used plastics in the world.

To improve their properties, plastics are often mixed with chemical additives such as plasticizers, fire-retardants and dyes. Many of these additives make the material more flexible or durable. But they may damage both the environment and health. They can escape from the material and enter the water or air, ending up in our food. They can also be released when plastic is recycled.

A new generation of plastics can be made from biopolymers such as maize starch. For example, a completely new production process has made it possible to make a biodegradable plastic from the shells of shrimp and other crustaceans. This modifies chitin from the shells to make a polymer called chitosan. The developers at McGill University in Canada hope for a bright future based on the 6–8 million tonnes of crustacean waste produced every year. This and other plastics based on natural raw materials are already being used to make drinking straws, disposable plates and cups, plastic bags and food packaging. But it is doubtful whether they can contribute to solving the plastic crisis.



WHY THE WORLD IS WALLOWING IN WASTE

Until the 1950s, people treated plastic with the same respect as they did glass or silk. Then consumer-goods companies discovered the advantages of polymers. A lifestyle emerged that generates increasing amounts of trash.

Once upon a time, things were made to last, and very little was thrown away. Food and drinks came in bulk. Packaging and bottles could be reused or returned. The greengrocer sold loose vegetables, and the butcher wrapped meat in greaseproof paper. Milk came in returnable glass bottles, delivered to the doorstep. Other bottles were washed and reused—or melted down to make new bottles. The pharmacist counted out tablets into a screw-top jar. Now all these items come cocooned in cellophane or encased in PET.

Right after World War II, as plastic was becoming mainstream, people reused it and treated it carefully, as they did with other materials and types of packaging. But in the late 1950s, the economy started to be driven by the need to consume ever-increasing quantities of resources. Manufacturers welcomed the chance to save money and simplify their supply chains, planting the seed of the throwaway culture. By the early 1960s, billions of plastic items were filling dumps, landfills and incinerators in the western world. The shift to throwaway packaging was gradual, until the late 1970s when it took hold globally. In 1978, Coca-Cola introduced a single-use plastic PET bottle to replace its iconic glass one. This shift symbolizes the beginning of a new era for consumer drinks.

By the mid-1980s, the belief that recycling would solve the growing problem of single-use plastics was widespread in the western world, and by the end of the decade, almost all refillable soda and milk bottles had disappeared, replaced by the plastic throwaway. This one-way supply chain approach helped food and beverage producers to consolidate distant new markets, just as developing countries were starting to follow the development model pioneered in the Western world. A throwaway lifestyle was a sign of modernity.

Towards the end of the 20th century, life got even busier. Employment levels rose as more women entered the workforce. Cities grew bigger and the numbers of commuters swelled. Expectations of leisure rose. Families (especially women) had even less time for cooking, gardening or housework. Freezers and microwaves made it possible to replace home-cooked meals prepared from fresh ingredients with precooked "TV dinners" bought from the supermarket.

This "convenience lifestyle" was made possible by single-use plastic. Plastic straws, single-use plastic bags, polystyrene plates and polypropylene utensils for takeaway food form the material basis of daily life. Everything can be acquired quickly, is easy to consume—and what is left can be simply dumped in the bin. Single-use products have become the symbol of the lifestyle in a capitalist economy. Such a lifestyle is both a cause and a consequence of the density and speed of modern life.

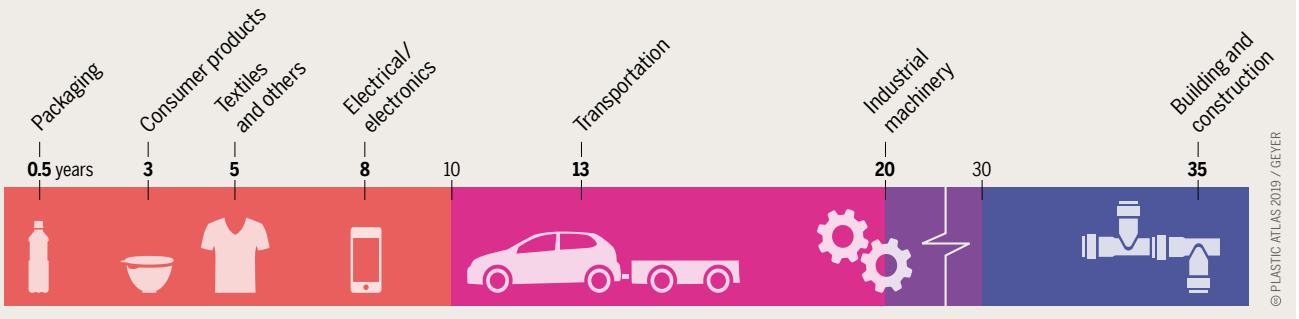
Such attitudes are reflected in the core of popular culture, such as in sport and music events and in Hollywood. Single-use plastics have made their way onto screens of all sizes: college parties heave with plastic cutlery, and television heroes make their way to work grasping a cup of takeaway coffee. Such images spread across the globe. In poorer regions, plastic throwaway items are seen as prestigious and are used en masse. Corporations actively encourage and support such trends.

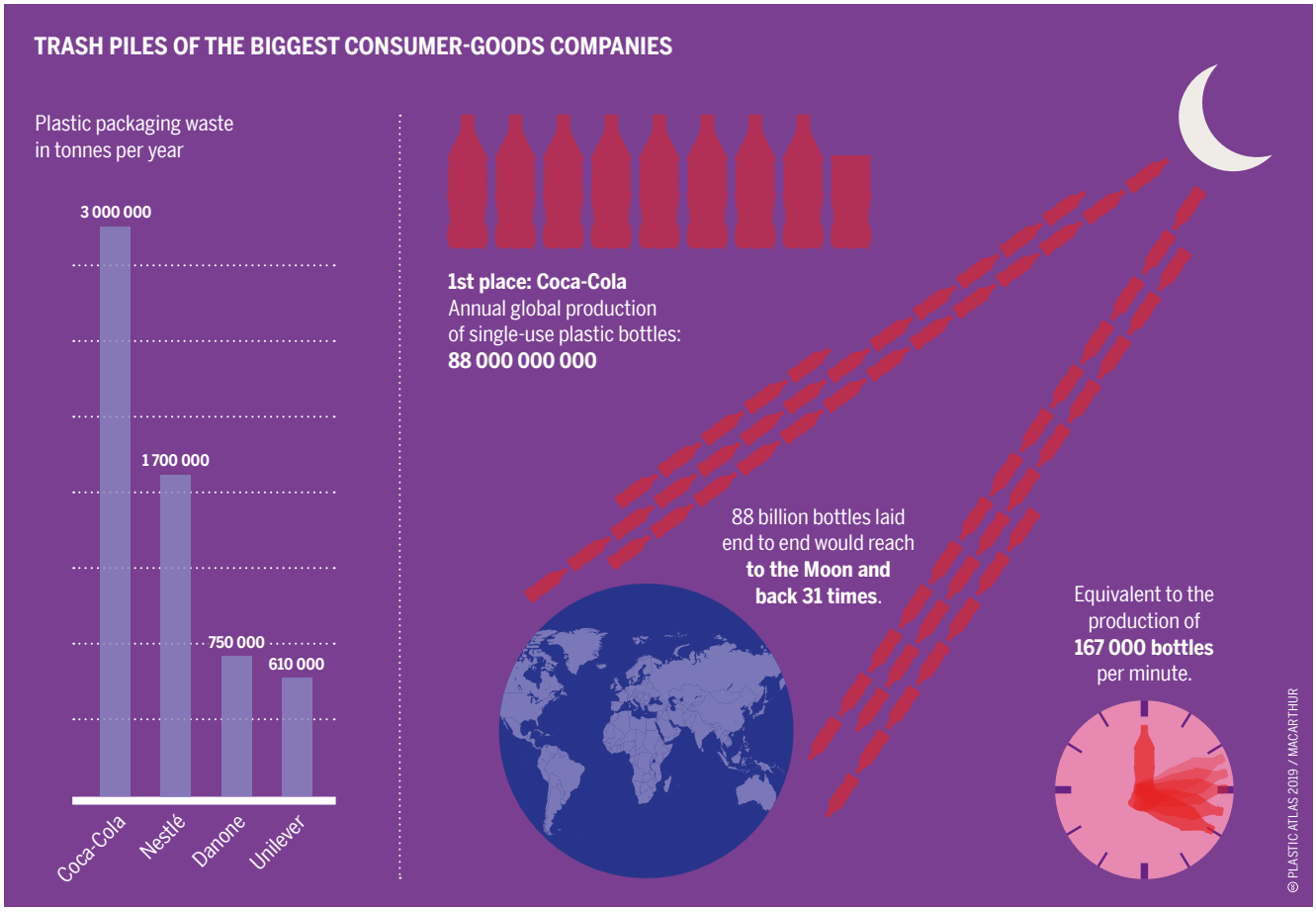
Festivals and other mega-events generate lorryloads of trash that can only be incinerated or landfilled. But this has triggered a rethink among some organizers of such events.

Not all plastic is created equal. Some items have a lifetime measured in decades. But packaging makes up the largest share and typically has a very short useful life.

LIFE IS SHORT

Average useful life of various plastic items, by industrial sector, in years



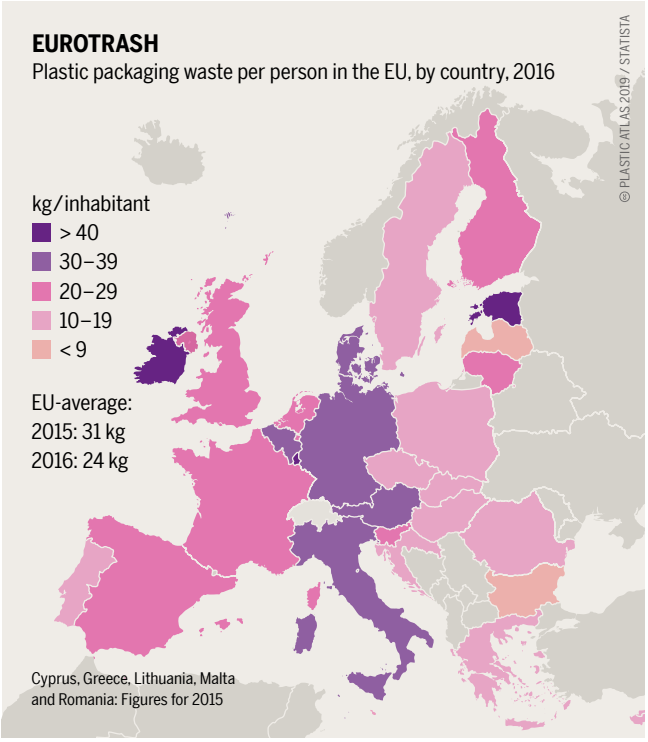


In 2019, along with 31 other companies, Coca-Cola published its plastic figures for the first time. The data show how much waste is generated by relatively few firms.

Some now charge a deposit for cups, which customers must return to get a refund. Food is increasingly served on compostable plates. More and more suppliers of takeaway food and drink are offering their customers a rebate if they bring their own reusable containers. But the throwaway mentality is still dominant, because it makes certain aspects of life that little bit easier. The costs that are incurred by waste are not included in the price of the product.

The specific mechanisms differ from one country to another. In many developing countries, a decisive factor was that consumer-products giants such as Proctor & Gamble supply their products in sachets: to gain market share, shampoo, detergent and ketchup are sold in small, sealed plastic envelopes. The suppliers argue that this makes it possible for low-income consumers to afford such products. But the result is yet more trash.

The disastrous aspect is that such mini-portions embody a drastic mismatch between the amount of packaging needed per unit of product, while at the same time boosting consumption. That is a catastrophe in places where drinking water supplies are inadequate and people resort to buying plastic bottles of water. Without a functioning waste disposal system, they drown in a flood of plastic trash. The producers offer no solutions for disposing of or recycling the packaging. Litter from convenience items has grown to be a massive problem in many cities in the developing world. For there is no incentive to collect them, and no way to dispose of them in an environmentally responsible way.



Luxembourg, Ireland and Estonia are Europe's leaders in chucking out plastic packaging. Good to see: the downward trend from 2015 to 2016.

BLESSING AND CURSE

Plastics have become indispensable. They are found in bags, smartphones and car dashboards. But almost half of all plastic products end up as waste within less than a month. Only a fraction is recycled.

Between 1950 and 2017, some 9.2 billion tonnes of plastic were produced. That is more than a tonne per person alive on Earth today. But the majority of plastic is produced and consumed in four main regions: Northeast Asia, North America, the Middle East and Western Europe.

Plastic is durable, lightweight and easily shaped. These properties make it ideal for many industrial products and everyday items. But contrary to the original idea of positioning plastic as a high-quality material, it is today used mainly for packaging and single-use products. Many items in everyday use are used just once, and usually only for a short time—and then land in the trash. The properties of plastics are both a blessing and a curse: they are very resistant. That is precisely why they degrade extremely slowly.

For various reasons, plastics are especially popular as packaging for food and other products. They retain their characteristics at both high and low temperatures. They may be either flexible or stiff, depending on their composition. Low-density polyethylene (LDPE), for example, is tough, flexible and transparent, and is therefore used to make films.

PET, on the other hand, is impermeable to both gases and liquids, and is the base material for making drink bottles. Polypropylene has a high melting point and is chemically resistant, making it attractive for use with hot liquids. Polystyrene may be stiff, brittle and clear, or made into a foam, making it a versatile material for protective packaging and food containers. And polyvinyl chloride, or PVC, can be used to make rigid or flexible packaging from which neither oxygen nor water can escape.

Plastic is finding an increasing number of uses in the construction sector, for example as floor coverings, doors, windows and pipes. These materials have a long service life, are flexible and resistant against mould and corrosion, and they have a firm consistency. Compared to other materials they are easy to install and maintain. They also protect against cold and heat, and thereby contribute to saving energy.

The plastic most commonly used in construction is PVC. Just as in the food sector, plastics enjoy several advantages for building: their durability and mechanical rigidity on one hand, and their light weight on the other. Pipes made from high-density polyethylene (HDPE) are watertight, resistant to environmental influences, and do not rust. They are also flexible, allowing them to be bent and threaded through existing ducts.

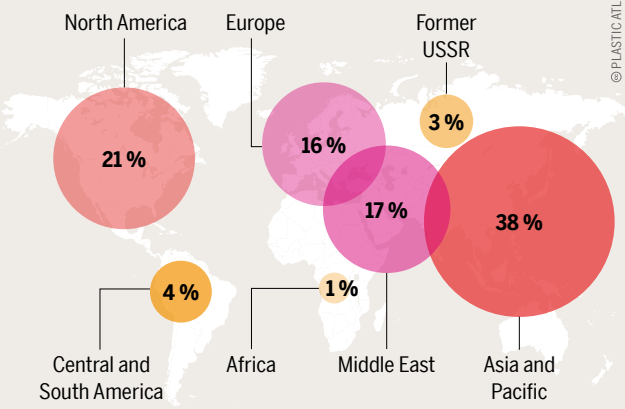
Plastic has become indispensable, too, in building vehicles and aircraft, trains and ships. This is because they are durable and lightweight, as well as flexible and recyclable. Plastic parts require little maintenance and are flexible enough to withstand permanent vibration. Without plastics, none of today's cars would be on the road. Most plastics are to be found in the bumpers, interior trim, seats, upholstery, electronics and dashboard. As the demand rises for lighter ships with lower fuel consumption, shipbuilding is using more fiber-reinforced plastics such as glass or carbon fiber. Such materials do not rust, and seawater does not affect them. That extends the maintenance intervals and lowers the vessels' operating costs.

In the aerospace industry, the materials used must tolerate temperature extremes, be immune to corrosion, and withstand jet fuels and chemicals. Plastics such as PVC, acrylic and polyamide have become essential in the construction of aircraft and spacecraft, for example for dashboard surfaces, partition walls, drinks trolleys, toilets, baggage containers and tank caps. Since the 1970s, the use of plastics in aircrafts has risen from four to around 50 percent.

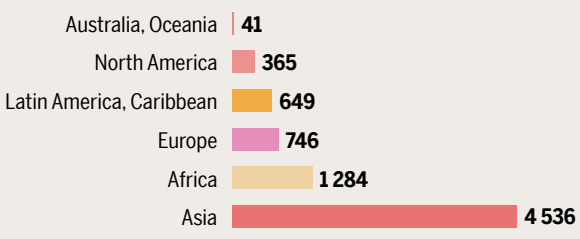
The rising demand for plastics has inevitably led to problems in waste disposal. According to current estimates, some

A WORLD FULL OF PLASTIC

Distribution of the production of single-use plastic articles, by region, 2014



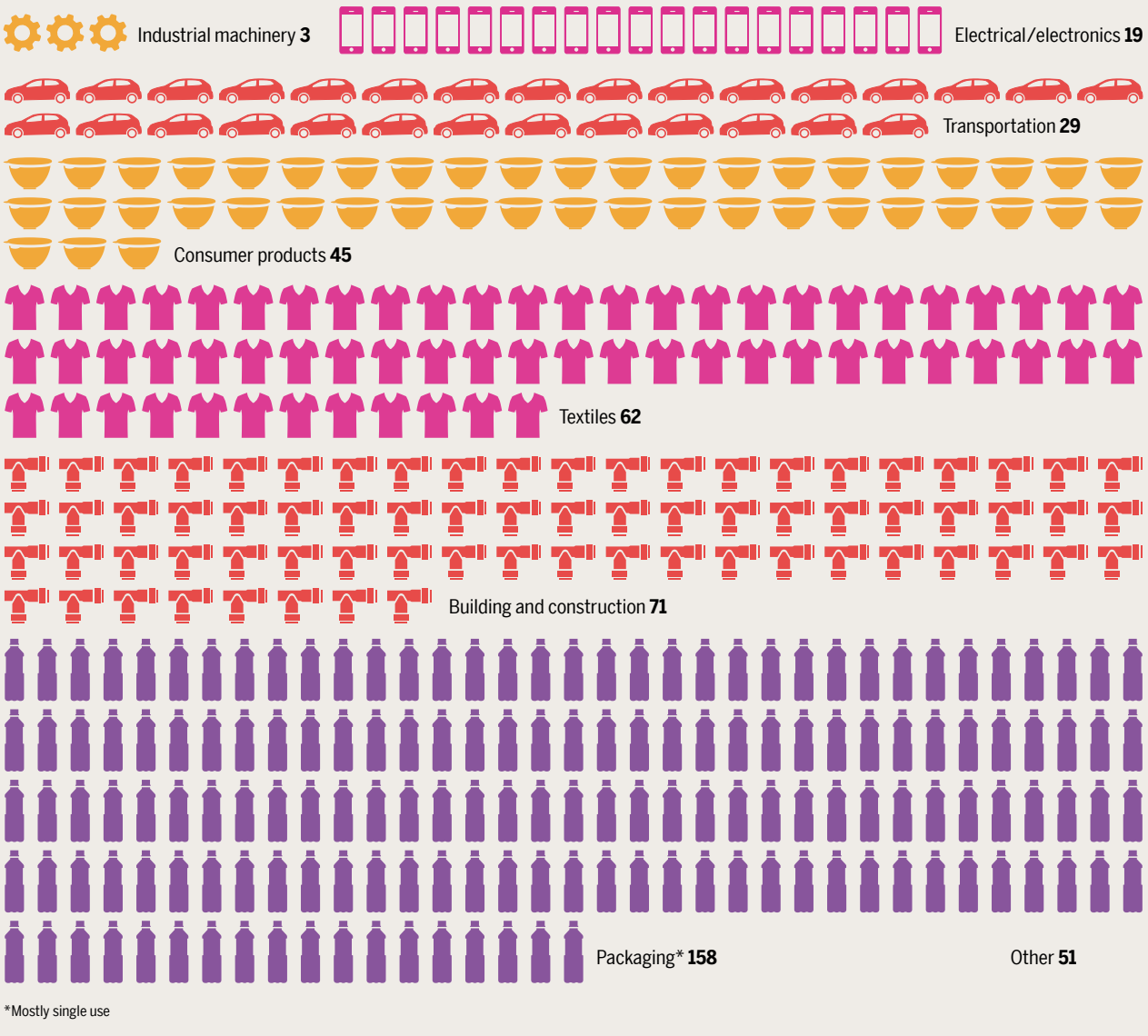
World population by continent, millions, 2018



Single-use plastics have become an icon of the global plastic crisis. Their production is limited to a few regions of the world.

WHAT DO WE USE PLASTIC FOR?

Usage by industrial sector, total volume 438 million tonnes, each symbol represents 1 million tonnes, 2017



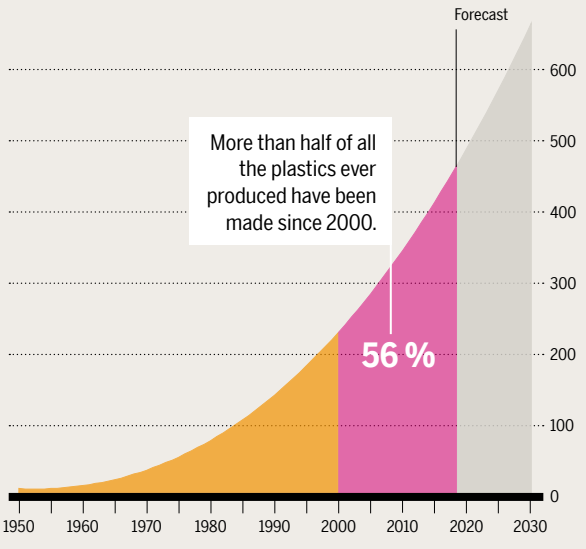
Worldwide, over 400 million tonnes of plastics are produced each year. Packaging accounts for more than a third of all plastics produced.

40 percent of plastic products are garbage after less than a month. This constantly growing mountain of plastic waste causes serious environmental problems. And recycling is only the second-best option to reduce it. In 2025, plastic production is expected to reach over 600 million tonnes per year. Current recycling systems cannot cope with such volumes of waste. A glance into history shows this: only ten percent of the more than nine billion tonnes of plastics that have been produced since the 1950s have been recycled. The best solution is easy to state but is hotly contested: just don't produce so much plastic in the first place.

Since 2000, more plastics have been produced than in the 50 years before. The output of plastics continues to explode.

PLASTIC PLANET

Global plastic production in million tonnes



FOOD CHEMISTRY

The effects of runaway plastic production on the environment can no longer be ignored. Its consequences for human health are less well known—from the extraction of raw materials through to waste disposal.

Most plastic items begin life as petroleum or natural gas. When the oil or gas is being extracted from the ground, especially through the controversial fracking technique, toxic substances are released into the air and water. Over 170 substances used in fracking are known to cause cancer, reproductive and developmental disorders, or damage to the immune system. People living near fracking wells are especially affected by these substances, and by pollution from the large number of diesel trucks used for transport in such areas. Up to 6,000 truckloads of equipment, water and chemicals are needed to develop a fracking field. Research in the United States indicates that expectant mothers who live near fracking sites have an enhanced risk of pregnancy complications and premature births.

Turning oil into plastic means refining it and splitting it into smaller molecules. These are then combined into polymers with longer chains by mixing them with chemicals and applying heat and pressure. Various additives are added to give the material the desired characteristics. Plasticizers turn rigid PVC into the flexible film that forms paddling pools, for example. Fluorinated compounds are used to impregnate weatherproof jackets. Brominated substances serve as flame retardants in electrical appliances and furniture. On average, plastic products contain about seven percent of such additives. For a ball made from PVC, plasticizers may make up to 70 percent of its total weight.

Many of these additives are harmful to health. They gradually escape and accumulate in food, indoor air and household dust. A US study suggests that younger children who always eat school lunches are more exposed to phthalates, a plasticizer used in food containers, than those who never do so. A study of the blood of pregnant Americans detected an average of 56 different industrial chemicals, many originating from plastic products or the processes used to make them. Still other compounds may have been present that were not being looked for. Research in Germany has found that children are especially exposed to plasticizers that may harm their reproductive health. In relation to their body weight, children breathe in more air and have a higher metabolic rate than adults. They are nearer the ground, often play on the floor, and are exposed to more pollutants.

Of particular concern are substances that are endocrine disruptors—a group that includes many plasticizers. These compounds mimic naturally occurring hormones and upset the body's finely balanced endocrine system. A multitude of diseases and disorders are associated with hormonally active substances. These include breast cancer, infertility, premature puberty, obesity, allergies and diabetes.

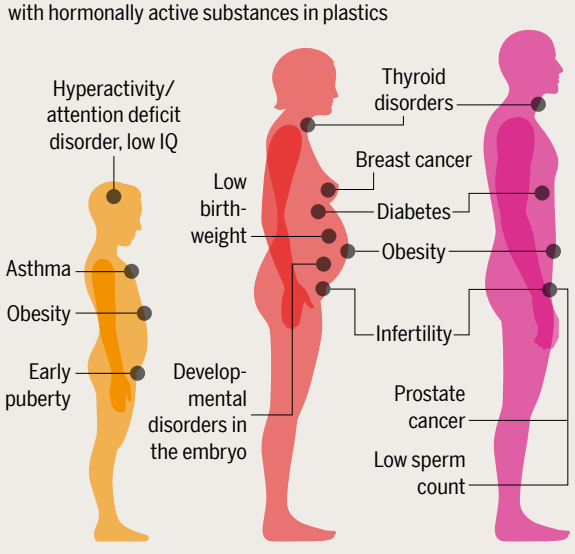
No-one knows the full extent of the chemicals we are exposed to in consumer goods. For consumers it is virtually impossible to identify risky chemicals that products contain. Most retailers have no idea what is in the products they sell: the information simply gets lost on the way through a long and winding supply chain or is often deliberately hidden by manufacturers because it is "confidential business information." There is an urgent need for publicly available information on the use of chemicals in plastics, and on the exact chemical composition of finished plastic products.

The circular economy would benefit from transparency. Industry currently reuses materials that have not been optimized for human and environmental health, turning them into items such as toys and food containers that may be highly contaminated. Research by environmental organizations from 19 European countries found that one in every four products made from recycled plastic contains flame-retardants hazardous to health. The toxins in recycled items come mainly from recycled electrical waste. Recycling is particularly harmful to those who dismantle contaminated materials. The toxic cycle could be broken if producers were made responsible for waste disposal. A general principle is that what goes in at one end comes out at the other. Using toxic materials in plastic should be avoided altogether.

From a global point of view, the recycling of plastics plays only a minor role. There is currently no such thing as plastic recycling, only open-loop recycling or downcycling. Every time a piece of plastic is recycled, it degrades

INVISIBLE DANGER

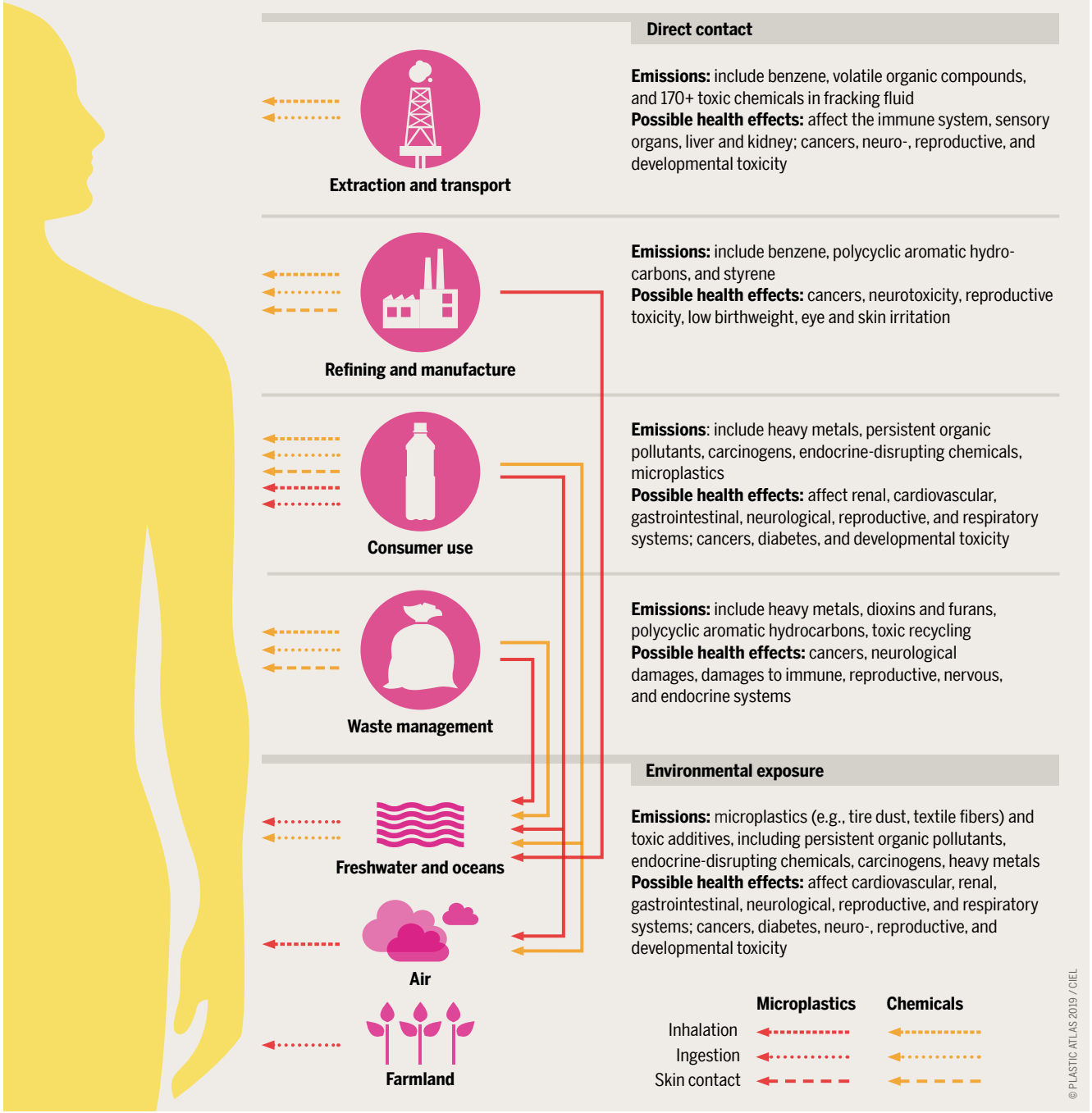
Possible health consequences of day-to-day contact with hormonally active substances in plastics



Many of the chemicals in plastic have an effect on human health. The consequences may be both serious and long-term.

NO WAY TO AVOID IT

We are exposed to toxic chemicals and microplastics at all stages in the plastics life cycle. The pollutants can get into our bodies in many ways.



Even if you try to avoid coming into contact with plastics, you will still be exposed to them. The body has no mechanism to protect itself.

in quality. Plastic can be recycled only a certain number of times before it ends up in the landfill or the incinerator. So what we call plastic recycling actually means merely postponing the final disposal.

In the struggle to manage the ever-increasing amount of plastic waste, cities and governments are turning to incineration. But this merely shifts the problem somewhere else. Emissions associated with incineration include dioxins and metals such as mercury, lead and cadmium. Workers and nearby communities are particularly affected, but the toxins can also travel long distances and be deposited on the soil and in water far away. Plus, incinerating plastics produces highly toxic by-products, which end up in ash or sludge and create a new waste disposal problem. This material can end up in landfills, caves, farmland and wetlands, creating a long-term threat to environment and health. Open burning is even more problematic: this is frequently done in developing countries and rural areas that have no access to organized waste management. Addressing the health impacts of plastic production, use and disposal will require actions along the whole supply chain. One thing is clear: transparency will be the key to success.

OVEREXPOSED

Women are more affected than men by plastics. Biological reasons are part of the problem: their bodies react in different ways to toxins, and the hygiene products that women use are often contaminated. But alternatives do exist.

The toxins contained in plastics have different effects on men and women, both in the workplace and in everyday life. This is partly due to biology—the differences in body size and the proportion of fatty tissue—but it is also due to the gender roles that women find themselves filling.

Women's bodies contain more fat than men's, and therefore accumulate more oil-soluble chemicals such as phthalate plasticizers. The female body is especially sensitive to toxins during life phases such as puberty, pregnancy, lactation and menopause.

During pregnancy, this can have serious consequences for the unborn child. Chemicals that function in a similar way to hormones—known as endocrine disruptors—are problematic. Because the placenta is not a secure barrier, these compounds may disturb all the developmental phases in the womb that are controlled by hormones. That can lead to malformations in newborns, as well as diseases that appear much later in life.

Endocrine disruptors affect both men and women to the same degree. The World Health Organization suspects that they are responsible for hormone-related forms of cancer such as breast and testicular cancer. It also seems possible that they affect fertility and sperm quality. Endocrine disruptors may also contribute to obesity, diabetes, neurological diseases, premature onset of puberty, and congenital malformations such as cryptorchidism (absence of one or both testes from the scrotum) and hypospadias (malformation of the male urethra). Increasing numbers of children are being born who have been exposed to harmful substances.

Women come into contact with the dangers of plastics in many different places. Some 30 percent of the workers in the plastics industry worldwide are women. So cheap plastic items can be mass-produced for the global market, women in developing countries are commonly employed in industrial production plants at low wages, very often in hazardous conditions and without protective clothing. A Canadian study found that women who handle plastics in the car industry are five times more likely to develop breast cancer.

Feminine hygiene products may also be problematic. Tampons may comprise up to six percent plastic, and sanitary pads consist of up to 90 percent petroleum-based plastic. Both may contain the hormonally active compounds bisphenol A (BPA) and bisphenol S (BPS). Tampon applicators also often contain phthalates. In the USA, a woman may use between 12,000 and 15,000 of these items in her lifetime. Alternatives include washable reusable products and reusable menstrual cups.

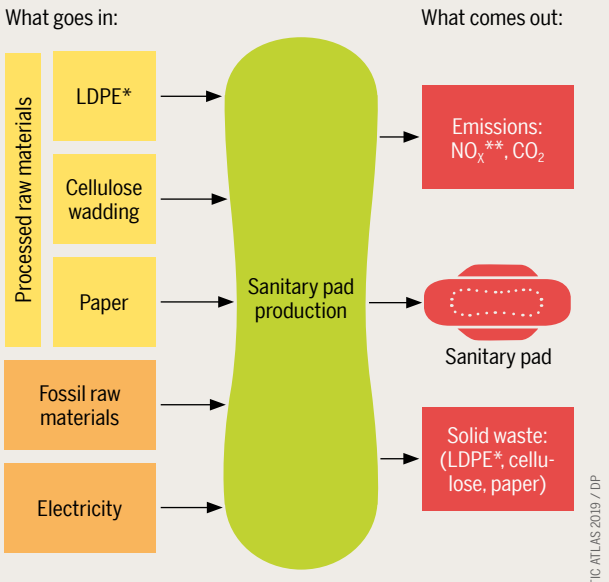
In poorer regions, many women and girls cannot afford to use such hygiene articles, or these products are simply not available locally. That may force a girl to miss school for an average of five days a month during her periods. Cheaper and safer reusable products could close this gap and reduce pollution and waste. Most single-use hygiene articles end up in landfills, in water sources and the sea, and clog sewage systems.

Cosmetics may also be a source of harmful substances. One-quarter of all women in western industrial countries use up to 15 different products every day. These commonly contain up to 100 chemicals, some of which are harmful to health. Many cosmetics contain microplastics, which can pass through the placenta into the foetus.

Last but not least, women are still often responsible for doing the housework, or work as cleaners. Cleaning products also contain microplastics and harmful substances such as surfactants and solvents. Choosing products more carefully, and using environmentally friendly materials or conventional agents such as soft soap and citric acid, could reduce the burden on mankind and the environment. But such consumer choices do not free producers of the responsibility to replace harmful ingredients and raw materials.

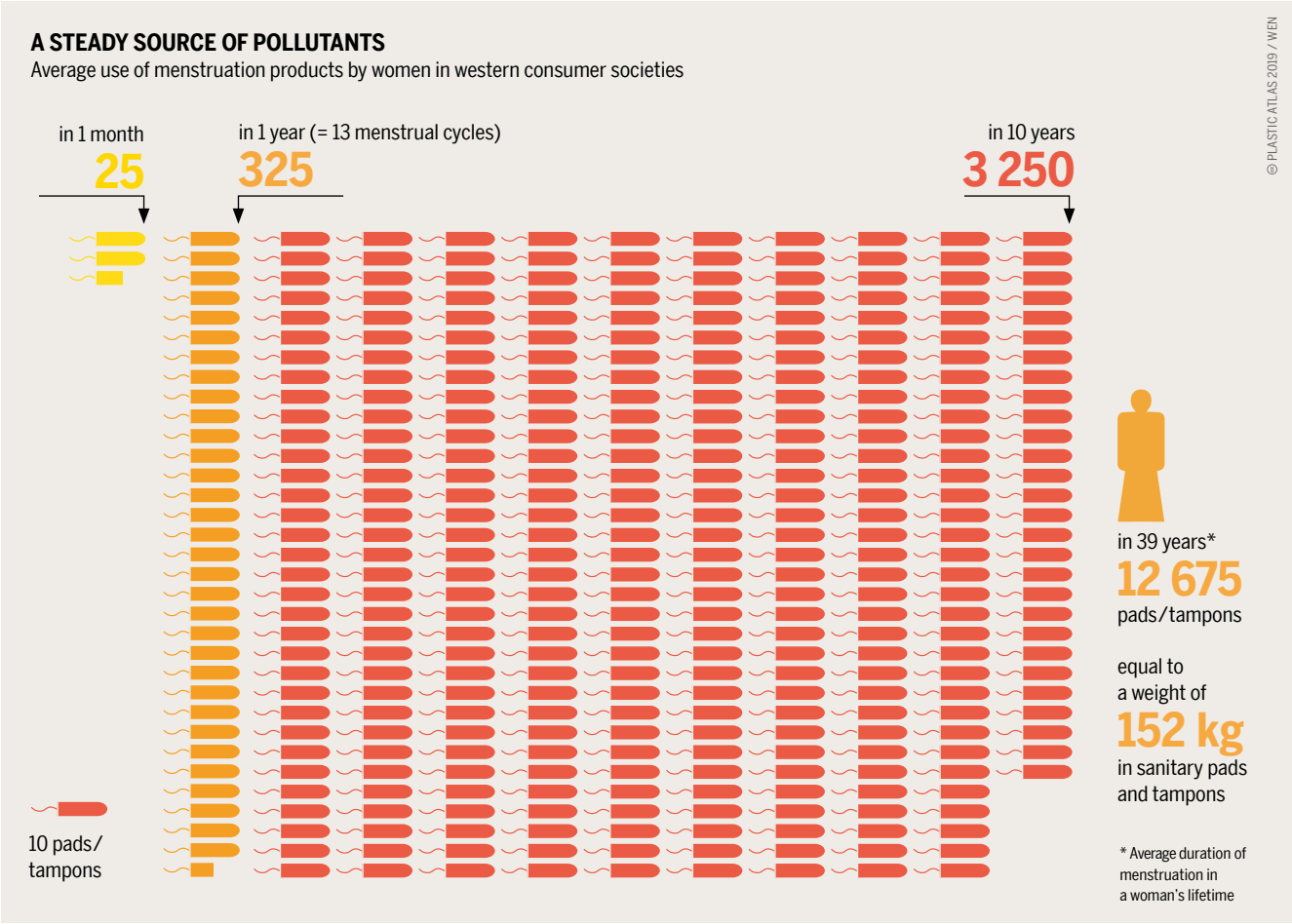
THE SECRET LIFE OF A SANITARY PAD

Life-cycle assessment of the energy and materials used in production



* Low-density polyethylene ** Nitrogen oxides

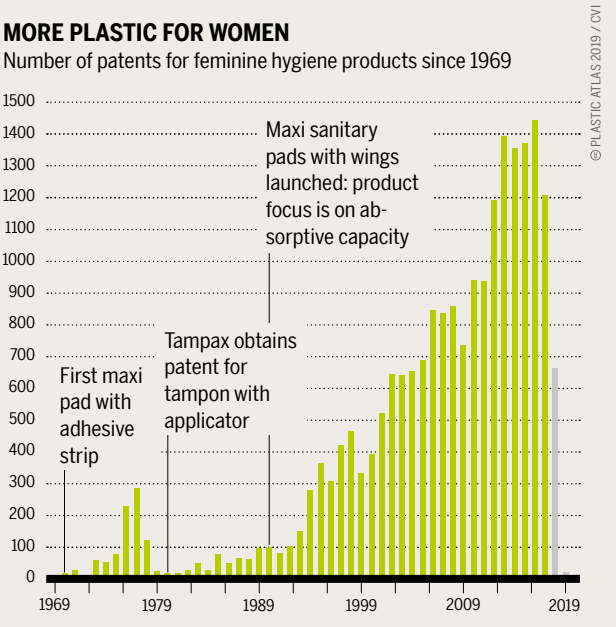
The production of a modern sanitary pad is not possible without using fossil raw materials and plastics.



A woman who uses disposable menstruation products comes into contact with hazardous plastics for nearly four decades.

When waste is exported to developing countries, landfills become important sources of income for the poor. Millions of waste-pickers around the world, often women and children from the poorest sections of society, pick over such sites for recyclable plastics and electrical waste. Often the only source of family income comes from these highly toxic locations. To get to valuable copper, PVC-coated cables are burned. The smoke contains highly toxic dioxins that are harmful to reproduction, damage the foetus, and can cause cancer. It is mostly women who burn household rubbish in backyards or who sort through toxic trash.

Knowledge about the dangers posed by plastics is unevenly spread throughout the world. Women are an important target group in efforts to trigger a fundamental switch in attitudes and everyday practices, as well as in demanding political action. Women are often more sensitive to various dangers than are men, and they are less prepared to put people and the planet at risk. That is true in their roles both as entrepreneurs and as consumers and managers of their families. There is considerable evidence that they act in a more environmentally responsible way than men. Initiatives that aim to reduce the consumption of plastic and protect people and the environment from pollutants are often started by women. They deserve an equal place in politics, businesses, families and communities so they can make an even greater contribution to bringing about a plastic and toxin-free society and environment.



Patents for feminine hygiene products have jumped sharply since the end of the 1990s. One reason is the mass availability of cheap plastics.

TASTY MORSELS

The food industry is a big user of plastic. Films and foams are meant to shield food from damage, keep it fresh, and make it look attractive. But beauty has a price: the plastic lands on fields and gets into our food system.

Cucumbers cocooned in polythene, pre-cut salad ready to eat in disposable bowls, ready-made meals in individual portions: supermarket shelves are laden with plastic-wrapped food. Plastic takes on a central role when food marketing moves out of local market stalls and into supermarkets with their rich assortments of processed food sourced from across the globe.

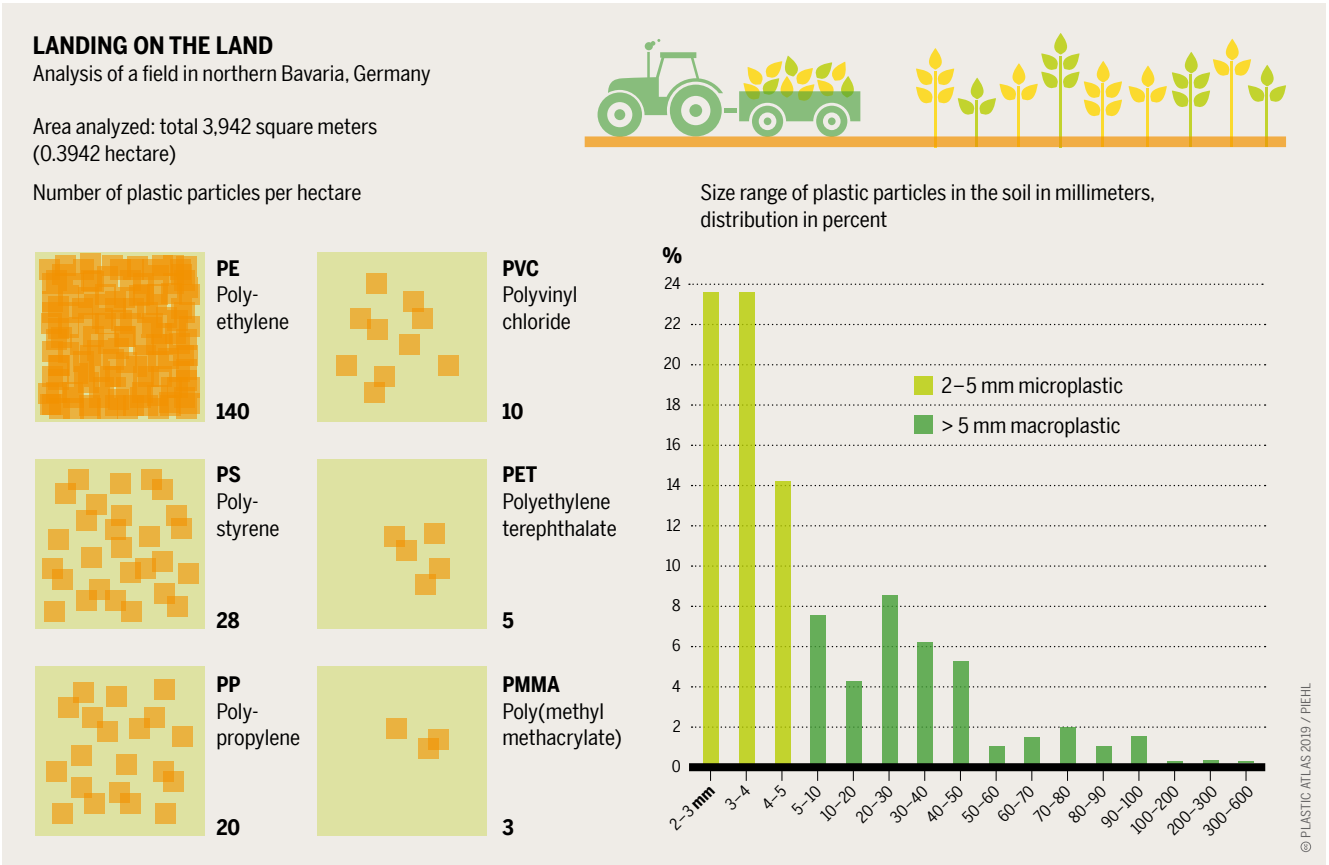
Supermarkets like to offer the same groceries year-round, regardless of the region. Packaging guarantees that items stay fresh and can be transported from afar. Plus, many consumers in the developed world want to be able to prepare food quickly: convenience is the order of the day. Research in Germany in 2019 found that 48 percent of people thought it important to be able to prepare their meals quickly and easily. The food industry responds to such demands by offering pre-cut and pre-cooked items, all wrapped in plastic.

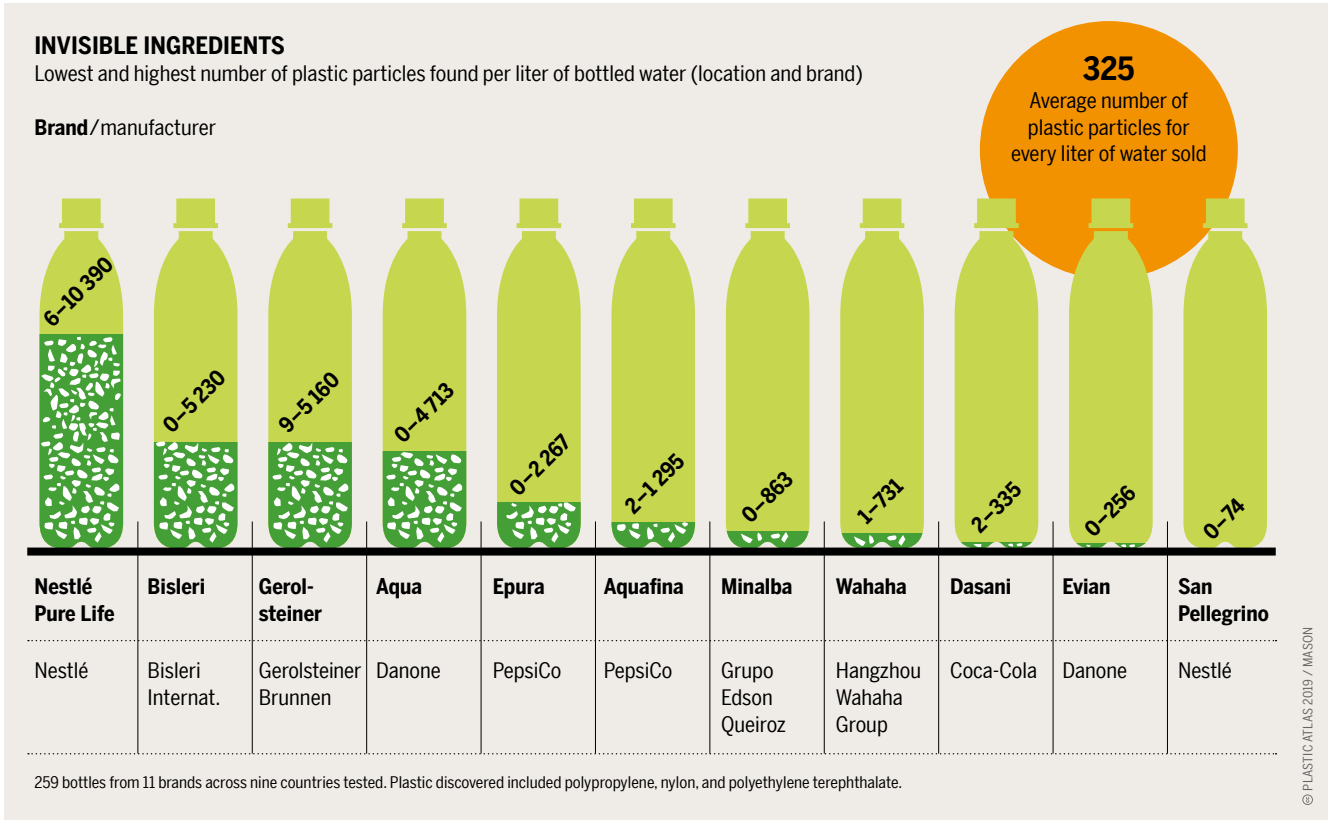
More and more people around the world now live in cities and alone. And middle-class eating habits are changing. These trends boost the market share of supermarkets as well as that of the packaging industry. The amount of packaging used in the food industry has been rising for years. Grand View Research, a US organization, estimated the market value of the food-packaging industry at $277.9 billion in 2017—with a forecast growth of over 5 percent for 2018. Trends in Europe are very similar: in 2018, the industry used over 1.13 trillion items of packaging. The most common type of packaging was, of course, plastic. An analysis by the Institute for European Environmental Policy supports these findings: most plastic trash in the oceans is discarded food packaging.

But packaging is not the only culprit. Agriculture is the sixth-largest user of plastics in Europe: worldwide it uses some 6.5 million tonnes of the material each year. Fruit and vegetable production seems unimaginable without plastic: irrigation systems, greenhouses and polytunnels are all made of it. Plastic nets keep birds out of fruit trees and bushes. Entire fields are covered with sheeting to warm up the soil and extend the growing season—for example by allowing asparagus to be harvested earlier.

The debate is only just beginning over microplastics in the soil, in livestock and in our food. Relatively little research has been done on the damage caused to the soil by plastics

How much plastic ends up in the soil is little researched. But soil contamination is thought to be between four and 23 times higher than in the sea.



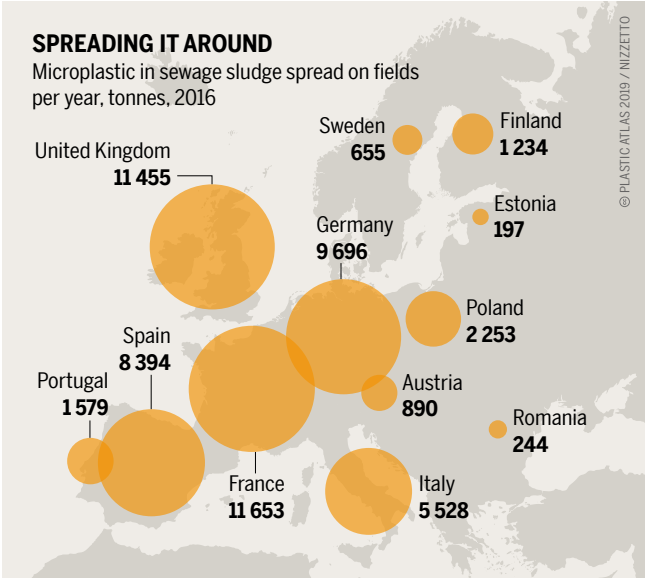


Bottled water is marketed as a healthy alternative to tapwater. Bottlers have to list the mineral contents in detail. Microplastic does not appear as an ingredient.

and microplastics. Scientists at the Free University of Berlin and the Leibniz Institute for Freshwater Ecology and Inland Fisheries, both in Germany, think that research on microplastics in the oceans is about a decade ahead of similar research on the soil. According to estimates, of the 400 million tonnes of plastic produced each year, about one-third ends up in one form or another in the soil or inland waters. Depending on the situation, that would make the contamination of the soil between four and 23 times higher than that in the sea. Microplastics change the structure of the soil as well as the habitat of living organisms that are important for maintaining soil fertility—from microorganisms to earthworms. In addition, microplastics act as a magnet that attracts certain types of toxic substances.

Worldwide, several hundred thousand tonnes of microplastics are spread on the soil through the application of sewage sludge as fertilizer. The sludge comes from treating wastewater from industry and urban areas. In Germany, treatment plants filter out nine-tenths of the plastic particles from the wastewater, leaving them in the sludge. One-third of the municipal sludge is used as fertilizer on fields: up to five tonnes per hectare over a period of three years. The wind may pick up these plastic particles and carry them far and wide. They have been detected in remote parts of the Alps: probably carried there by the wind.

The possible effects of microplastics on the human body are still largely unresearched. But it is known that plastics can get into the body when we eat and drink. A study by the University of Newcastle in Australia in 2019 estimates that people may ingest up to 5 grams of plastic every week—about the weight of a credit card. Another study, from Canada, found that people who drink water from plastic bottles wash something like 130,000 microplastic particles down their throats every year. With water from the tap it is just 4,000 particles. Those are worrying numbers. But they say nothing about what the health consequences might be. It is not known if ingested plastics can get into the bloodstream and thus into the internal organs. It is quite possible that they leave the body again through the digestive tract.



Microplastic particles that sewage-treatment plants cannot separate out are sprayed onto fields with the residual sludge commonly used as a fertilizer.

WEARING THIN

At first sight, fabrics made from synthetic fibers have many advantages. They are cheap, dry quickly, and shape themselves to the body. But they have become disposable articles and contribute significantly to climate change. They may also be harmful to human health.

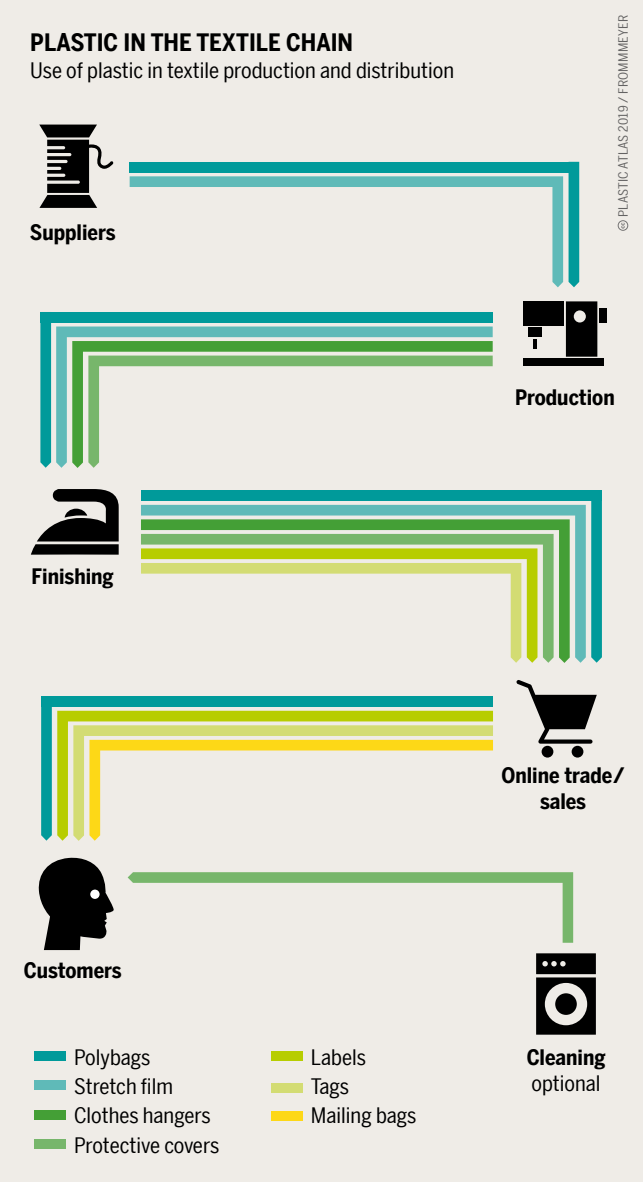
Many of the garments we wear every day are made in part or entirely out of polymers. Consumers often do not know that terms like polyamide, polyester, acrylic and nylon actually refer to synthetic fibers—in other words, plastics. Such materials are popular among producers and consumers alike. They are elastic and dry quickly. They feel soft to the touch and weigh less than comparable clothes made from natural fibers such as cotton.

The polymers that are used to make chemical fibers fall into two categories. Those based on cellulose, such as rayon, are usually made from wood. Synthetic polymers, such as polyester, undergo several production steps, but ultimately they are made from crude oil or natural gas. In 2017, around 70 percent of all fibers produced globally were synthesized chemically. At 80 percent, polyester accounts for by far the biggest proportion of synthetic fibers, and production is rising steadily. In 2017, some 53.7 million tonnes were sold. About 94 percent of the material is produced and processed in Asia, mainly in China. About half of the polyester fibers produced go into clothing. Textiles—including industrial textiles, make up 15 percent of the world's annual output of plastics.

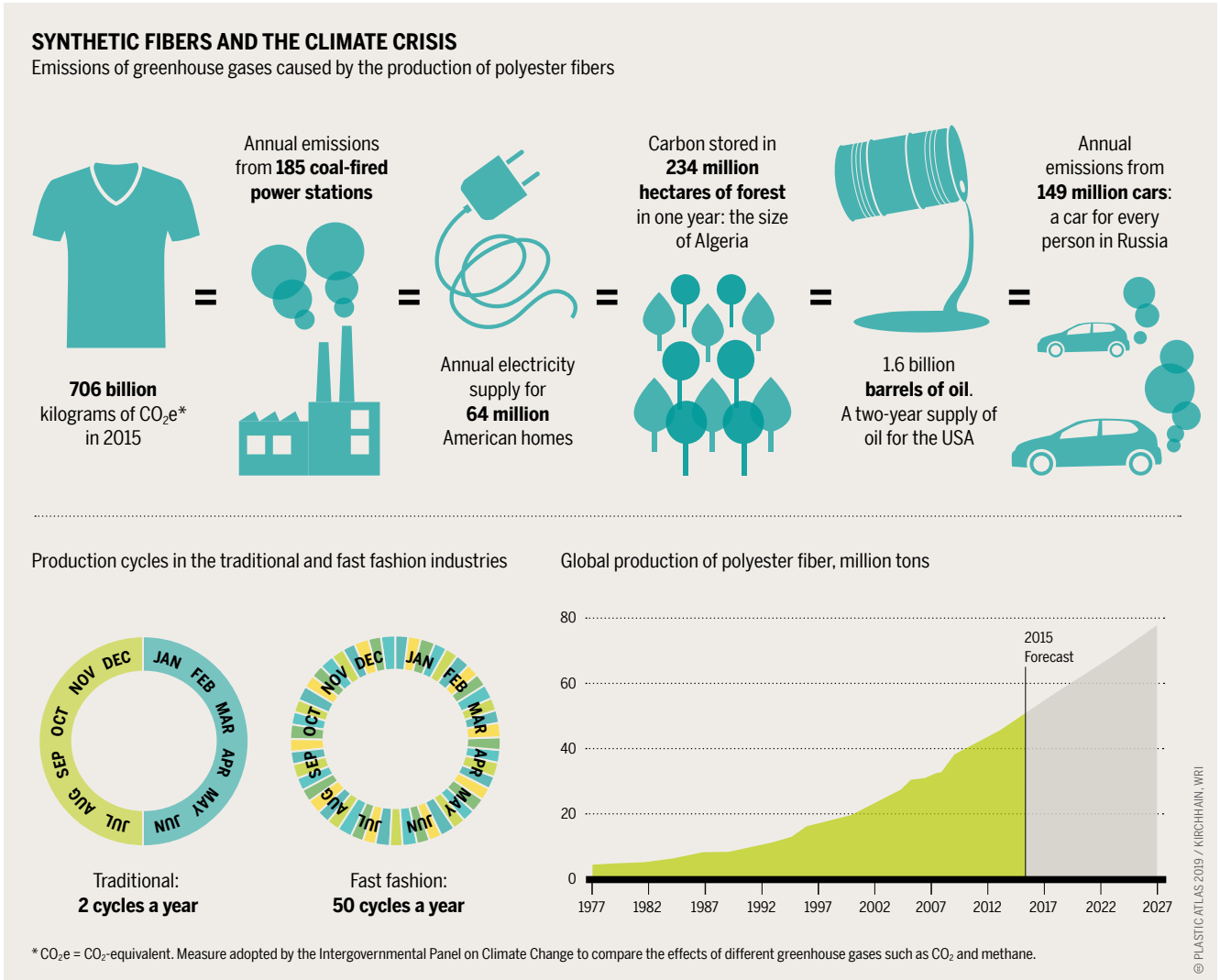
The textile industry is a major polluter of groundwater, rivers and the sea. Between 20,000 and 40,000 different chemicals are used to process and dye clothing. Many of them are carcinogenic, alter the genetic code, and impair reproductive ability. They may also cause allergies and influence the hormone system. Known harmful additives include formaldehyde, the so-called perfluorinated chemicals, fire-retardants, and dyes and other additives. Workers are exposed to such contaminants at numerous points along the value chain. These substances also harm the people who live near production plants and wastewater streams.

The consequences are far-reaching. Many workers in the textile industry—some 70 percent of them worldwide are women—suffer from work-related illnesses. A link between formaldehyde and deaths due to leukaemia has been proven. Women who work with synthetic fibers in textile factories have a high risk of contracting breast cancer. And textile workers in China who come into contact with these fibers have been found to have an increased risk of miscarriage.

Clothing made from synthetics continues to cause problems after the last button has been sewn on. When they are washed, microplastic particles enter the environment. Researchers have found that washing five kilograms of clothing can release six million microfibers into the wastewater; washing a single synthetic fleece jacket can set free 250,000 such particles. Little is known about the effects of these microplastics on human health. But it is particularly worrying that microplastics attract other contaminants like a magnet. These contaminants includes persistent organic compounds and other long-lived toxins that are especially harmful to health. These compounds attach themselves to the microplastics and enter the food chain. They have already been detected in salt, fish, mussels and even in human faeces. Sewage treatment plants and washing machines are not yet able to filter out the offending microfibers.



Plastics are used in the textile industry not just in the production process, but also to protect items during distribution and marketing.



The textile sector has less obvious effects on the climate than the car industry. But producing polyester generates a broad plume of greenhouse gases.

Consumers must bear part of the responsibility. Even though the clothing could still be worn, 64 percent lands in the garbage. In the European Union, 80 percent ends up either in a waste incinerator or in a landfill. Of the remaining garments, just 10 to 12 percent are resold locally. The remainder is exported to developing countries, where it undercuts local clothing producers and destroys their markets. Textiles that end up in the sea float at a greater depth than other plastic products and can interfere with marine life there.

One cause of these problems is the "fast fashion" industry. Companies flood the market with huge amounts of cheaply produced clothing. In the USA in the last 20 years, the volume of clothing that is thrown away each year has doubled from 7 to 14 million tonnes. That means the fast fashion industry contributes in a big way both to environmental pollution and to health risks. Outdoor culture, which demands clothing that is as functional as possible, also fuels the production of synthetic fibers.

The recycling of clothing is gathering pace, but it makes little difference to the underlying problem. The global consumption of recycled polyester rose by 58 percent between 2015 and 2016. But to make large-scale recycling feasible, different types of fibers should not be mixed. Separating blended fibers during recycling is very costly. Along with the need to produce fabrics that are suitable for recycling, a comprehensive system to return used clothing is needed—one that does not yet exist in many countries. But this still remains a superficial, temporary solution. Recycling makes it possible to use synthetic fibers for a longer time, but their quality deteriorates with each cycle, and in the end they still land in the trash.

A more sustainable mode of consumption is unavoidable if we really want to reduce the environmental and health risks. Buying clothing in second-hand shops and swapping garments with other people are good ways to slow down the production of new clothes. Producers cannot currently meet the demand for clothing using fibers from sustainable sources, such as organically grown cotton. Organically based textiles exist, and new approaches are being developed to transform natural materials, such as crustacean shells, trees, hemp, nettles and flax—ideally from local sources—into fibers suitable for making textiles. But these processes too must be checked for their effects on the environment, health and society. Potential pitfalls that must be avoided include monocultures, the use of chemicals that are harmful to the health or the environment, and unsustainable forestry practices.

TURNING THE TIDE ON THE TIDE OF TRASH?

Sun-kissed beaches, swaying palm trees... and a knee-deep carpet of garbage at the water's edge. Tourists come to see pristine beauty, but help destroy it through their carelessness, and because waste systems cannot cope.

Pictures of plastic floating in the sea and washed up on beaches have become common in the media over recent years. Millions of tonnes of plastic items enter the ocean every year: carried there by rivers, discharged by drains, dumped or lost from ships, or carried away from the shore by the waves. The high-tide lines of beaches around the world are now marked by a tangled mess of plastics, putting off tourists and damaging the brand images of iconic locations such as the Caribbean islands and Bali.

The tourism industry is having to take note—and in a few places it is beginning to live up to its responsibilities. Eighty percent of all tourism takes place in coastal areas, putting a special burden on seaside locations that cannot cope with the sheer numbers of visitors they welcome each year. Tourist sites are faced with substantial costs of the clean-up necessary to maintain the attractiveness of their shorelines.

The damage caused by plastic pollution of the oceans is huge: one estimate from the United Nations Environment Programme puts it at $13 billion a year. Some of these costs are borne by certain industries and coastal communities directly, in the form of clean-up costs and litter removal. Other costs come in the form of lost revenues from fishing and tourism. The costs are hard to quantify because of a lack of research and data. Plus, it is inherently difficult to put a monetary value on things like the impact of invasive species that live on plastic debris that drifts along with the ocean currents.

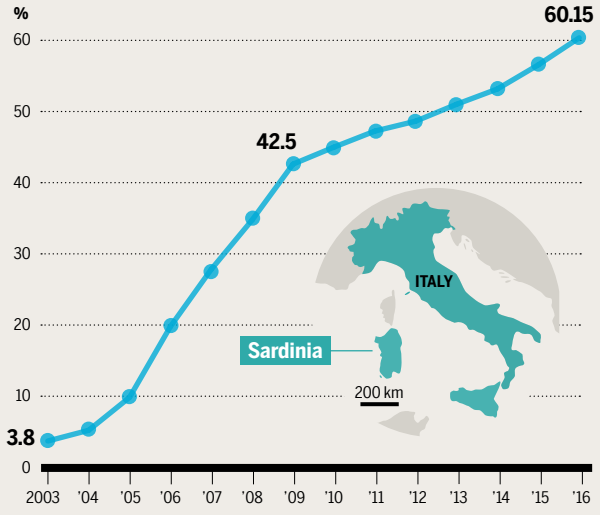
Tourism is not just an innocent victim of plastic pollution. It is also a major cause of it. Tourism expands the environmental footprint of travellers. The journey to an exotic destination—most often by car or plane—generates carbon emissions. And tourists are much more likely to consume single-use plastics and packaging than they normally do. Catering services in airports, on board planes and trains, and at gasoline stations, solve their supply-chain constraints by distributing food and drinks in single-use packaging or plastic bottles.

When they arrive at their destination, tourists are faced with unfamiliar products and situations. They are more likely to buy packaged food, and they may not know how to use the local recycling service (if indeed such a thing exists). Many tourist destinations lack the facilities required to collect and handle the growing mounds of waste generated by the large numbers of visitors they receive. Too many tourists carelessly toss away litter in a way they would not do at home. The amount of plastic litter going into the Mediterranean rises by 40 percent during the summer months, demonstrating a direct link between the tourist industry and plastic pollution.

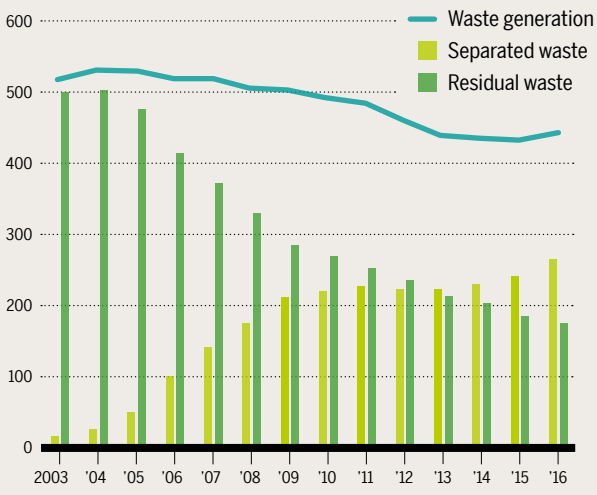
In the early 2000s, Sardinians separated little of their waste. Public awareness and waste-collection practices have since changed radically.

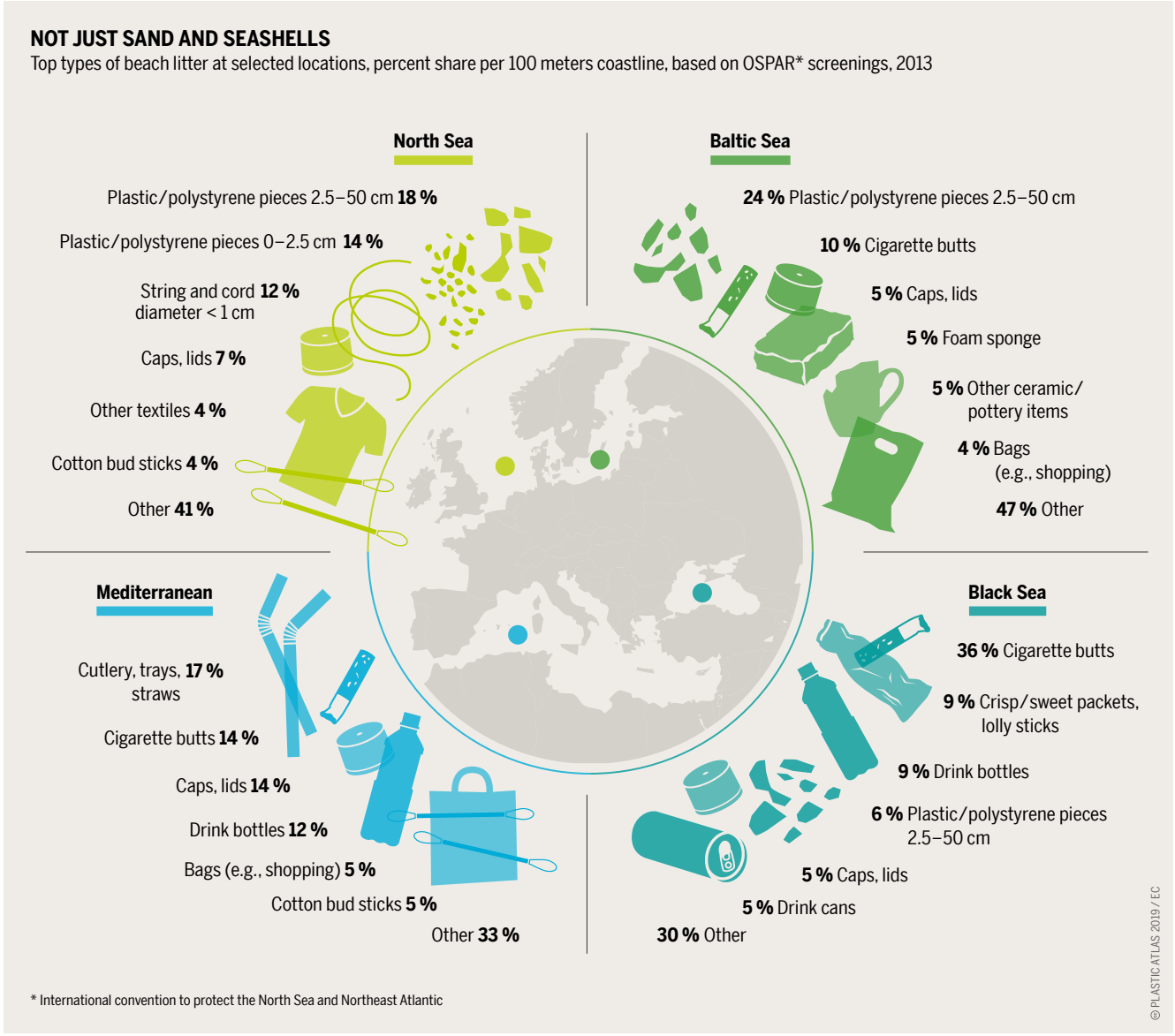
LESS TRASH IN THE TYRRHENIAN SEA

Separate waste collection in Sardinia, in percent



Changes in waste generation and disposal, in kilograms/inhabitant/year





Plastic bottles, straws and bags are easy to spot. But the trash on beaches also includes less-visible garbage such as cigarette butts or cotton bud sticks.

The average airline passenger generates 1.4 kilograms of waste per flight, according to the International Air Transport Association. In 2017, that resulted in 5.7 million tonnes of passenger waste. The waste bags that are collected by flight attendants and cleaning crews contain a mix of garbage that the planes offload at their destinations. Waste-management systems differ at each location, so little of this airborne trash is ever recycled.

Over the years, as planes have turned into highly optimized environments, plastic has become the material of choice: hygiene regulations require serviceware and food to be packaged, further stimulating the use of cheap plastic items. Reducing weight is important for airlines because it cuts fuel consumption, costs and carbon emissions, so lightweight plastic usually wins out against more environmentally friendly but heavier alternatives.

A few airlines are formulating an alternative vision and are taking the first steps towards plastic-free flights. They are switching to compostable or reusable trays, tableware, cutlery and packaging made of paper, bamboo or wood.

Elsewhere in the travel industry, TUI Group the largest leisure, travel and tourism company in the world, promised in 2018 to remove 250 million pieces of single-use plastic by 2020 from their hotels, cruise ships, airlines, destinations and offices.

Seasonality is a major challenge for tourist cities, resorts and organizations. Waves and tides wash in plastic waste from the ocean all year long, but garbage-management measures and infrastructure have to cope, especially in the high season, when tourist numbers and waste generation are highest.

The Italian island of Sardinia has shown how to turn the tide on waste production and disposal locally. In 2003, only 3.8 percent of the waste was segregated by type. This is now over 60 percent, and on track to reach the target of 80 percent by 2022. This has been possible because waste is collected separately, door-to-door, rather than from central collection points, as is common elsewhere in Italy. The tax on disposal has been increased, and municipalities have been given economic incentives to reach staged targets, with rewards and penalties for cities and towns according to their waste-management achievements.

NOT GREEN, BUT GREENHOUSE

Plastics are sometimes seen as environmentally friendlier than other materials—not least because of their light weight. But the plastics boom is pumping huge amounts of greenhouse gases into the atmosphere.

Making, using and disposing of plastic have serious effects on marine ecosystems, coastal environments and human health. While their impact on the climate is less well-known, it is just as significant.

In the 2015 Paris Climate Agreement, nations committed to limit global warming to well below 2 degrees Celsius—and to pursue efforts to keep the temperature rise below 1.5 degrees. In 2018, the Intergovernmental Panel on Climate Change concluded that to keep warming below the 1.5 degree limit, we must cut global greenhouse gas emissions by 45 percent by 2030, and we must reach zero net emissions no later than 2050.

In climate policy, attention is largely focused on the transition to renewable energy and cleaner transport. But industry is also important: it accounted for 30 percent of global greenhouse-gas emissions in 2010. The production of plastics is one of the largest and fastest-growing contributors to these emissions. Plastics, along with many fertilizers, pesticides and synthetic fibers, are petrochemicals, derived from mineral oil and natural gas. More than 99 percent of plastics come from such fossil-fuel feedstocks. Petrochemicals are the fastest-growing form of oil consumption globally; the International Energy Agency forecasts that they will account for half of the extra demand for oil by 2050. In the United States and elsewhere, plastics and other petrochemicals form a large and rapidly growing destination for fracked gas.

As plastic production grows, it will lock in new fossil-fuel infrastructure and increase emissions that arise from the exploration, extraction, transport and refining of oil, gas, and coal. Global production of plastics has increased from 2 million tonnes in 1950 to 400 million tonnes in 2015. The production and use of plastics have nearly doubled in the last 20 years; they are expected to double again over the next 20, and quadruple by the early 2050s.

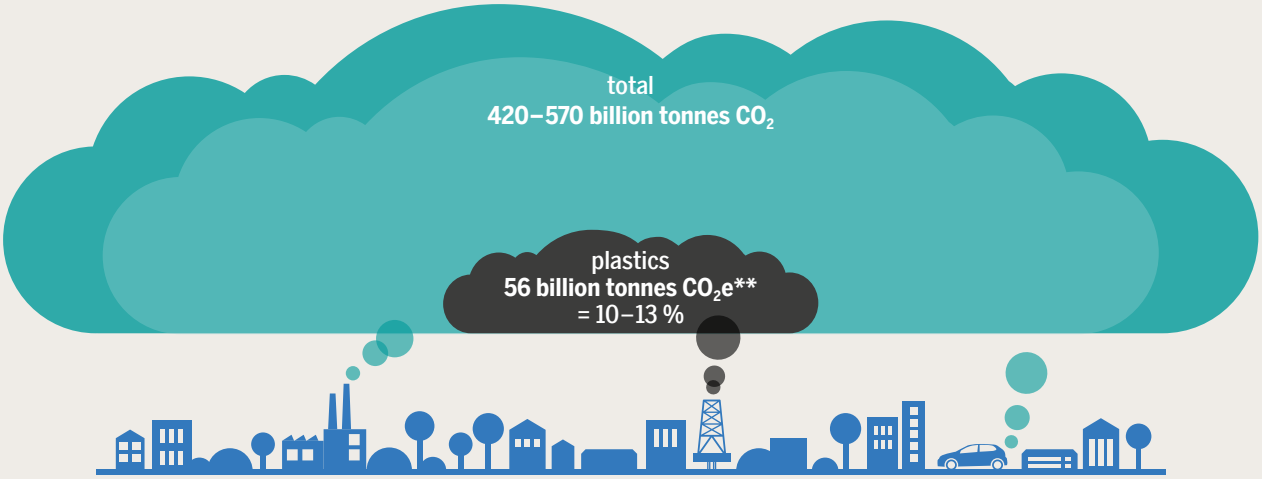
Carbon dioxide, methane and an array of other greenhouse gases are released at each stage of the plastics life cycle—from the extraction and refining of fossil fuels, to the energy-intensive processes that produce plastic resins, to the disposal, incineration, and potential environmental release of waste plastics. This has big implications for efforts to meet global climate goals. To avoid overshooting the 1.5 degree target, total emissions must stay below the remaining (and quickly declining) budget of 420–570 billion tonnes of carbon dioxide.

The non-profit Center for International Environmental Law estimates that at current and projected rates of growth, the production of plastics alone could generate 53.5 billion tonnes of carbon dioxide emissions by 2050. Adding the incineration of waste plastics pushes this total up to nearly 56 billion tonnes. In other words, plastics alone could consume between 10 and 13 percent of the earth's remaining carbon budget for staying below 1.5 degrees. Even assuming plastic production grows much more slowly after 2050, and

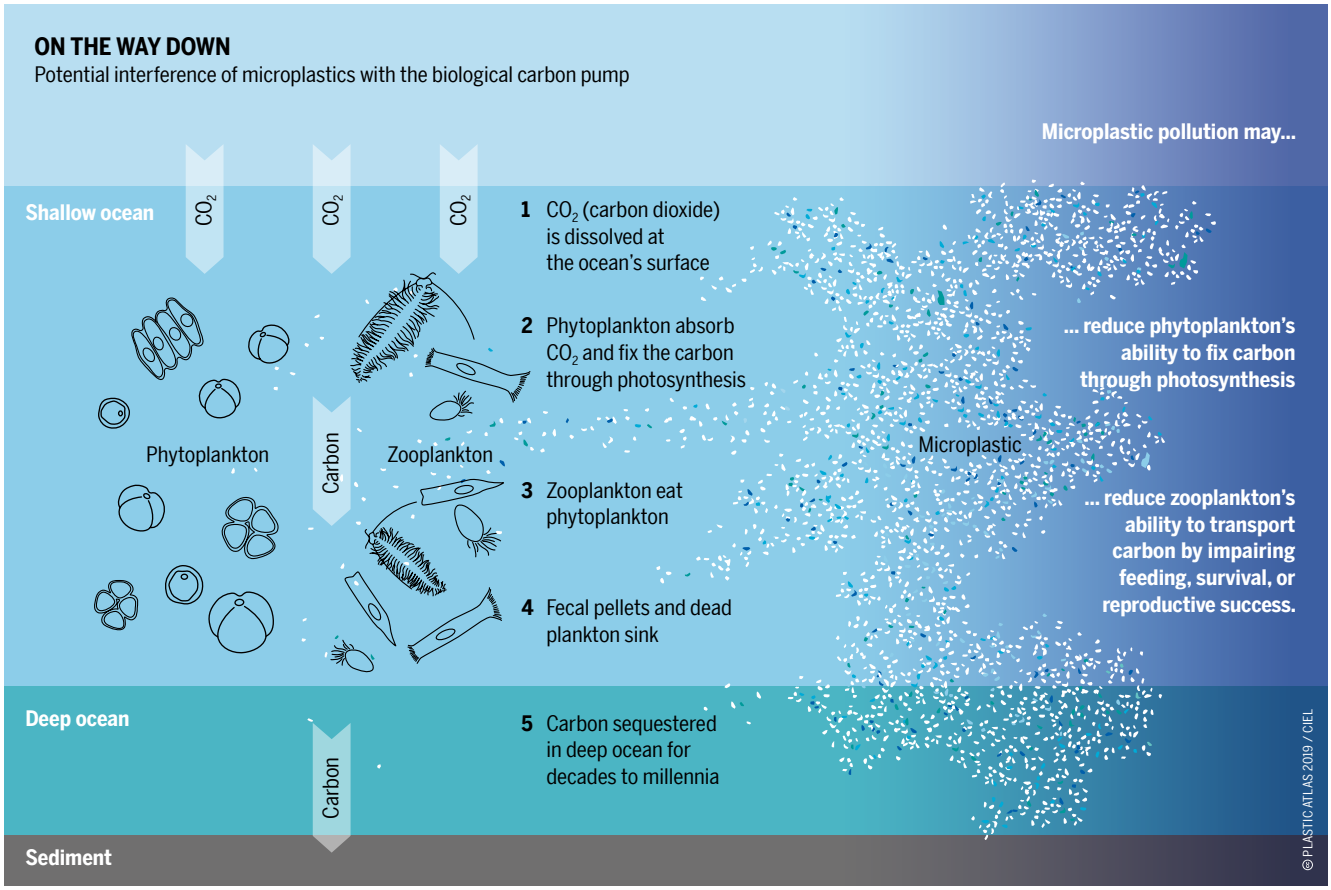
Transport, energy and farming are the three sectors most often blamed for climate change. The emissions caused by plastics production are often forgotten.

THE THREAT TO THE WORLD'S CLIMATE POSED BY PLASTIC

Projected share of CO_2 emissions from global plastic production, maximum budget to meet **1.5 degree warming target*** by 2050



* In 2015, the international community agreed to limit global warming to well below 2 degrees Celsius and to pursue 1.5 degrees Celsius compared with the pre-industrial times.
** CO_2 equivalents: unit of measurement for standardizing the climate impact of different greenhouse gases.



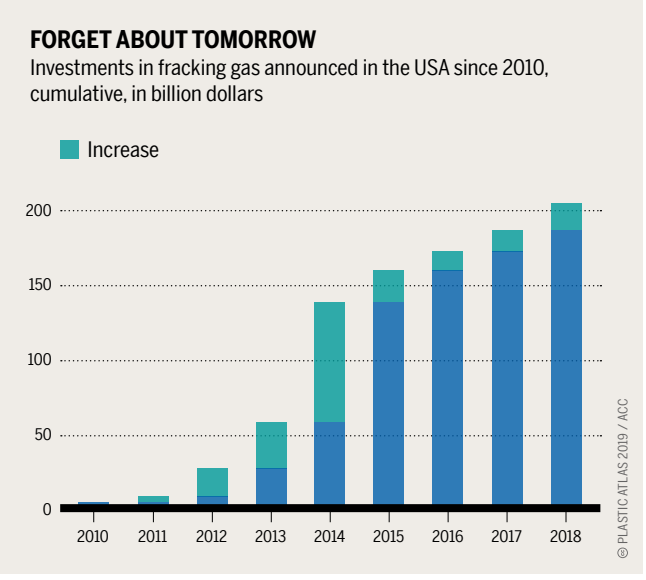
The oceans absorb a quarter of anthropogenic greenhouse emissions. Pollution by microplastics may put the biological carbon pump at risk. More research is needed.

incineration does not grow at all, emissions from plastic production and incineration could total nearly 260 billion tonnes of CO_2 equivalent by the end of the century, potentially consuming over half the available carbon budget.

But these figures may still underestimate the total climate impact of plastics. We know little about some aspects of the extraction, transport, and refining of fossil feedstocks for plastics. In North America, for example, official estimates of emissions from natural gas production routinely exclude the effects of forest clearance and other land disturbance needed for new drillpads and pipelines. Gas pipelines and facilities can leak substantial quantities of methane, a potent greenhouse gas—but government and industry estimates of the number of these facilities differ by orders of magnitude.

Emissions from plastics do not end when they are thrown away. Waste-to-energy projects that incinerate plastics are increasingly being proposed as a solution to plastic pollution. Because incineration emits a lot of greenhouse gases, the widespread deployment of waste-to-energy could lead to a big rise in emissions. The research group Material Economics projects that in Europe, incineration for waste-to-energy could make plastics a major source of emissions. And waste plastic continues to release greenhouse gases as it degrades in the environment. The true scale of these emissions is unknown.

The effect on emissions may also be indirect. Growing levels of microplastic debris in the oceans may interfere with the biological processes through which plankton capture carbon dioxide at the sea surface and sequester carbon in the deep oceans. The biological carbon pump is part of the oceanic carbon sink, contributing to the earth's climate balance. The mechanisms and extent to which microplastics may be interfering with that balance are of great importance, but remain poorly understood. More research on these mechanisms and interactions is required.



Cheap fracked gas from the United States is flooding the market and fueling the plastic crisis around the world.

ALL AT SEA?

Marine pollution is fed mainly by trash floating down rivers, like smog is fed by fires and smokestacks. But plastic does not stay long in the open ocean. It moves into shallower waters, sinks to the sea floor, or is washed ashore.

Every year, some 10 million tonnes of plastic waste enter the oceans from land: equivalent to a truckload every minute. Plastics that end up in the sea tend to concentrate in five enormous gyres: in the north and south Pacific, the north and south Atlantic, and the Indian Ocean. The gyre in the North Pacific, popularly known as the "Great Pacific Garbage Patch", is the most famous.

But contrary to common perceptions, these are not areas of consolidated plastic waste: rather they are merely where the concentration of waste is highest. In reality, microplastics are widely distributed in all aquatic environments worldwide: they form a plastic smog, like air pollution over large cities. We can think of rivers as horizontal smokestacks that release plastics into the global ocean. Even in the most remote areas, in the deep ocean or in the Arctic, plastic now drifts along or litters the shoreline. The levels of pollution are growing rapidly: within a decade, the amount of litter in the deep sea of the Arctic Ocean has risen twenty-fold. On the sea surface, between 15 and 52 trillion plastic particles weighing 93,000 to 236,000 tonnes are floating.

The Mediterranean has similar levels of plastics to the five great oceanic gyres. With less than one percent of the world's sea surface, the Mediterranean is home to around seven percent of its microplastics. Surrounded by land, it exchanges only a limited amount of water—and plastic—with the world ocean, allowing trash levels to build up. In other seas too, high concentrations of plastic are to be found. On every square kilometer of the seabed of the North Sea 11 kilograms of marine litter can be found.

Marine trash comes from various sources. In the Mediterranean, most comes from poor waste management and single-use plastics used in coastal settlements. In the North Sea, much waste comes from fishing, the marine industry and shipping. The Baltic suffers mainly from tourist waste. The composition of the waste depends on how the particular sea is used and the types of settlements along its coast.

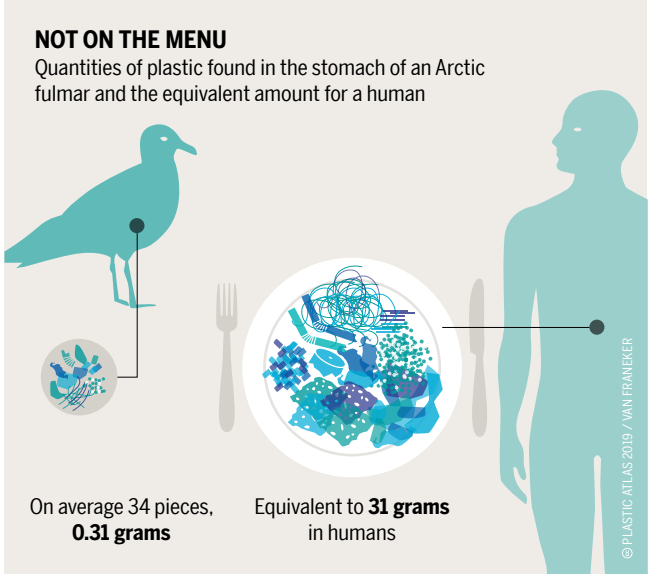
Maritime activities such as aquaculture, fishing and shipping are the source of some floating plastic. Some comes from the land: trash from beaches, microplastics carried by the wind. But the most is carried down to the sea by rivers. Estimating how much is difficult because of a lack of data. Estimates vary widely: from a low of 0.41 million to as many as 12.7 million tonnes a year. Ten major rivers, eight of them in Asia, are thought to be the source of the vast majority of this waste—part of which is trash exported by the US and Europe. But rivers elsewhere also carry significant quantities: the Rhine, for example, has an average microplastic load of 893,000 particles per square kilometer.

Evidence suggests that plastic does not stay afloat for long. Currents, biological interactions and degradation mean that it gradually moves elsewhere: into shallower water, down to the sea floor, and onto the shore. Of all the plastic entering the ocean since the 1950s, 98.8 percent is no longer on the surface: most has fragmented and sunk.

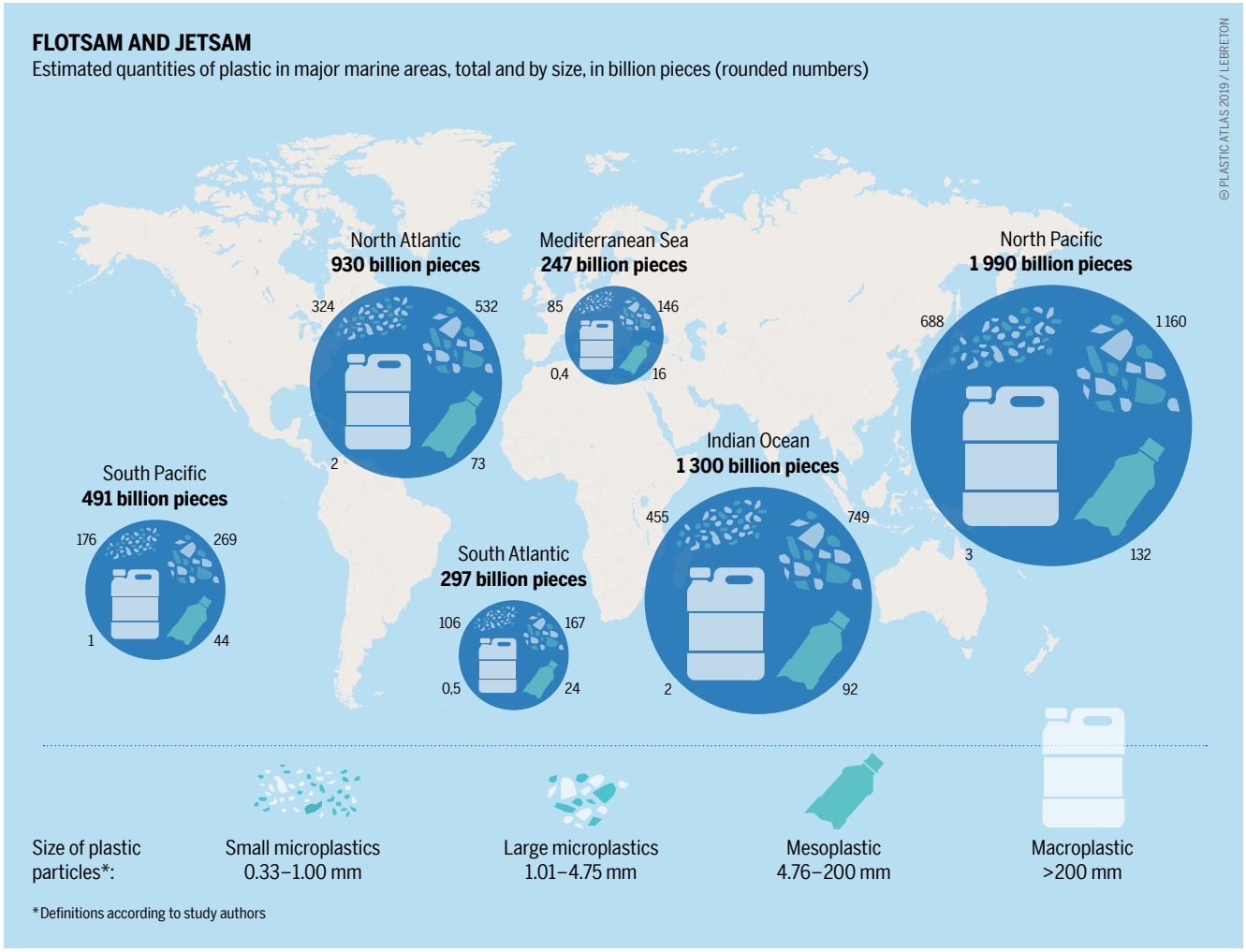
Chemical processes, mechanical abrasion and photodegradation through sunlight and ultraviolet light gradually degrade plastic floating at or near the surface, breaking it up into smaller and smaller pieces. But there is much less small microplastic (i.e. particles up to 1 mm in diameter; in general microplastics are defined as particles smaller than 5mm) than expected: it appears that such particles do not stay in the surface layer but are transported elsewhere. Some are washed ashore. Most sink: they lose buoyancy as they degrade, colonization by marine organisms makes them heavier, or they are eaten by marine life and then excreted in feces. Fishes that live between 200 and 1000 meter deep in the North Pacific eat an estimated 12,000–24,000 tonnes per year. Seabirds consume perhaps 100 tonnes a year.

While the plastic pieces become smaller and smaller, they are unlikely to disappear completely. A recent study on marine microbial assemblages on microplastics found that bacteria cannot decompose plastic, and that they are unlikely to acquire this ability through evolution.

Like the ocean surface, rivers are not the final resting place of plastics. A study of riverbed sediments in northwest England found up to 517,000 microplastics particles per square meter. But after seasonal rains, around 70 percent



As they hunt, many birds cannot distinguish between a fish and a glistening piece of plastic floating in the water.



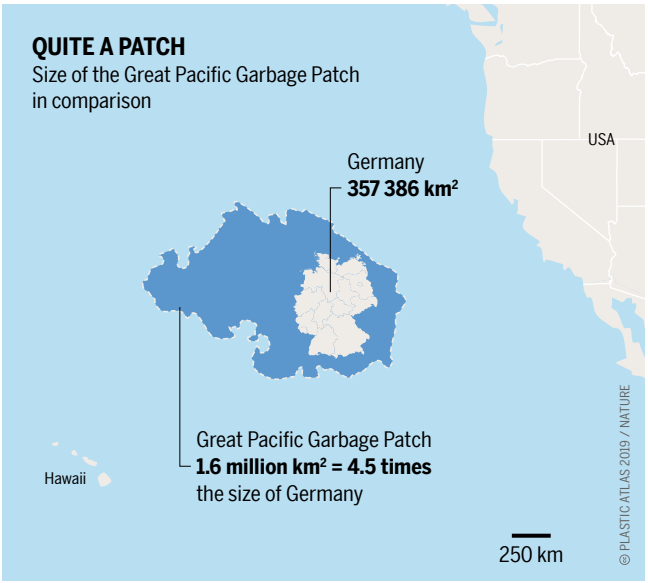
Only a small share of plastic trash stays on the sea surface. The vast majority is either washed ashore or sinks: out of sight, out of mind.

had been removed: flooding had flushed them downstream. Another study found that microplastics in rivers harbor a distinct set of bacteria, helping transport them downstream—and out to sea.

Fish and birds are directly exposed to the dangers of floating plastic: they get entangled in it or mistake it for food. Packaging, especially rings and strings, are particularly hazardous. Worldwide, at least 2,249 different marine organisms interact with plastic trash in some way. Many are harmed and have become endangered. Of the 120 species of marine mammals on IUCN's Red List of Endangered Species, 54 are known to eat plastic garbage or get caught up in it.

On Heligoland, an island in the North Sea, 97 percent of nests in the Northern gannet colony contained plastics, and one in every three injured or dead gannets found there is tangled in plastic. Another example: Arctic fulmars are a good indicator of plastic pollution in the ocean because outside the breeding season they live solely at sea, where they feed at and close to the sea surface. They mistake plastics for food. 95 percent of fulmars found dead on North Sea beaches have plastic in their stomachs. The birds starve to death on a full stomach: their gastrointestinal tracts blocked, injured or inflamed.

Toxic substances such as PCB and DDT accumulate on the floating plastic. Animals ingest not only the harmful substances in the plastic itself, but also high concentrations of these other toxic compounds.



The Great Pacific Garbage Patch floats off the coast of California. Here, currents bring together different types of plastic trash from across the world.

BLAMING THE CONSUMER

Masters in lobbying, petrochemicals firms and plastic producers focus attention on waste management and recycling so they can evade their responsibility for the true problem: the growth in the volume of plastics being made.

Plastics are the downstream end of the vast petrochemicals industry, which is dominated by a handful of giant corporations. More than half of all plastics go into consumer products, mainly in the form of single-use packaging. While analyses of plastic waste in the ocean or elsewhere tend to focus on countries as the source, only a few dozen food and consumer-goods corporations are the sources of almost all the "litter". Even fewer multinationals dominate the production of plastic resins, making the polymers that go into plastics.

As early as the 1950s, chemicals corporations like Dow, and petroleum producers like Esso (now ExxonMobil) held discussions, internally and publicly, sometimes with government representatives present, about the growing plastic pollution crisis. Yet those same corporations strongly resist efforts to limit plastic output and the damage it causes. They often push a dual strategy of lobbying and high-profile advertising of "litter" being a problem of consumer behavior that can be solved by recycling alone, as with the popular "Keep America Beautiful" campaign.

Under-funded NGO advocates are dramatically outspent by industry interests. Corporations use their vast resources to ensure preferential regulations to maintain their profits and minimize any liabilities. The top plastics producers, based in just a few countries (USA, UK, Saudi Arabia, Switzerland, Germany, Italy, South Korea) with a production footprint in almost every country of the world, hire teams of lobbyists to influence policymakers. The industry also jointly funds hundreds of global, regional and national trade associations. The American Chemistry Council alone, which represents over 150 chemicals and plastics producers, has spent nearly $100 million on lobbying since 2009.

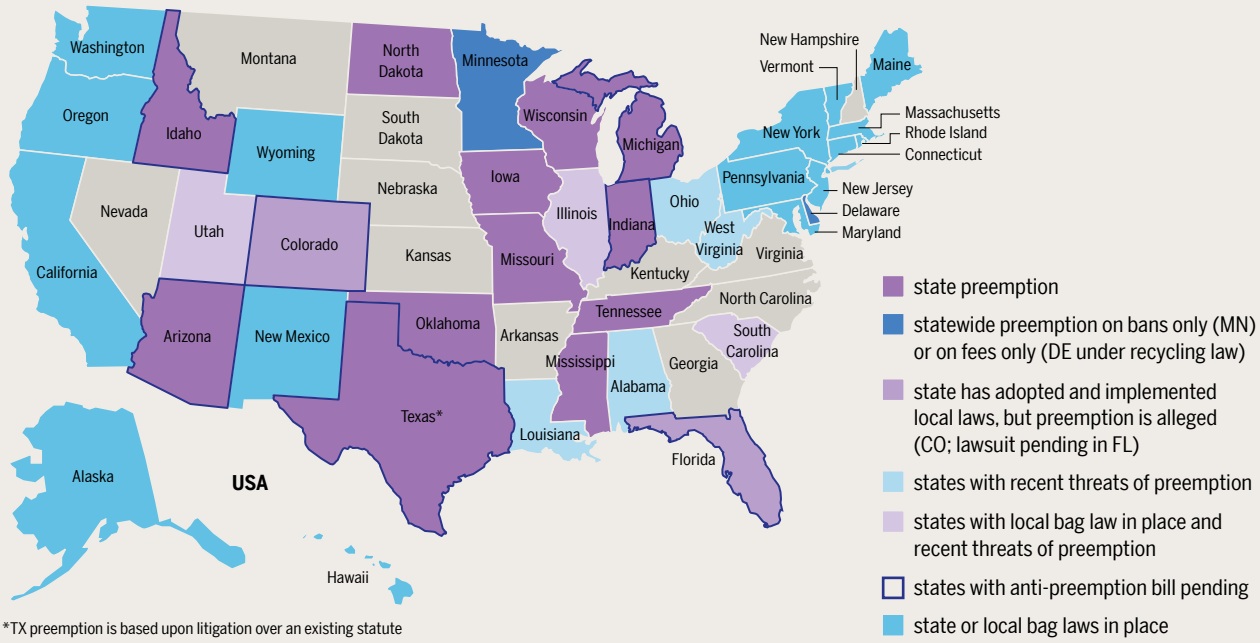
Fracking is a key driver of plastic production. In 2005, a US commission made up of regulators and oil industry lobbyists (with little public input) wrote legislation to exempt fracking from the Safe Drinking Water Act. In Louisiana, Texas and other states, fracking plants are exempt from billions of dollars in taxes. In 2017, the British petrochemicals firm Ineos, and its allies got the UK government to exempt it from fees intended to fund the shift away from fossil fuels. Rather than investing in clean energy, Ineos and its partners avoid more than £100 million in taxes. Lobbyist-authored rules and exemptions drive the production of plastics by enabling profit where it would not otherwise exist.

In the USA, an industry-funded playbook propagated by the conservative American Legislative Exchange Council, is eliminating the power of local authorities to restrict plastics,

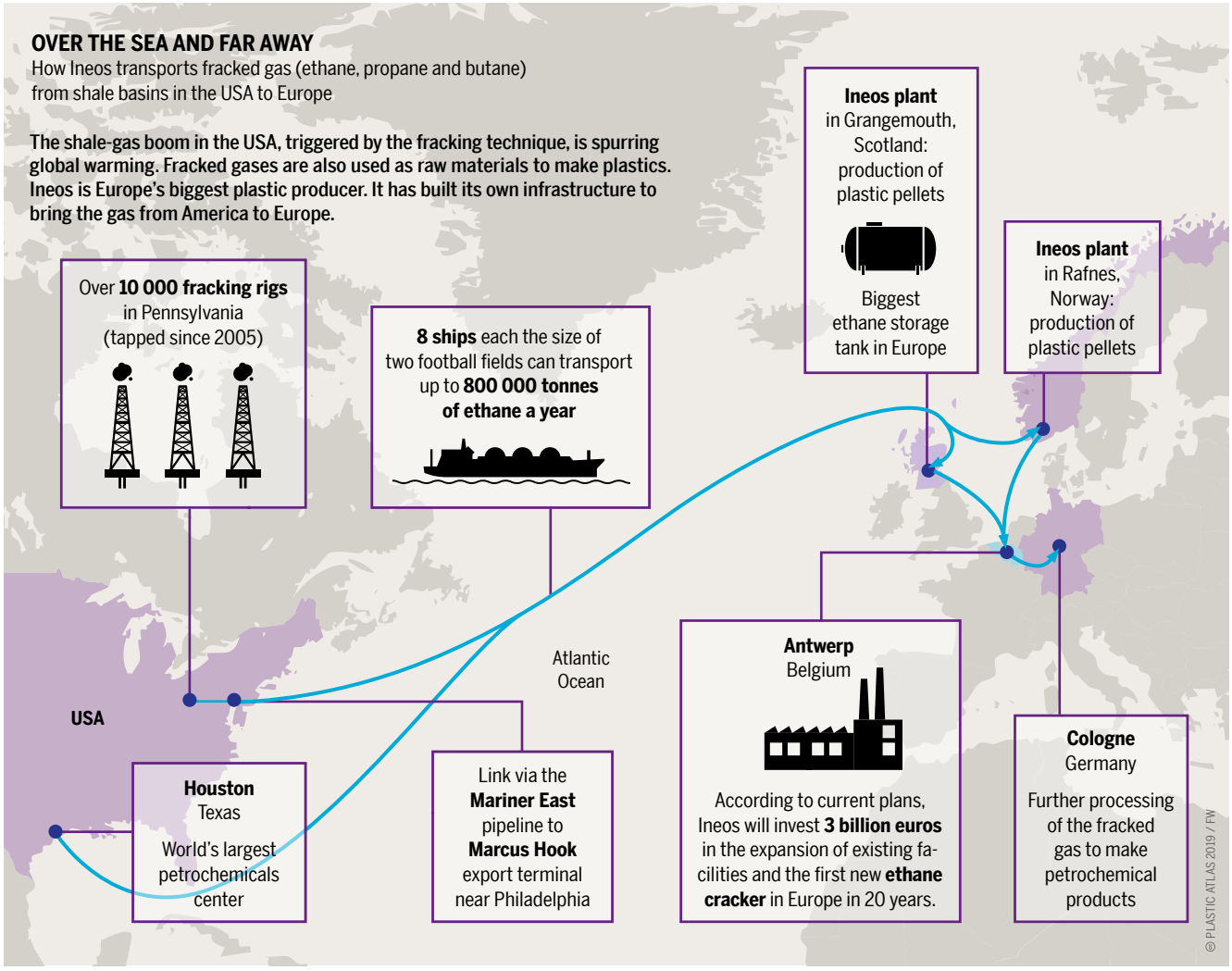
In the USA, progressive states and cities aim to restrict the use of plastic bags. Industry lobbyists are working with conservative states to prevent such initiatives.

THE BAG STOPS HERE

State-level preemption of local authority efforts to limit or ban the use of plastic bags



*TX preemption is based upon litigation over an existing statute



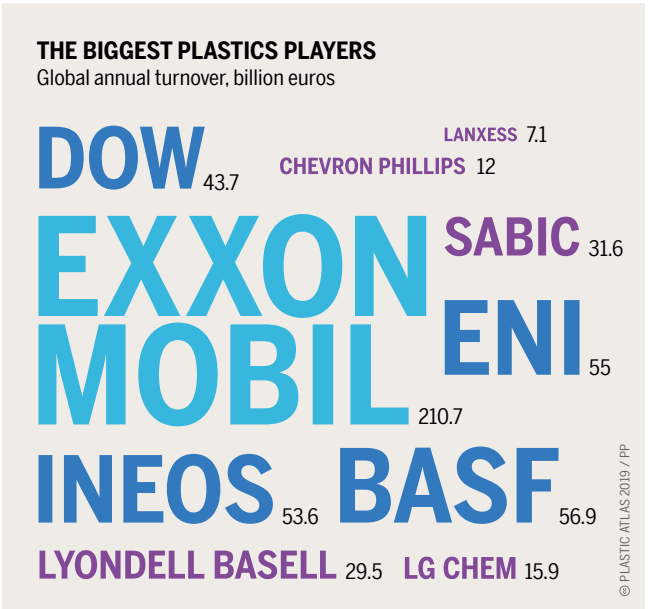
Ineos was founded in 1998 by the chemical engineer, Jim Ratcliffe, one of the richest men in Britain. He plans to expand plastics production in Europe.

for instance, by preventing them from banning plastic bags. Such moves undermine waste prevention and perpetuate the myth of better waste management as the solution.

Corporate lobbyists rotate between government and industry jobs, facilitating privileged communications between the two. In the process to publish the European Commission's Plastic Strategy in 2017, corporate representatives (including from PlasticsEurope, an industry association) had nearly three times as much access to members of the Commission as did NGOs.

Even the lines between NGOs and industry representatives are blurred. A two-pronged strategy has emerged: corporations make big donations to existing mission-driven NGOs, while simultaneously creating and funding organizations that are organized as NGOs but which exist primarily to drive industry interests. Leading up to the 2018 European Union plastics strategy, industry-funded NGOs served as a front to ensure industry interests were served.

This power imbalance results in regulations that favor the petrochemicals and plastics industries, and that devalue the rights of people and the environment. Industry lobbying leads to policies focused on recycling and consumer behavior (i.e., "avoiding litter"), and that ignore the need to reduce the production of plastics.



Just a few major corporations produce most of the world's plastics. Some are household names; others are far less well-known.

THE CHILD OF GLOBAL TRADE

Global economic growth since World War II would not have been possible without plastic. Plastics are both the result of globalization and a fuel that powers it. Online shopping is piling mounds of rubbish higher still.

After World War II, the Western world enjoyed unusually rapid growth by historical standards. The economy entered a golden age: productivity rose steadily, driven by increasing automation and the use of energy derived from fossil fuels. Large sections of the population were able to achieve a hitherto-unknown degree of prosperity. The average middle-class household soon had its own car, washing machine and television. Industry churned out consumer products in ever-increasing volumes at ever-lower prices.

Plastic played a key role in this. Technological advances in the petrochemicals industry made the production of plastics so cheap and flexible that they could be used for single-use items and as packaging, thereby making it possible to sell yet more items. For shoppers that meant consumption any time, anywhere, and simply disposing of the packaging. At the same time, supply chains became ever longer. Transporting goods over huge distances made new types of packaging necessary. Plastics were ready to smooth the way to this wonderful new world.

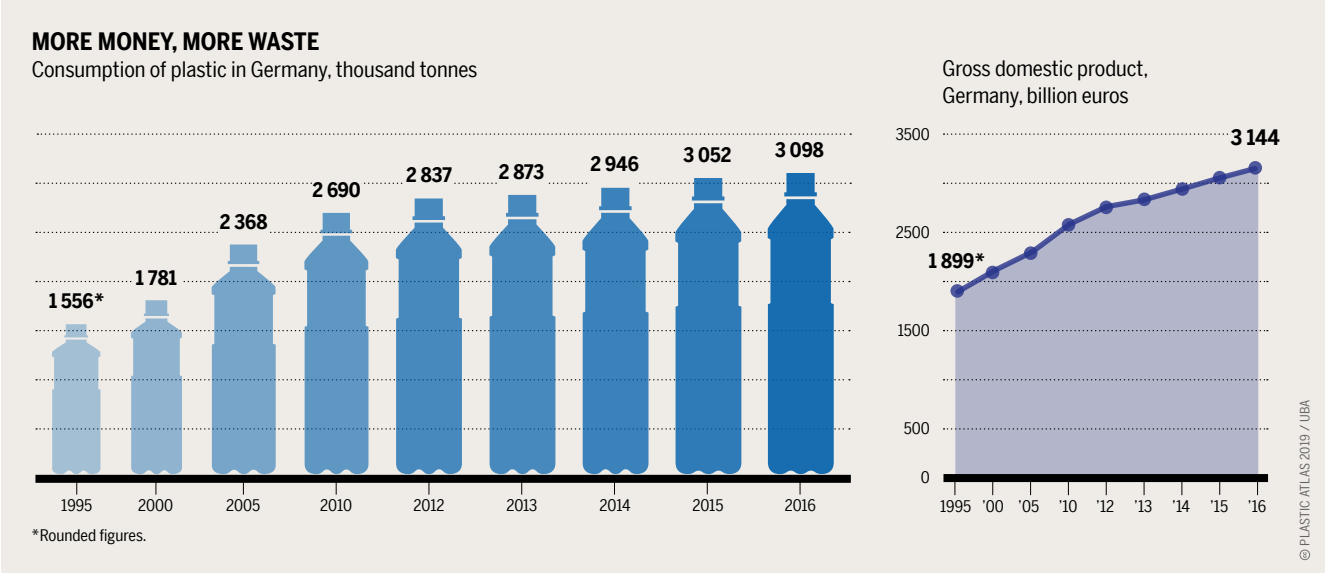
From the invention of Bakelite—the first modern plastic—in 1907, to today's multitude of synthetic compounds, plastics have become nearly indispensable. Companies like Dow Chemical and Mobil Corporation (now ExxonMobil) developed new products, thereby creating new markets for their oil and gas. Chemical giants turn the primary constituents of hydrocarbons into intermediate chemicals, and then into numerous polymers that they mold into a huge variety of end products.

Some materials and products are designed for a specific use; for others, new market applications must be created. This is how the oil and gas industry, threatened by the transition to green energy, is trying to diversify and strengthen its markets. That in turn creates a pressure to develop new materials: to transport food ever further, to offer more attractive packaging properties, or to maximize durability for a given weight. In this way the plastic industry has sunk strong roots into the product design and packaging sectors. Packaging is forecast to remain the most prominent use for plastics until at least 2025.

The massive expansion of single-use packaging is both a result of globalization and a driver of international trade. When a supply chain crosses the globe and the consumer is far away from where the product is made, returning reusable packaging to the production facility is costly and complicated. That is why in the 1960s companies such as Coca-Cola and PepsiCo lobbied against deposit laws that would have required them to take back their glass bottles. Things got worse with an oversupply of plastic feedstock. It was much more convenient and cost-effective to package products in single-use containers. That allowed brands to shed the cost and burden of reverse logistics and ignore any responsibility for what happened to the containers after their contents had been consumed.

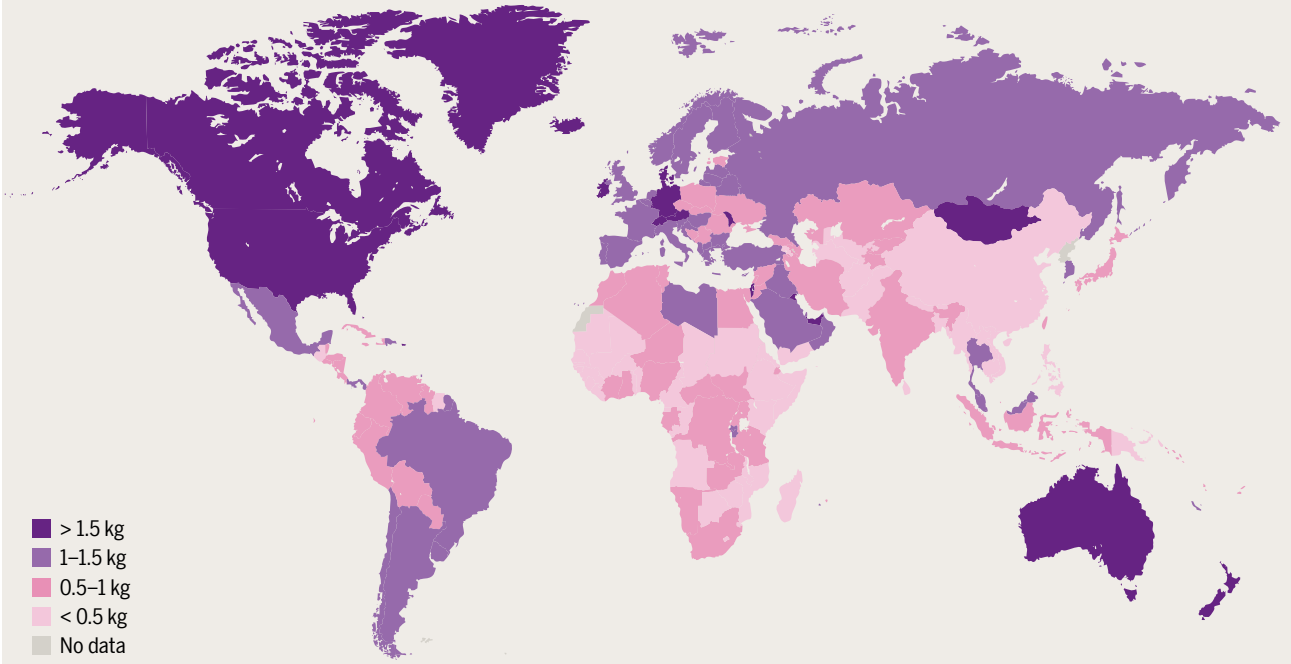
In the digital age, consumers have succumbed to this type of thinking. To save time and effort, more and more people are shopping online. Led by mega-players such as Amazon and Alibaba—today the most valuable companies in the USA and China—online retail has grabbed a significant share of consumer purchases, generating sales of

The tide of plastic is tied to the economy. Economic growth leads to greater consumption, which means more packaging that must be thrown away.



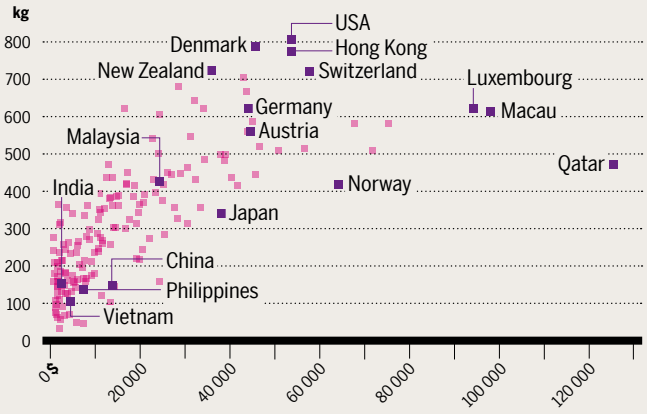
AFFLUENCE AND EFFLUENCE

Waste generation per person per day, 2016



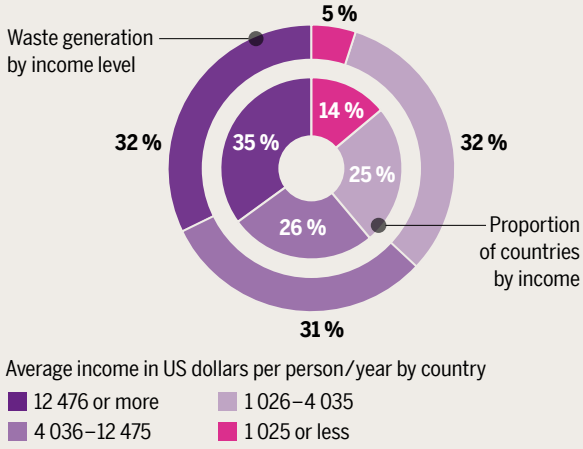
Waste generation and gross domestic product

Kilograms per person/year, GDP per person in US dollars, 2016



Relationship between waste generation and income level

All countries, 2016



On average, each person on Earth generates 0.74 kilograms of waste each day. The amount increases with rising incomes.

hundreds of billions of dollars a year. With huge numbers of packages shipped, the environmental impact of producing and disposing of plastic and cardboard has become a major issue. Industry leaders are coming under increasing pressure to use reusable, recyclable or compostable materials. In 2017 in India, the plastic crisis led to a ban on certain single-use plastic articles.

Simply eliminating single-use plastic and packaging cannot be done without drastically changing how global markets operate. It has become clear that plastic recycling has no chance of coping with the scale of the environmental challenge. Single-use plastics continue to dominate, and plastic-free alternatives are restricted to a few niche markets. The stimulus is lacking for a true paradigm shift. Plastics are still both eminently practical and super-cheap.

Nonetheless, consumer habits have to change. The first signs of this are evident: sustainable packaging is playing an important role in local food and other items—a market that is growing slowly but steadily. A few years ago the first grocery stores opened that dispense with packaging completely: they sell items loose, and customers bring their own containers. Increasing numbers of takeaways are offering discounts for customers who bring their own cups. And bans targeted by the European Union on certain single-use plastic items are at least sending out a signal at an international level that things must change.

REPLACING OIL WITH MAIZE IS NO SOLUTION

Plastics made from renewable raw materials are supposed to be environmentally friendly. They degrade more quickly—at least, according to their corporate backers. A close look shows that they create a new set of problems.

Its biggest advantage is also its biggest drawback: plastic that is made to be very robust does indeed last almost forever. Depending on the type of material, it can take several hundred years for a plastic to break down naturally. Renewable raw materials are already being used as alternatives to petroleum as a plastic feedstock. The so-called “bioplastics” come with an implicit assurance: unlike conventional plastics, they biodegrade more quickly. But they fail to live up to this promise. Just because their name says “bio” does not mean that they are any more environmentally friendly.

“Bioplastics” come in two main types: bio-based and biodegradable. Bio-based plastics are nowadays commonly used instead of PET and PE in packaging. They are based on raw materials such as sugarcane, mainly cultivated in Brazil. This crop is grown as a monoculture with the considerable use of pesticides, which has massive consequences for nature and mankind. Some of the chemicals applied are banned in the European Union to protect the health of people and animals—and especially bees—from their toxic effects. Global price pressure and the dominance of a few firms in Brazil have led to low wages and poverty in the growing regions. The cultivation of genetically modified sugarcane has been permitted in Brazil since 2018.

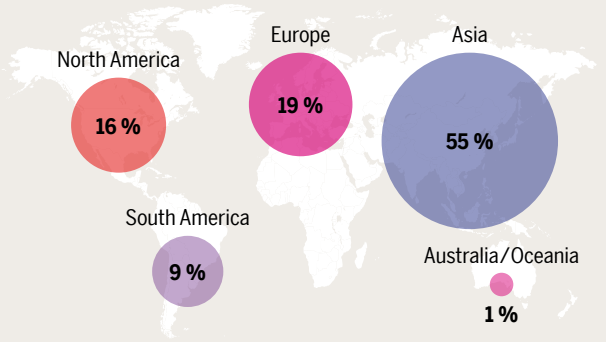
Other agricultural commodities used as raw materials for “bioplastics,” such as maize and potatoes, are also products of highly industrialized farming. Large-scale industrial plants convert these agricultural commodities into the chemical building-blocks that are fed into a production process similar to conventional plastic production. Depending on the item, the renewables may account for between 20 and 100 percent of the end product. The rest consists of fossil raw materials, or increasingly of recycled ingredients.

In 2017, the production capacity of bio-based plastic was about one percent of total plastics output. Currently, only 0.02 percent of the global agricultural area is used to grow the plants that go into them. At first sight, replacing fossil raw materials with agricultural commodities may therefore seem unproblematic. But this proportion is expected to grow rapidly in the coming years. If one considers the forecast growth in plastics production against the use of arable land, and one thing becomes clear: the pressure on the current cultivated area is going to rise even more. In some parts of the world this is already leading to water shortages, species extinction, desertification and the loss of natural habitat. Expanding the cultivation of agricultural raw materials is not an option for producing environmentally friendly plastic.

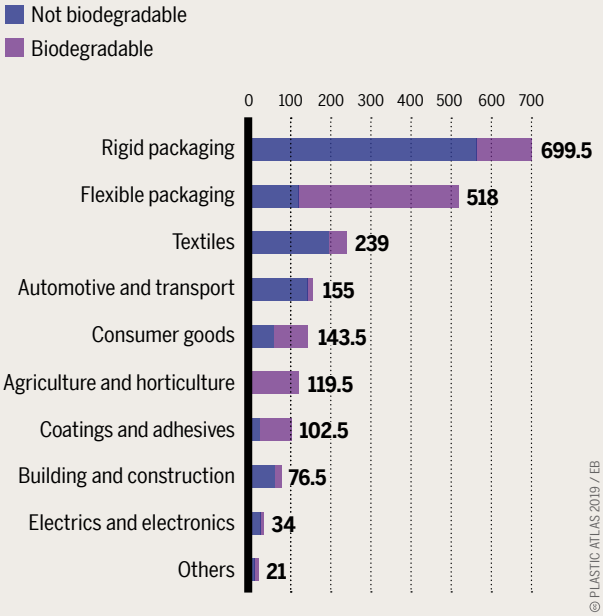
The second category—biodegradable plastics—are designed to be degraded by microorganisms under specific conditions. These plastics may also be bio-based, but they do not have to be. Biodegradable plastics are used for everything

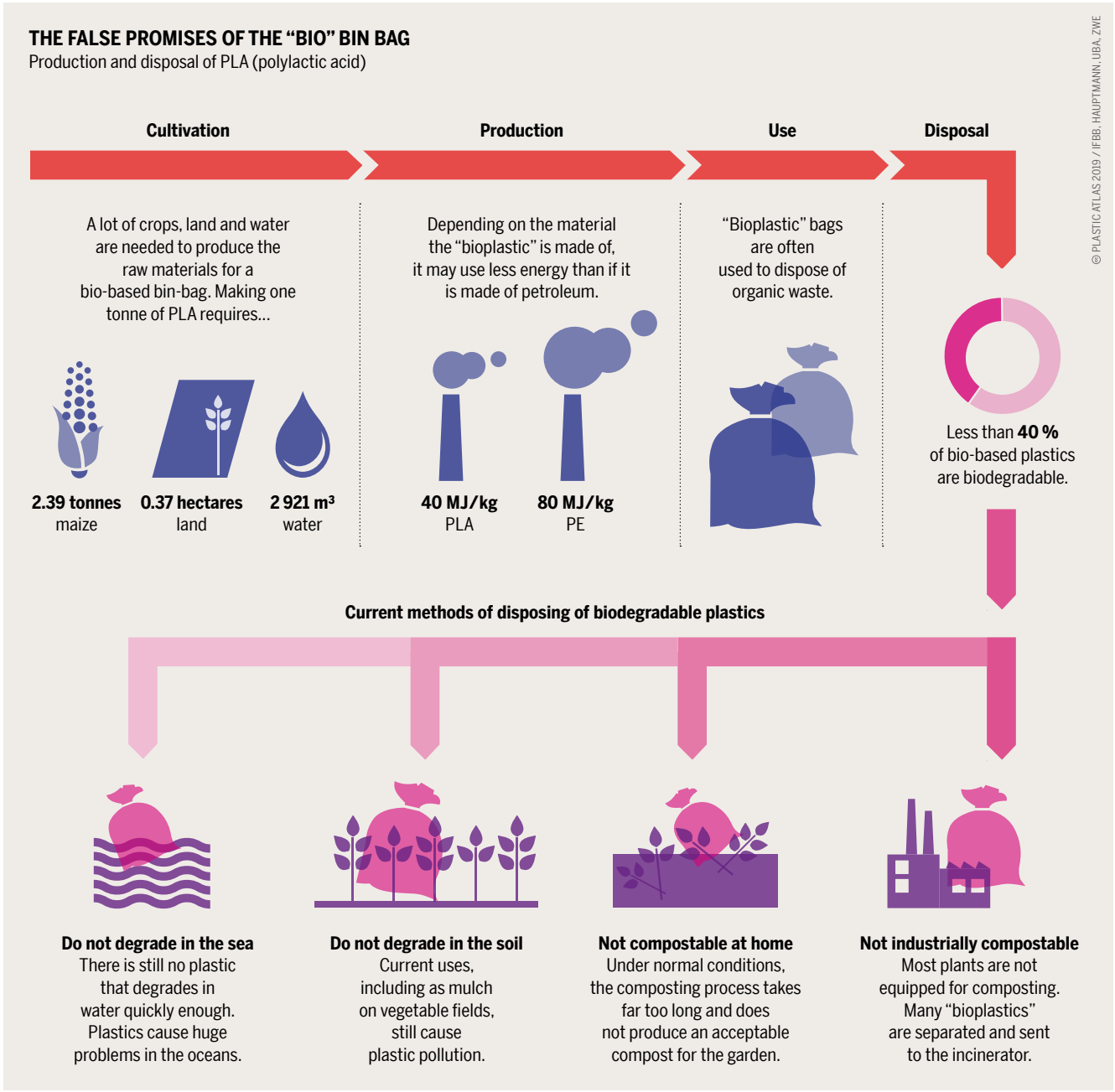
The volume of “bioplastics” produced worldwide is still small. But it is becoming more popular as an alternative to fossil raw materials.

PRODUCTION AND USE OF “BIOPLASTICS”
Production capacity of bio-based plastic in percent, 2018
(total: 2.11 million tonnes)



Bio-based plastic by industry sector, thousand tonnes, 2018





A bin bag that is made out of renewable raw materials implies a sustainable cycle, but it creates significant environmental problems.

from compostable bin liners, to food packaging such as yoghurt containers, to takeaway coffee cups and fast-food trays. A specially designed international label is supposed to certify that the item can be composted. But reality is rather different.

According to the test criteria for the label, the plastic has to be 90 percent degraded after 12 weeks at 60 degrees Celsius. But most composting plants allow waste to rot for just four weeks. Extending this period does not make economic sense. At the end of the process, only water, carbon dioxide and mineral additives remain, but no materials that can form humus. Plus, heat is released that cannot be used in the further recycling process. To make the next bin liner or yoghurt pot, more energy must be generated. Strictly speaking, this process is not really composting, but simply waste disposal. Regardless, the majority of Europe's biodegradable plastics currently ends up in incinerators.

One argument often used to justify bio-based and biodegradable plastics is that taking their whole life cycle into account, they have less of an impact on the climate than comparable, conventionally produced plastics. But even that claim is undermined by the overwhelming acidification and overfertilization of soils and water caused by the conventional cultivation of the crops used to make bio-based plastics. And even such life-cycle assessments fail to take into account the direct and indirect changes in land use or the effects of using genetically modified crops. The consequences for biodiversity in the areas that produce crops for "bioplastics" have not yet been adequately studied.

The attempt to simulate biological cycles will not be enough to stem the flow of plastic waste. "Bioplastics" only shift the problem and distract attention from the real solutions.

WE CANNOT RECYCLE OUR WAY OUT OF THE PLASTIC CRISIS

It is a widespread misconception: as long as we separate our waste into different types, we do not have to change our consumption patterns. But the reality is different: a large proportion of plastic waste is not recycled, much of it is incinerated or ends up in the environment.

Since the start of large-scale production of synthetic materials in the 1950s, 9.2 billion tonnes of plastic have been made. Only 24 percent remains in use, resulting in 6.3 billion tonnes of waste. No way has yet been found to deal with this waste without causing yet more problems.

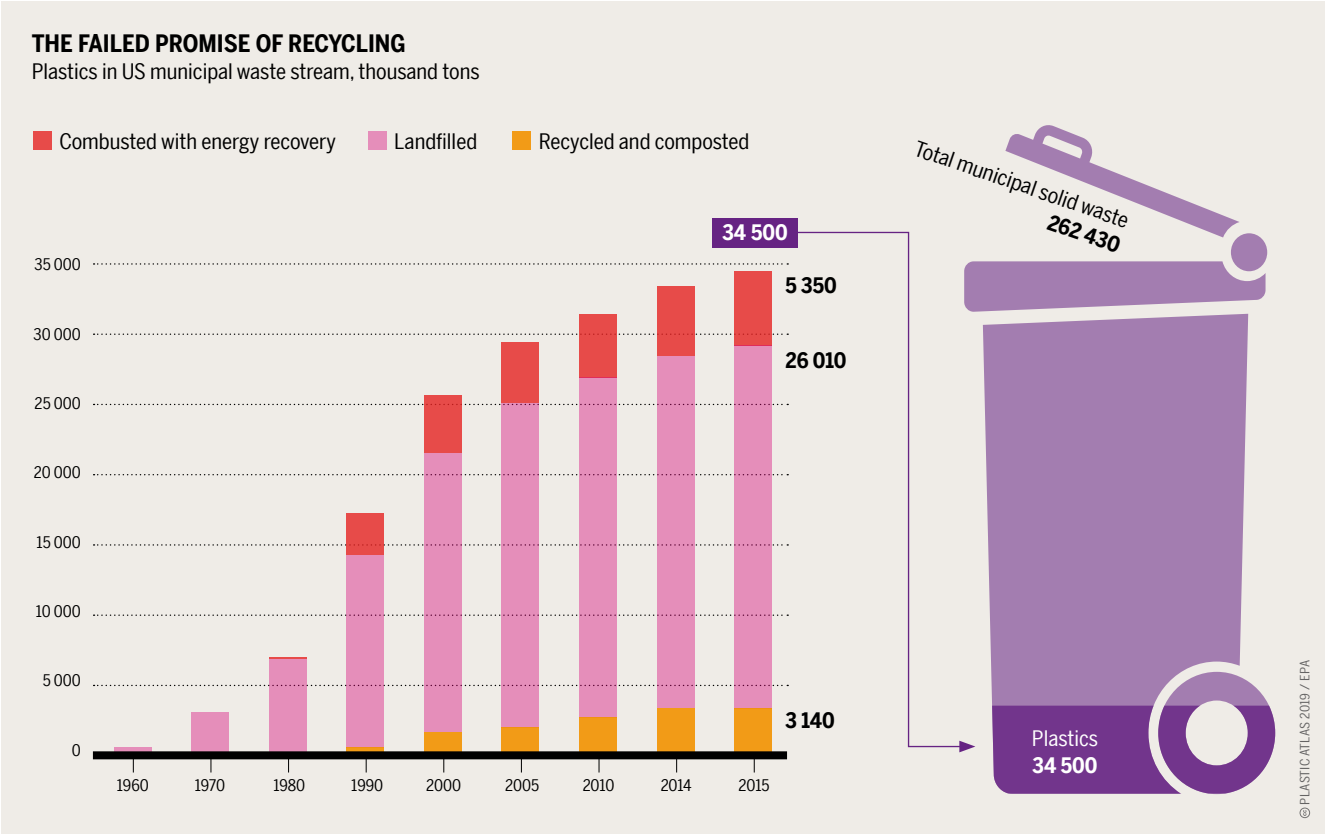
Packaging, which makes up 40 percent of all plastic waste, poses a particular set of difficulties. Most is designed to be thrown away after a single use, but it is extremely difficult to recycle as it is commonly made from multi-layered materials. On a global scale, 14 percent of plastic packaging is currently recycled—though this usually means "downcycling" to make an inferior-quality product. Another 40 percent is disposed of in landfills and 14 percent is burned in incinerators. The remaining 32 percent finds its way into the environment, including dump sites, rivers and the sea, or into the air we breathe.

Allowing plastic waste to enter the environment presents a myriad of environmental and health hazards—beyond the well-known visual blight of plastic bottles on our shores and bags and wrappers blowing along our streets. Originally derived from fossil mineral oil and gas, and mixed with hazardous additives, plastic has the potential to remain on the land or in the ocean for hundreds of thousands of years. In the sea, plastic litter threatens marine organisms, especially fish, seabirds, and marine mammals. On land, the health effects and other impacts of plastic gradually breaking down and seeping into the soil or entering food streams are still being researched.

Open burning is one way to get rid of plastic, but this simply releases carbon dioxide and many toxic chemicals that plastics contain into the atmosphere. In addition to dirtying the air we breathe, it is no secret that burning hydrocarbons is a leading contributor to climate change.

Incineration takes the practice of open burning and does it at an industrial scale. Incineration facilities come in many forms, including "waste-to-energy" plants, co-incineration

Despite the hype, very little plastic is recycled in the USA. The US recycles less than one-tenth of the plastic waste it generates. Most goes into landfills.



in industrial boilers and cement kilns, and "plastic-to-fuel" technologies such as gasification and pyrolysis. As with open burning, these solutions convert plastic waste into air pollution in the form of respiratory irritants, cancer-causing dioxins and furans, heavy metals including mercury, cadmium and lead, and major greenhouse gases. Even sophisticated pollution control equipment cannot prevent all pollutants from being released into the air. The captured pollutants are concentrated in the ash, which is sent to landfills or mixed in cement and other building materials. From there the pollutants can leach into the soil and groundwater.

Incineration is also cost-prohibitive, both because of the massive investment and maintenance requirements, and due to the low efficiency of waste as a fuel and a constant demand for feedstock to keep the system operational. Solid-waste combustion is the most environmentally damaging industry in the US relative to the benefit it provides. Meanwhile it undermines recycling by consuming recoverable materials as feedstock and taking investments away from true renewable energy and zero-waste solutions.

While recycling is preferable to incineration, it too presents considerable economic and technical challenges. This is why only ten percent of all discarded plastic has been recycled. Different types of plastic require separate processing, and even the most advanced technology can recover only small amounts of material that is as good as new. Recycling usually produces low-quality mixed plastics that can be used only for low-value items such as the bases of traffic signs. The market for such products is restricted.

Manufacturers tend to prefer using virgin plastic rather low-quality recycled material. The rock-bottom price for new plastic, and the costly sorting and processing needed for plastic scrap, has led to much plastic waste from developed countries being shipped overseas. In January 2018, China, the main importer of such scrap, ended this practice, forcing the market to find other destinations for the waste. In the United States, Philadelphia is now sending its recyclables to be burned in the nearby city of Chester.

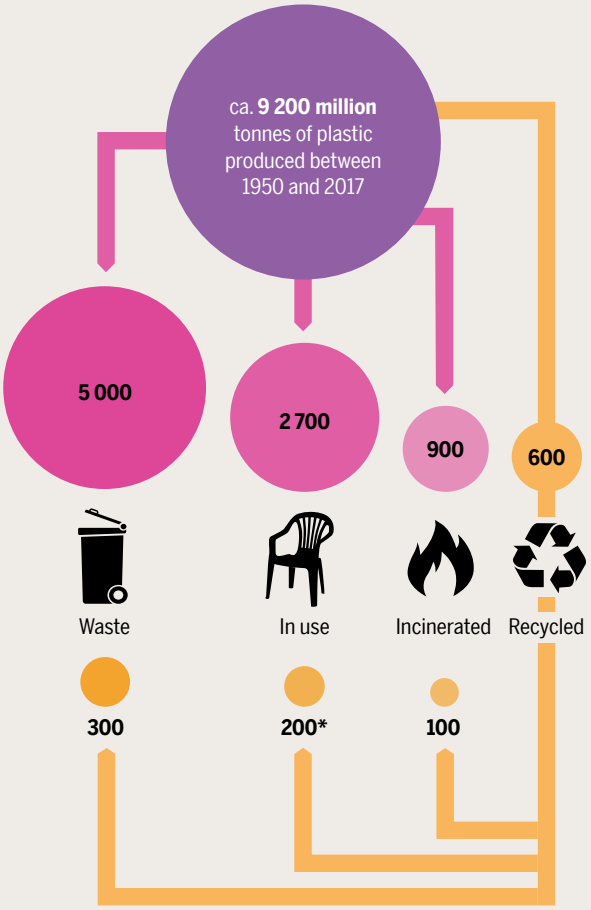
So-called "chemical recycling" is no better. This type of processing turns plastics into fuels and gases. But attempts to break scrap down into basic constituents that can be turned into new plastic have so far proved to be impractical at a large scale. Problems include the emissions, toxic by-products, and high energy consumption. Attempts have been dogged by high-profile failures, fires, explosions and financial losses. The US Environmental Protection Agency thinks that such processing poses similar health risks to conventional waste incineration.

All the current processes to use waste plastic in other ways lag far behind the huge volumes of new materials being generated. As consumption continues to grow, even high-quality recycling cannot diminish the amount of oil and gas being pumped to make new plastic. The most effective way to reduce the damage caused by plastic after its useful life is over would be to reduce the flow at source. The first step must be to eliminate single-use plastic items.

Recycling saves a large majority of the energy contained in plastic waste. That is not the case with incineration, where most of the energy is lost.

THE CAUSES OF THE CRISIS

Global production, use and disposal of plastics, 1950 to 2017, in million tonnes

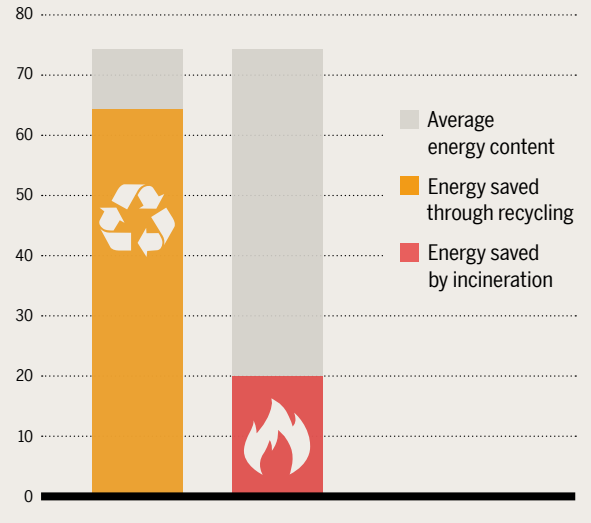


* Of this, half is again recycled.

A glance at the flows of plastics made since the 1950s shows that recycling is part of the problem, not part of the solution.

WASTED ENERGY

Energy balance of incinerating waste, energy in megajoules/kg



THE RUBBISH DUMP IS CLOSED

What to do with your unwanted plastic bottles and bags? Simple: send them somewhere else. Until recently, much of the developed world's hard-to-recycle waste was shipped off to China. That is no longer an option.

Until January 2018, China was the main destination where exporting countries (predominantly G7 nations) sent their plastic waste to be recycled. Since 1988, around half the planet's plastic waste has been sent to this country to be melted down and turned into pellets. That changed dramatically when China announced it would only accept bales of plastic waste with less than 0.5 percent contamination by non-recyclable materials—a much higher bar than the previous level of 1.5 percent. The new standard is almost impossible to meet, given that plastic material entering recycling facilities in the United States may contain 15–25 percent contamination. The new rule effectively banned the vast majority of plastic scrap imports and created a moment of reckoning for international recycling markets.

China had many reasons for shutting its doors to foreign waste. "Materials recovery facilities" in the developed world would sift through plastic waste, sort out the valuable stuff (like PET and HDPE) for recycling locally, and ship the remaining low-quality items off to China. Such waste contains a variety of materials, chemical additives and dyes that make it next to impossible to recycle. Workers who process these shipments are often exposed to hazardous chemicals. The plastic that cannot be recycled is disposed of in incinerators, landfills or dumpsites, polluting the air, land and sea. These environmental and social ills led China to close its borders, drastically shifting worldwide flows of plastic waste.

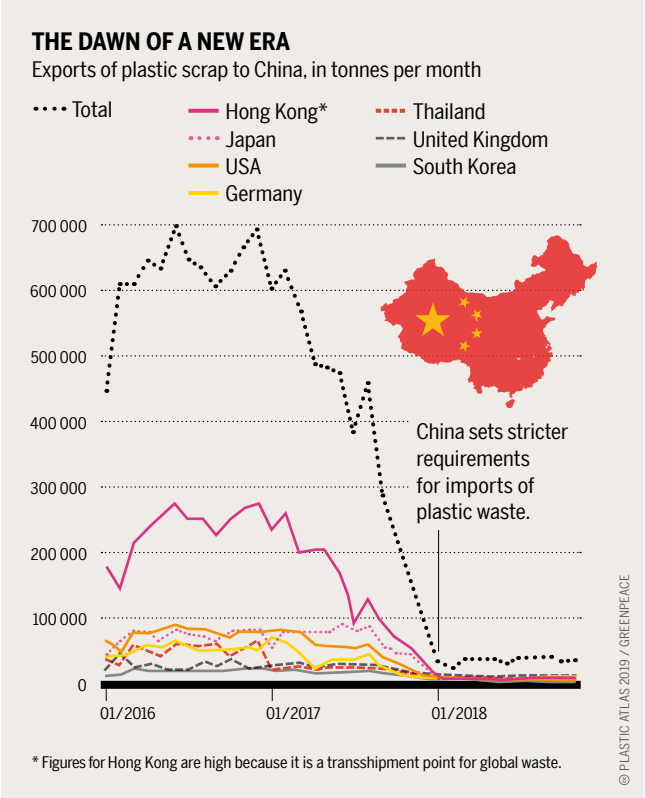
With the primary importer of plastic waste out of the market, exporting countries began sending increasing volumes of scrap to Southeast Asia. In Thailand, imports of plastic scrap rose nearly seventy-fold in the first four months of 2018 compared to the same period in 2017, and in Malaysia they rose over six-fold. In the same time period, imports in China fell by 90 percent. The sheer quantity of imported scrap overwhelmed ports and caused a sharp uptick in illegal recycling operations and waste shipments. In May 2018, a big Vietnamese shipping terminal temporarily stopped accepting scrap materials after it had amassed more than 8,000 containers full of plastic and paper. In Malaysia, almost 40 illegal recycling factories were set up, dumping toxic wastewater into waterways and polluting the air with fumes from burning plastic. In just a single raid, inspectors in Thailand found 58 tonnes of illegally imported plastic.

The environmental and human health impacts have led many importing countries to restrict or ban imports of plastic scrap. In 2018, both Thailand and Malaysia announced bans on imports of plastic scrap by 2021; in 2019 India and Vietnam followed suit with their own plastic import bans. Indonesia has restricted imports of non-recyclable waste.

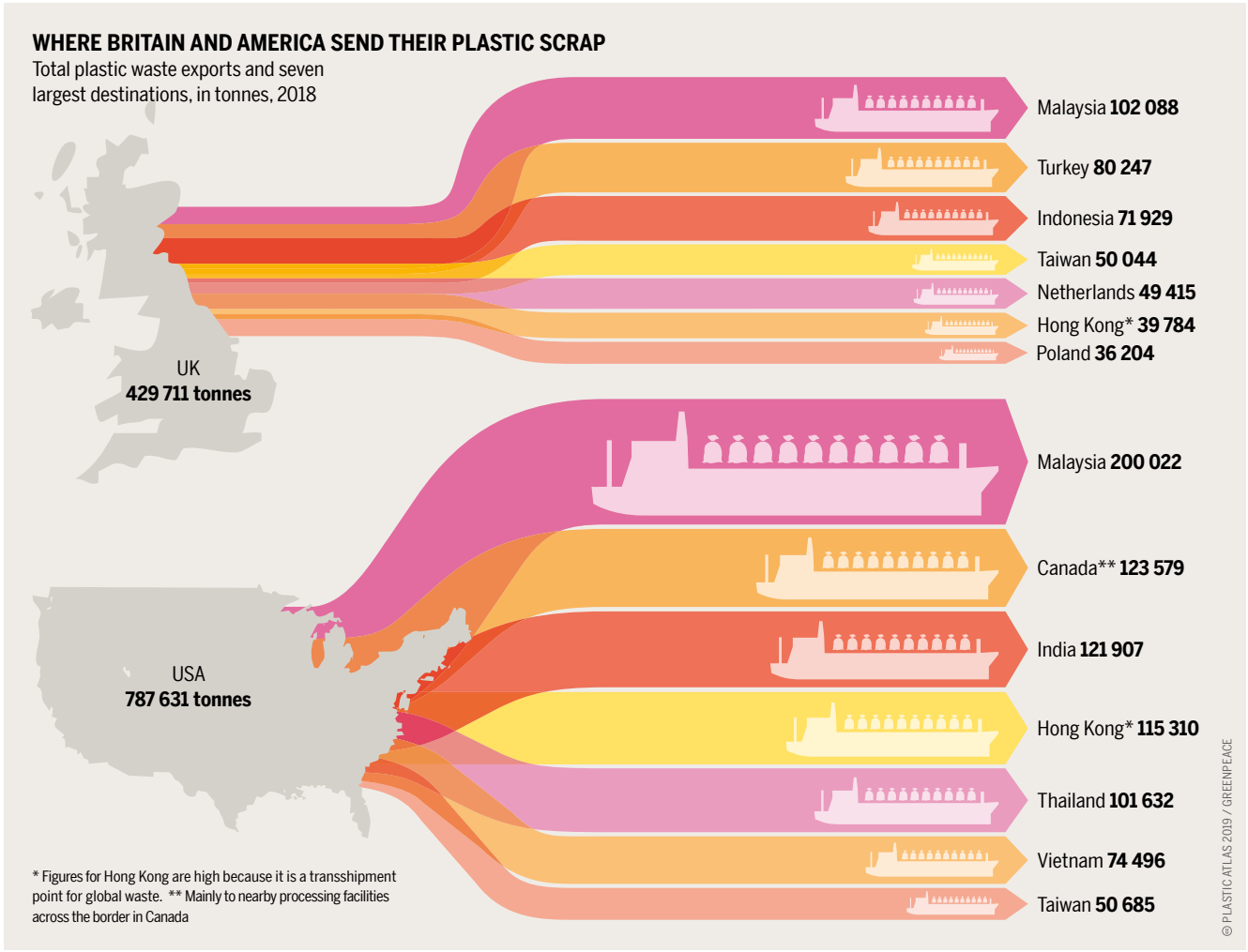
These countries are also cracking down on contaminated foreign waste imports—by sending them back where they came from. In May 2019, the Philippines succeeded in getting Canada to take back the waste that had been mislabeled and dumped there six years previously. That same month, the Malaysian Minister of the Environment, Yeo Bee Yin, said her country would by the end of the year ship back a total of 3,000 tonnes of waste, or around 50 containersful, to countries like the UK and USA.

In July 2019, Indonesia announced it would return 49 containers at Batam port to Australia, France, Germany, Hong Kong and the USA because their contents violated laws on the import of hazardous and toxic waste. That same month, Cambodia declared it was "not a dustbin" for foreign waste, and would be sending back 1,600 tonnes of garbage.

Facing mounting piles of post-consumer plastic and a collapsing global recycling market, exporting countries have resorted to landfilling or burning recyclables. In the UK, thousands of tonnes of mixed plastics collected for recycling are being sent to incinerators. In the USA, cities in Florida, Pennsylvania and Connecticut incinerate their recyclables; other municipalities across the USA landfill materials they cannot stockpile. Australia has announced that exports of



In 2016, monthly exports of plastic trash to China exceeded 600 000 tonnes a month. By 2018, they had shriveled to less than 30 000 tonnes.



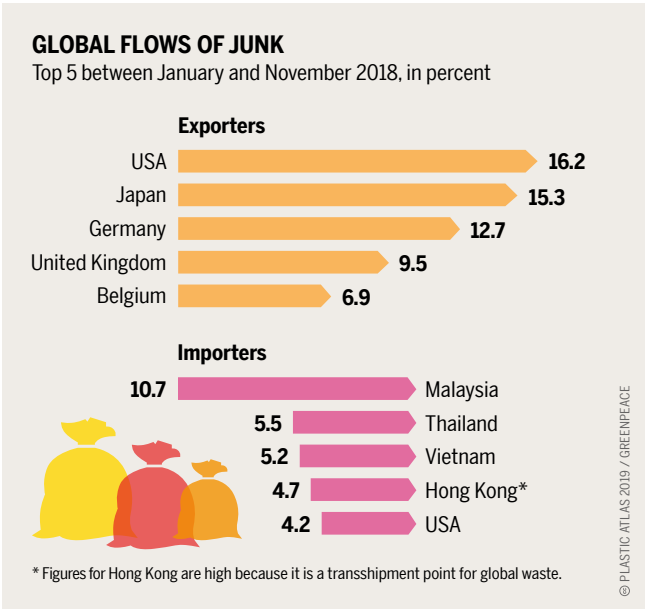
Britain and the USA are among the world's top exporters of plastic waste. Most of what arrives in Asia is almost impossible to recycle.

recyclable waste would be banned to prevent ocean pollution, and is considering incinerating its plastic waste.

But incineration emits carbon monoxide, nitrous oxide, particulate matter, dioxins, furans, and other pollutants linked to cancer, respiratory illness, nervous disorders and birth defects. Such emissions threaten nearby communities. The residual ash may end up contaminating land and water.

Asia's bans and restrictions and the mounting urgency of the plastic waste problem have led to suggestions for reforms to the global waste trade system. In May 2019, 187 countries agreed to amend the Basel Convention (which governs trade in hazardous wastes) to subject shipments of scrap plastic to tighter controls and greater transparency. Set to come into effect in 2021, this amendment will create more accountability around the plastic scrap trade, preventing its worst effects and paving the way for more substantial reforms.

While the world struggles to handle the flood of waste, industry plans to increase plastic production by 40 percent in the next decade. The rising costs of plastic waste are forcing governments to take action. Cities and countries are imposing bans, fees and other restrictions on single-use packaging in an effort to force producers to change their business practices. The world is starting to understand that we cannot recycle our way out of plastic pollution: we simply need to make less of it.



The industrial world is the source of most plastic waste exports. The biggest importers are in Asia. Most waste consists of containers, films and sheets.

SCRAPS FROM THE TABLE

In many poor countries, waste pickers take over the tasks of the municipal garbage truck and waste processing plants. They divert a significant amount of waste back into productive uses.

Waste pickers survive by sifting through waste and selling items that are of value: glass, paper, cardboard, metal—as well as plastic packaging, bottles and bags. They are a common sight in the cities of Africa, Latin America and Asia, but they are also found on the streets of North America and Europe. It is not known how many there are, but local organizations in Latin America estimate that about 4 million, including large numbers of women and girls, work in that sector. In a survey of 763 waste pickers in Africa, Asia and Latin America, 65 percent of the respondents said they earned the majority of their income by collecting and selling waste.

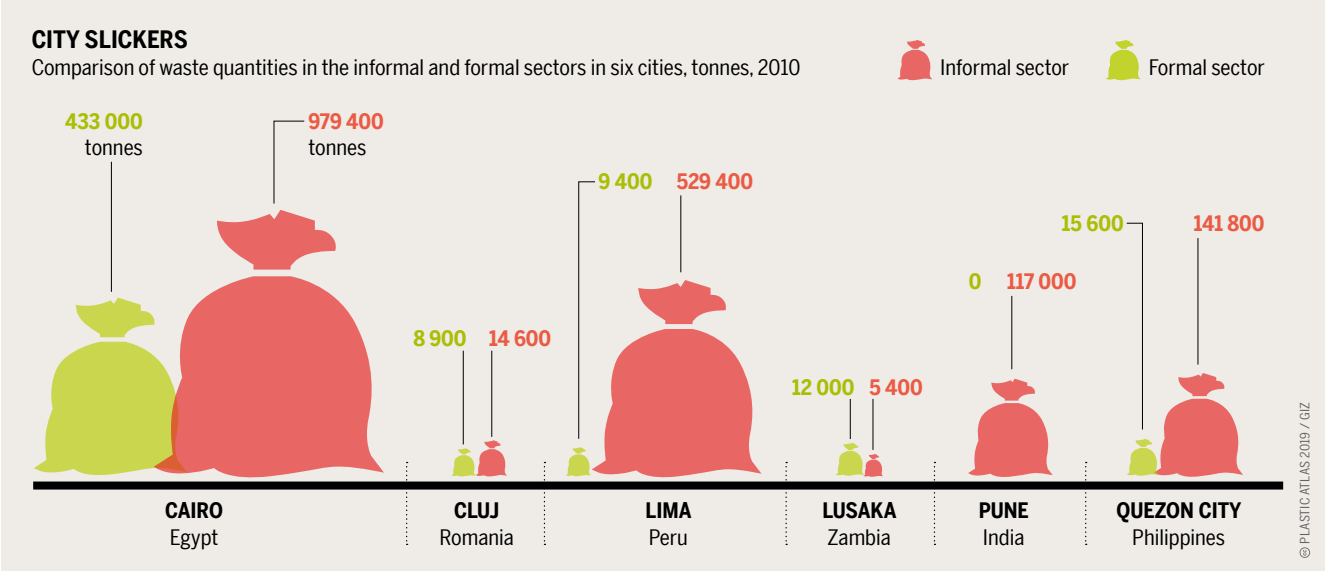
Waste picking is intrinsically related to widening social and economic inequality. People without access to education, housing, health services and even food have no choice but to scrape a living by processing other people's garbage. Many waste picker families—some of which span three generations—live on dumps and next to open pits. Fallen into a cycle of poverty, they face numerous health problems from handling contaminated materials, eating spoiled foods and contracting diseases from flies, rats and cockroaches. Dumps are physically dangerous: it is not uncommon for people to die trying to get at the best materials that garbage trucks bring in. Some waste pickers are homeless or live far from the wealthier residential or commercial areas that generate trash. They pull handcarts to such areas to collect rubbish from bins and roadsides, then haul them home to sort and sell the recyclable portion.

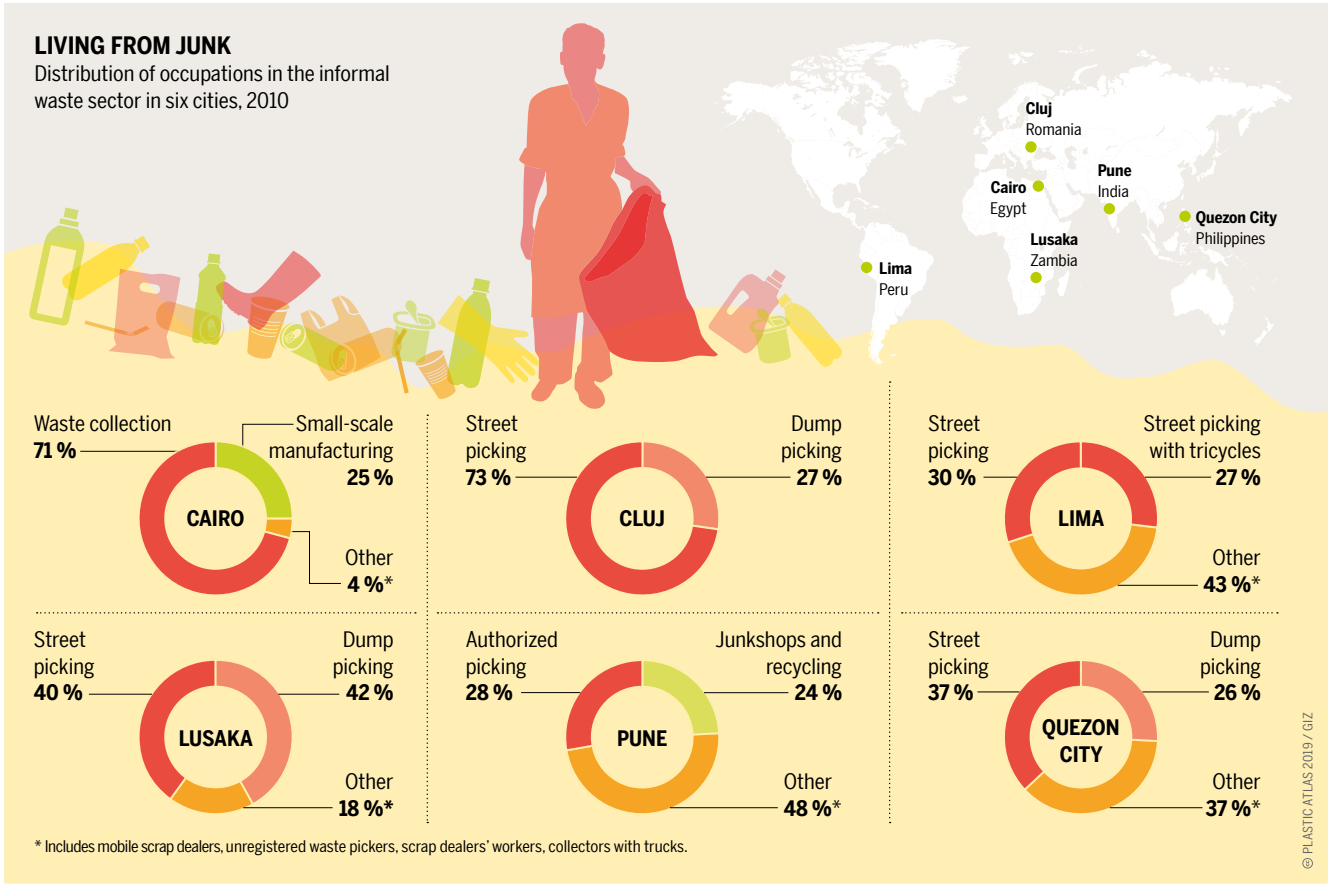
Many waste pickers have organized into associations, cooperatives or community groups. These can gain access for their members to waste materials with greater market value, and fight for less contamination and safer working conditions. By pooling larger quantities of materials, they can leverage their bargaining power and secure better prices from buyers. They can also advocate for national and local policies that guarantee rights to better working conditions, safer equipment, personal protection equipment, and higher remuneration. For example, in many countries, waste pickers collect and separate materials in categories required by the recycling industry, and they carry out environmental education activities with residents to separate recyclables properly so they can be sold.

These workers spend more time than anyone else with the detritus of the global consumer economy, so they know more than most about the composition and nature of post-consumer plastic products and packaging. Because they make a living by reselling discarded material to secondary markets, they have an acute sense of which items are valuable and which are not. Plastic products are typically the most problematic to collect and resell, due both to their design and to market conditions. In some places, the vast majority of plastic has no aftermarket value; in others, recyclable products are limited to a few items. In Latin America, waste pickers find it worthwhile to process only three of the seven major types of plastic: PET, HDPE and LDPE.

A survey of waste pickers in Africa, Asia, and Latin America found that 65 percent earned a major part of their household income from collecting and selling recyclable products. They are often the only people to divert reusable

The informal sector plays a huge role in keeping mounds of rubbish under control, especially in cities with little recycling or waste disposal infrastructure.





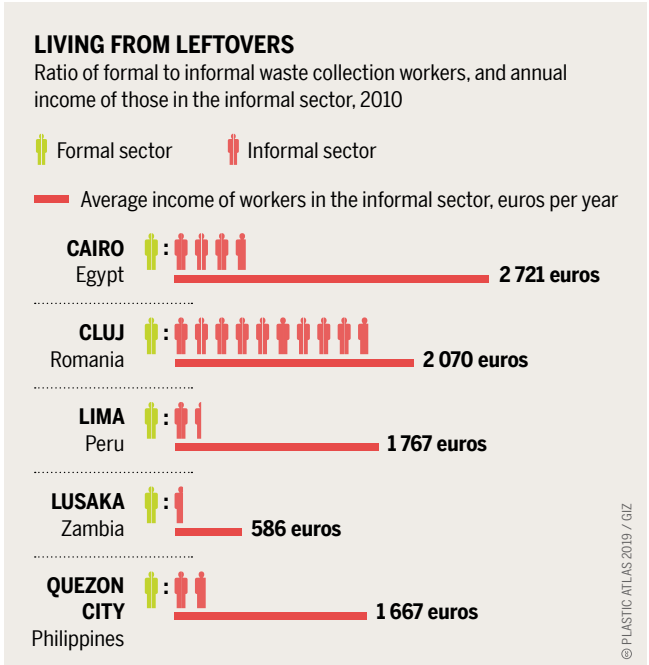
A broad spectrum of informal waste picking businesses exists. All rely on the processing and sale of waste as their basic source of income.

materials from landfills and dumps into the secondary market, so closing the loop and creating a circular economy. In Latin America, recycling companies rely on waste pickers to provide some 25–50 percent of all recyclable material. Their efforts help reduce the need to extract and process raw materials, reduce greenhouse gas emissions, and provide environmental-health benefits to the community.

Waste pickers have been at the forefront of identifying plastic as problematic. By aggregating and sorting different types of rubbish, their coops can assess waste streams more comprehensively than individuals can. The prices paid for plastics are very low compared to paper, cardboard and metals. Any demand for plastic is typically seasonal, making it difficult to earn a reliable income from it. Sorting plastic takes a lot of time, for example to separate non-recyclable plastics from those that have some value. Often, a significant portion of the plastic collected and sorted cannot be resold.

Waste pickers around the world are often marginalized and their efforts go unrecognized. Laws are needed to recognize and strengthen them as professionals performing a vital service. Funding for space, facilities, equipment, trucks and other types of support can mean the difference between a waste picker co-op struggling to survive and flourishing. Initiatives can support waste pickers and their families by improving their working conditions, and by providing housing and health services. One scholarship programme in the Philippines offers stipends so children can stay in school instead of having to help support their family by picking waste themselves. Producers can help build circular economies by making products reusable or recyclable and by implementing "extended producer responsibility" schemes that properly compensate waste pickers.

For many of the poorest families in the developing world, their sole source of income comes from sorting waste and selling it to recycling firms.



SOLUTIONS AT THE WRONG END

There is no lack of agreements and initiatives to manage the plastic crisis. But almost all address waste disposal only; they are not coordinated with each other, and they absolve manufacturers of their responsibilities.

Approaches exist at various levels to regulate plastic production and the handling of the resulting waste at the end of the product's useful life. But all these approaches have something in common: they are of limited effectiveness. That is partly because the large number of binding international agreements and voluntary initiatives have been developed independently and have not been coordinated with each other. It is also because most current agreements reduce the plastics problem to one of waste. That prevents them from dealing with the full implications of using plastics.

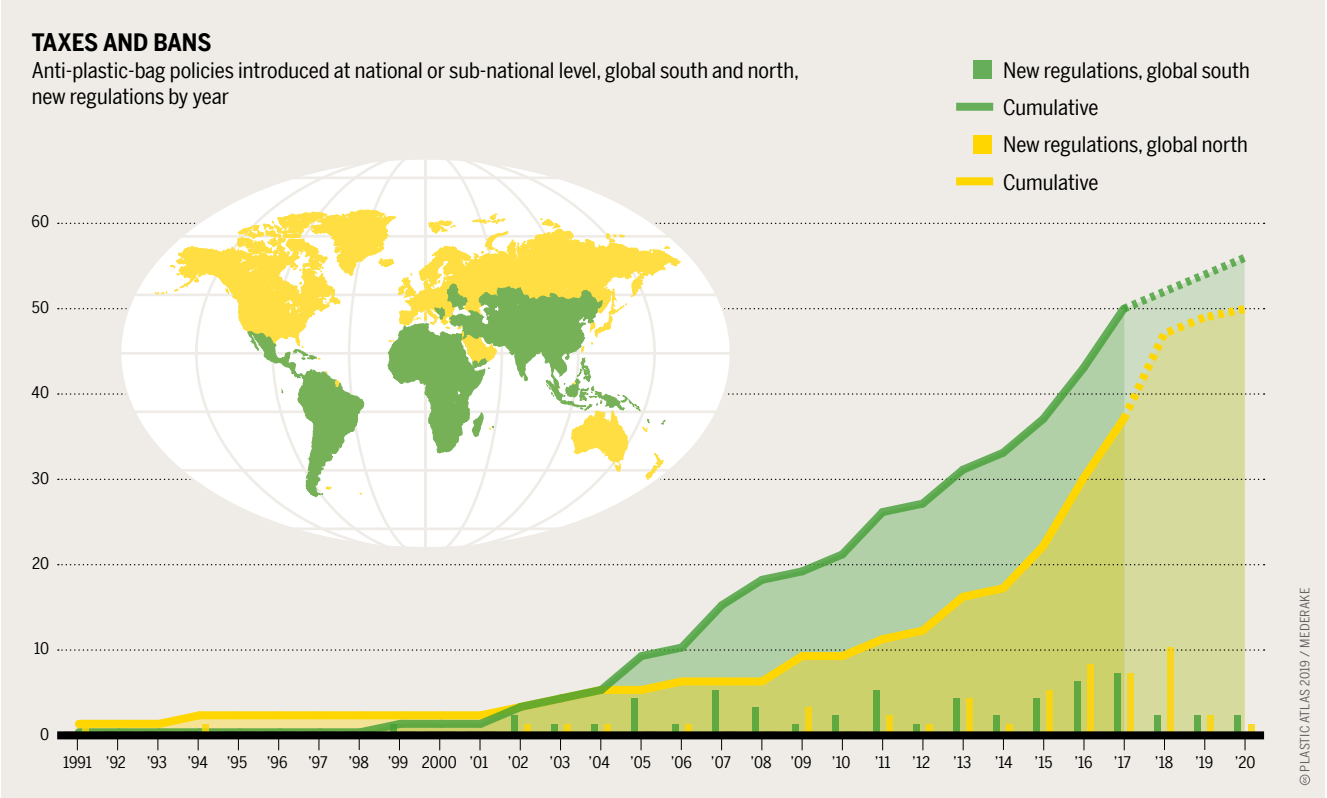
Examples abound. The International Convention for the Prevention of Pollution from Ships (MARPOL) was signed in the 1970s to prevent the littering of the oceans. The 1982 United Nations Convention on the Law of the Sea (UNCLOS) also regulates the dumping of waste at sea. Then there are currently 18 different conventions covering 12 regional seas: some of these refer to marine sources of plastic waste, some focus on land-based sources, and some are concerned with both. Another treaty, the Stockholm Convention on Persistent Organic Pollutants, prohibits the use of certain harmful chemicals in plastics, such as plasticizers. Some international conventions are ambitious, but all are so narrowly drawn that they fail to be fully effective.

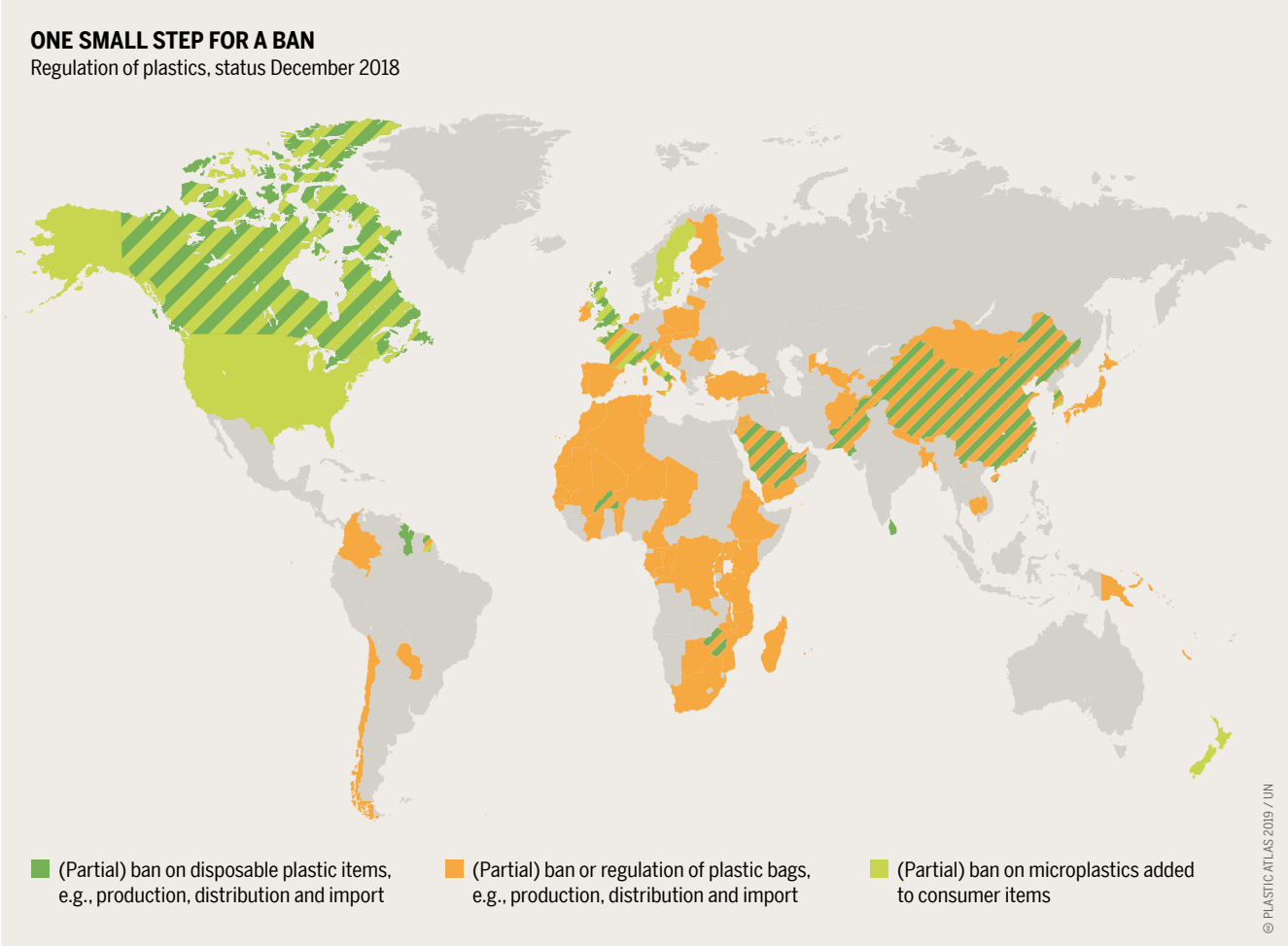
More recent agreements attempt to take a holistic approach to marine litter. The language used in the action plans of the G7 and G20 on marine pollution and garbage, and a resolution of the Third Session of the UN Environment Assembly (UNEA-3) in December 2017, at least give the impression that there is a lot of pressure to act. But none of these agreements are binding on their signatory member states.

But progress is being made, albeit slowly. As agreed upon at UNEA-4 in March 2019, an expert group is now developing options for action based on the UNEA resolution. That might possibly lead to a binding international convention on plastics. This would anchor global reduction targets in international law, and states would have to take responsibility for not doing enough to reach these targets.

Meanwhile, in May 2019 the parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal adopted stricter regulations on plastic waste. A new classification aims to ensure that dangerous and contaminated plastic waste can be shipped only with the consent of both the importing and

Germany and Denmark introduced taxes on plastic bags in the early 1990s. Since 2004, developing countries have introduced more restrictions.





Measures differ markedly: North America regulates microplastics, while many countries in Africa and Asia have banned plastic bags.

the exporting countries. This will make it more difficult to dispose of plastic waste in countries that have laxer environmental standards.

In January 2018, the European Commission proposed a strategy that identifies three key problem areas. First, the low levels of recycling and reutilization rates. Second, the entry of plastics into the environment; and third, the carbon dioxide emitted during the production of plastics. A central aim of this strategy is for all plastic packaging to be 100 percent recyclable by 2030. In December 2018, the European Council, Parliament and Commission, the three main decision-making bodies in the EU, initiated a ban on various single-use plastic articles, including straws and cutlery. They also agreed a series of other measures, such as a quota of 25 percent recycled material in PET bottles from 2025 on. Avoiding single-use plastic items is of special importance. Along with the USA, Japan and China, the European Union is one of the world's biggest producers of plastic waste.

At the national level, approaches have long been limited to the question of how to collect and recycle plastic waste. The concept of "extended producer responsibility" refers mainly to this. Since 1991, packaging producers in Germany have had to pay for the removal and recycling of packaging waste as part of a waste separation scheme known as the "Grüne Punkt", or "Green Dot". A symbol printed on each item of plastic packaging tells the consumer whether it can be recycled.

Increasing numbers of countries are trying to reduce the use of items such as plastic bags by imposing rules and bans. But most such rules are very narrowly defined. They either stipulate the thickness of the material the bag is made of—so only certain types of bags are banned—or they impose levies on bags. More comprehensive bans on plastic bags are to be found only in the global south, where the pressure on governments to do something is particularly high because plastic bags clog up drainage canals—as happens frequently in India and Bangladesh. But if cheap and viable alternatives do not exist, there is a danger that a black market for plastic bags will develop.

Various countries have attempted to regulate the inclusion of microplastics in cosmetics and the use of disposable plastic items such as polystyrene boxes and plastic cutlery. A few pioneers, such as Costa Rica and India, are striving for a general ban on disposable plastics.

But all these approaches do nothing to tackle the basic problem. Almost all the regulations are targeted at the waste disposal end of the chain, and put the onus on the consumer. Very few binding rules exist to force producers to cut back their production of plastic items or to develop products that can be recycled more easily. And current regulations fail to cover a large part of the plastics, or microplastics, that gets into the environment. The abrasion of automobile tires is an example: according to estimates, it accounts for around one-third of all microplastic emissions in Germany.

HOW THE PLASTIC-FREE MOVEMENT IS EXPOSING THE GIANTS

The global Break Free From Plastic civil society movement is working to stop plastic pollution for good. It is using public exposure and transparency to put corporations under pressure.

Drop into your local store and buy a snack or a drink. Most likely it will come in a package or container made of plastic—which you then have to dispose of somehow. The same is true of a wide range of consumer items. It is hard to make any purchase, large or small, without coming home with a pile of plastic packaging that will end up in the bin. Yet consumers are blamed for the waste problem. A new movement is showing where the fault really lies—with the global industry that produces and uses plastic.

For decades, industry has framed plastic pollution as a problem of litter and waste management. This framing is widely promoted globally, and unquestioningly accepted by governments and the public alike. It allows corporations to churn out throwaway plastic products and packaging while passing on the blame for plastic waste to consumers, and the responsibility for managing what is discarded to local authorities.

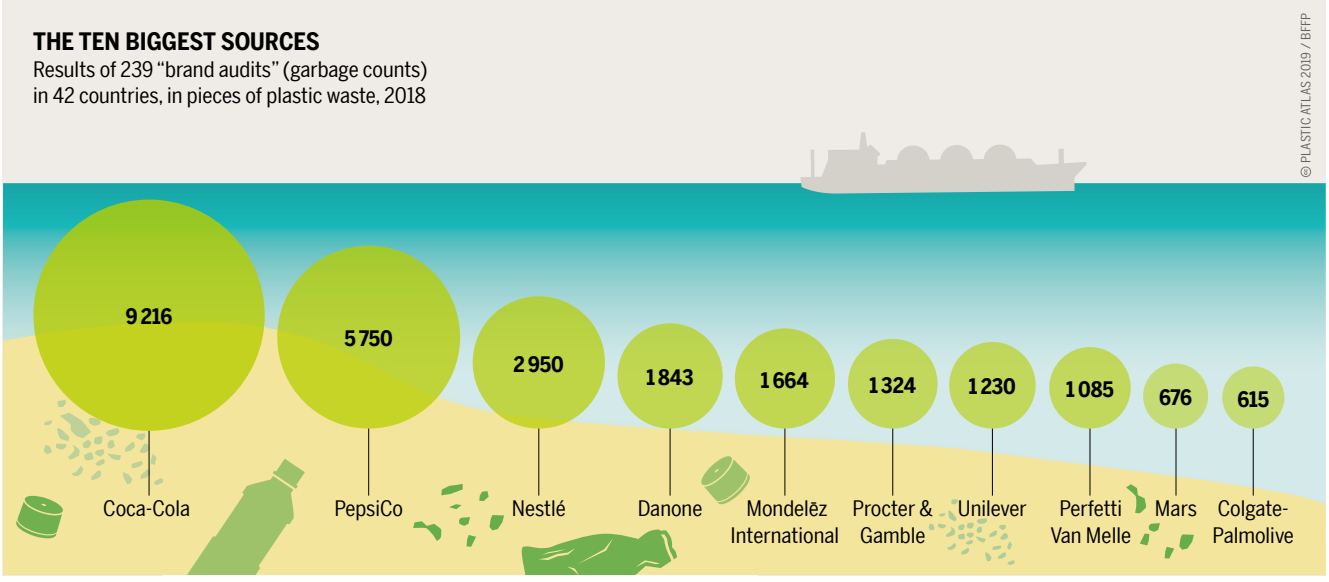
But grassroots and environmental organizations around the world have started coming together to expose and confront the plastics industry. Since its launch in 2016, a global movement called Break Free From Plastic (BFFP) has united more than 1,500 organizations and thousands of supporters across six continents. They are trying to put an end to plastic pollution by demanding massive reductions in the production and use of fossil-fuel-based plastics. By exposing how plastic pollution is a systemic problem that needs to be tackled at source, these groups are standing up to the plastics industry and are calling for transparency, accountability and action.

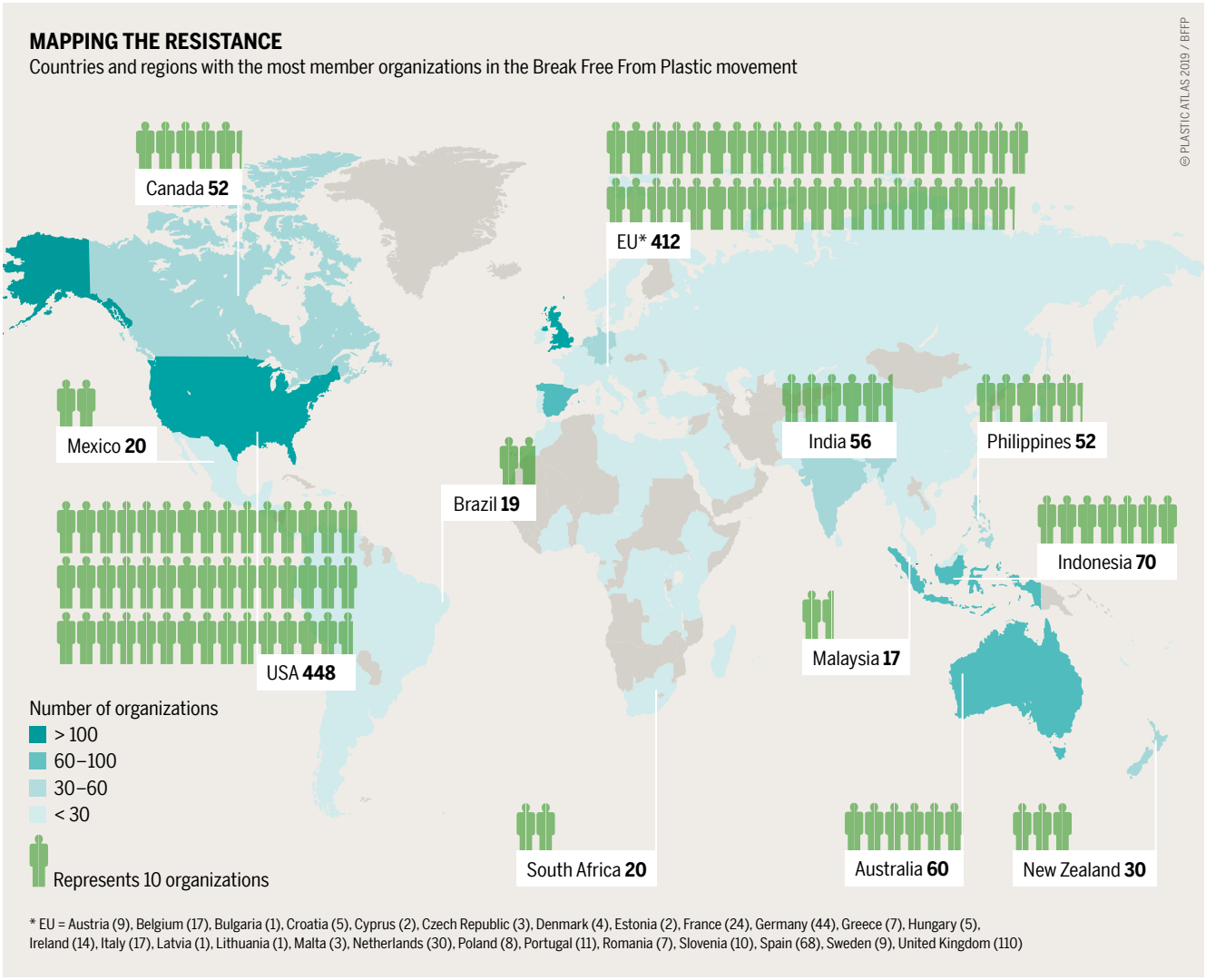
BFFP is the first movement in which groups all over the world, working at different stages of the plastics lifecycle, have come together under the same banner to work towards a shared vision. The goal is to achieve fundamental change by tackling pollution along the whole plastics value chain, focusing on prevention rather than cure, and advancing lasting solutions.

The challenge is enormous. The production, distribution and disposal of plastics involves a long list of the world's biggest companies, including oil majors like ExxonMobil, Chevron, Shell and Total, chemicals firms such as DowDuPont, BASF, SABIC and Formosa Plastics, consumer-goods giants such as Procter & Gamble, Unilever, Nestlé, Coca-Cola and PepsiCo, and waste-management firms like SUEZ and Veolia. Most, if not all, of these companies resist the call to reduce plastics production: accepting the need to do so would force them to abandon their optimistic growth projections, upend their ingrained business practices that depend on single-use plastics, and accept lower profits. Instead, these companies strive to keep throwaway plastics as part of people's everyday lives.

BFFP challenges industry on four fronts. First, it puts pressure on corporations to massively reduce the production and use of single-use plastics. Second, it unmasks the

In 2018, "brand audits" conducted by Break Free From Plastic collected a total of 187,851 pieces of plastic waste from locations around the world.





More than 1,500 organizations around the world are members of Break Free From Plastic. Most of them are in North America, Europe and Southeast Asia.

industry narrative around plastics, and reveals the truth. Third, it promotes zero waste cities, especially in Asia. And fourth, it continues to build and strengthen the plastic-free movement.

BFFP campaigns to get manufacturers, who have "outsourced" their pollution to consumers, to change their practices. BFFP and its partners conduct "brand audits," where waste is collected and classified according to the company brand from which it originates. Since 2017, the movement has conducted numerous such brand audits around the world: in Asia, Europe, Africa, North and South America, and Australia, popularizing the term "branded trash" and putting consumer-goods companies on the defensive. With their brands directly associated with trash, a number of multinationals have started pledging targets for eliminating some problematic types of items and increasing the collection and recycling of their packaging. That is progress, but such commitments still fall far short of what is required to dramatically reduce the amount of throwaway plastic that is being generated.

By putting a spotlight on the problematic and unnecessary plastics being churned out by companies, these brand audits expose the real actors behind the pollution, helping debunk the industry myth that consumers, and waste management systems—particularly in poor Asian countries—are the problem.

Brand audits do not just criticize: they also help advance solutions. In Asia, several BFFP member organizations are working with cities to establish environment and community-friendly waste management systems using audit data. Under the BFFP banner, at least 26 local governments in the region have pledged to become "zero waste cities." In Europe and the USA, BFFP members are enabling groundbreaking policy shifts against the disposable and throwaway culture fostered by industry.

In January 2019, under growing pressure, the industry formed the "Alliance to End Plastic Waste." An initial 30 companies pledged $1.5 billion for waste management and disposal infrastructure, particularly in Asia. But the same companies will invest over $ 89.3 billion on plastic expansion projects by 2030, further entrenching the production of fossil-fuel-based plastics.

Building and strengthening the movement is vital to be able to stand up to giant multinationals. The movement is new, but its membership and reach are growing organically, seeding a network of resistance to the plastic industry's ambitions, and helping to usher in a world free of plastic pollution.

STOPPING THE PROBLEM AT THE SOURCE

Recycling alone cannot solve the plastic crisis. New ideas are needed that tackle the roots of the problem. A growing movement is showing how that can work—and a few pioneering cities and towns are blazing the trail.

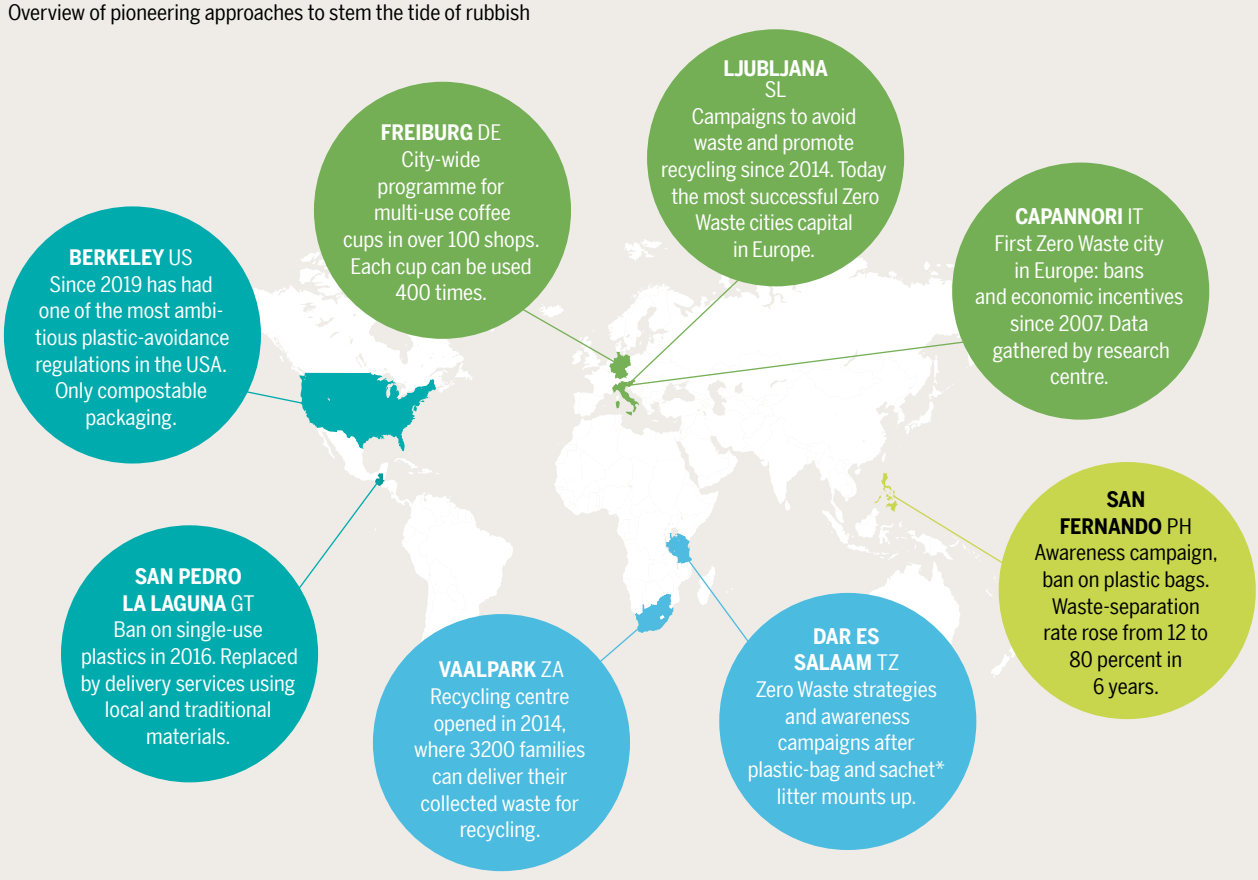
A movement called "Zero Waste" has emerged: its goal is to stop the tide of waste at its source. This means that products, packaging and materials are produced, consumed and recycled in a responsible manner. No waste is incinerated. Toxic materials do not end up in the ground, in the water or the air. Communities, visionary policymakers and innovative entrepreneurs are showing that it is possible to use resources efficiently, maintain a healthy environment, consume in a sustainable way, and at the same time create local jobs.

Nearly 400 municipalities in Europe, and an increasing number of local authorities worldwide, are adopting Zero Waste strategies. These are an effort to phase out waste—not by burning or landfilling it—but by creating systems that do not generate waste in the first place. The fight against plastic waste begins at the source: it means eliminating single-use plastics and promoting alternative distribution and delivery systems. It also means building on the growing interest in a Zero Waste lifestyle.

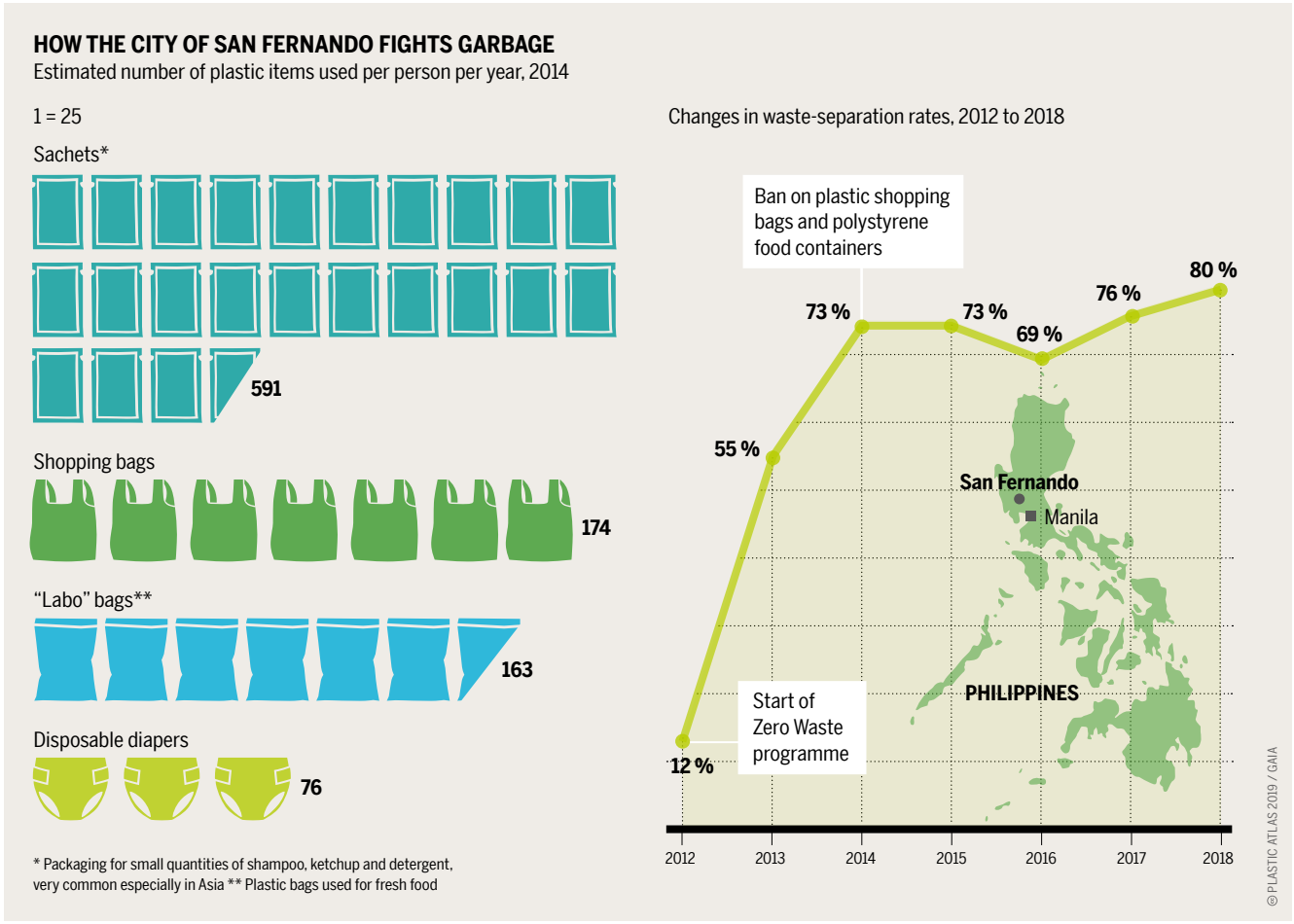
Capannori, in northern Tuscany, Italy, was the first town in Europe to set up a Zero Waste strategy in 2007, committing to sending zero waste for disposal by 2020. This municipality has developed a comprehensive approach: it aims to maximize material recovery by collecting different types of waste separately, and gives economic incentives to reduce waste at source. It strives to reduce residual waste in various ways. For example, it has opened packaging-free shops

Zero Waste concepts are spreading across the globe. Some local authorities have been fighting the plastic crisis since the start of the millennium.

OVERFLOW BUFFER: ZERO WASTE STRATEGIES SHOW THE WAY
Overview of pioneering approaches to stem the tide of rubbish



DE=Germany, SL=Slovenia, IT=Italy, US=United States, PH=Philippines; GT=Guatemala; ZA=South Africa; TZ=Tanzania
* Packaging for small quantities of shampoo, ketchup and detergent, very common especially in Asia



San Fernando counted the waste it generated each day. It used the data to design its Zero Waste programme —from reduction to improved waste separation.

that sell locally produced items, and installed public drinking water fountains to eliminate the need for bottled water. It has set up a reuse centre where people can take clothes, shoes and toys that they no longer need. These items are then repaired and sold to people on low incomes. The town also subsidizes washable diapers. It organises Zero Waste challenges to help citizens accept these initiatives and adopt new habits.

The results have been impressive. In the 10 years from 2004 to 2013, the amount of waste generated in Capannori dropped by 39 percent, from 1.92 kilograms to 1.18 kilograms per person per day. Even more impressively, the rate of residual waste per person fell from 340 kilograms per year in 2006 to only 146 kilograms in 2011. That is a fall of 57 percent. In the same year, the average person in Denmark threw away 409 kilograms of waste.

In the developing world, the spread of similar approaches is key to ensuring a just transition to a plastic-free economy. An example: in 2018, the city of San Fernando in the Philippines diverted 80 percent of its waste away from landfills by having a cooperative recycle it.

The city has taken a series of steps to further reduce its plastic-waste footprint. It has banned plastic shopping bags, affecting 9,000 businesses. It has set a levy on single-use packaging, and has made sure alternative options are available. It has achieved an 85 percent compliance rate among residents through continuous efforts to explain the approach: through house-to-house information, a regular radio show, dialogue with business groups, and individual meetings, for example with shopping malls that generate a lot of waste.

This has also been good for the city's finances. The annual cost of transporting solid waste to a landfill about 40 kilometers away has dropped by 82 percent. The savings have been used to hire more waste workers and improve waste-management facilities.

Capannori and San Fernando show that the path to Zero Waste must combine both "hard" and "soft" measures. "Hard" measures concern the waste-management system itself such as organic-waste management, the separate collection of different types of waste, decentralized and low-tech models, economic incentives, bans on certain materials, and waste minimization policies and practices. "Soft" measures include involving residents and businesses in all stages of policy development. This helps give rise to new business models, as well as generating savings that flow back to the community.

Plastics are so ubiquitous that it is unrealistic to expect to find a magic bullet; solving the plastic problem instead requires a holistic approach. Once this is identified, a self-reinforcing cycle is set in motion. When citizens post pictures of plastic-wrapped fruit and vegetables on social media and tag them with #DesnudaLaFruta (Spanish for "UndressTheFruit"), they promote a new plastic-free norm. Innovative business leaders help mainstream such Zero Waste forms of consumption. We only have to start questioning things that we have come to accept as normal.

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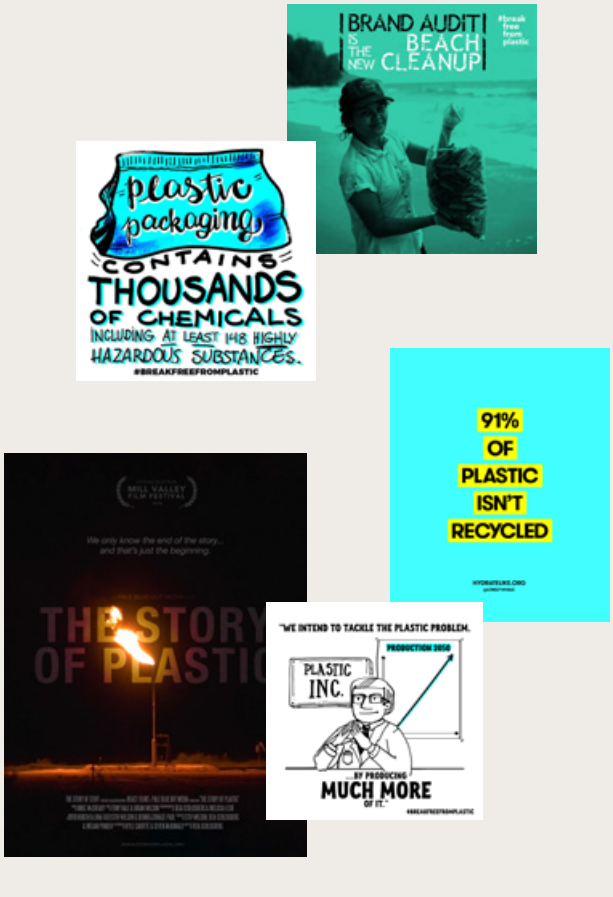
BREAK FREE FROM PLASTIC



Break Free From Plastic is a global movement envisioning a future free from plastic pollution. Since its launch in September 2016, over 1,500 organizations from across the world have joined the movement to demand massive reductions in single-use plastics and to push for lasting solutions to the plastic pollution crisis. These organizations share the common values of environmental protection and social justice, which guide their work at the community level and represent a global, unified vision. Sign up at www.breakfreefromplastic.org.

We believe in a world where the land, sky, oceans, and water is home to an abundance of life, not an abundance of plastic, and where the air we breathe, the water we drink and the food we eat is free of toxic by-products of plastic pollution.

In this world the principles of environmental justice, social justice, public health, and human rights lead government policy, not the demands of elites and corporations. This is a future we believe in and are creating together.

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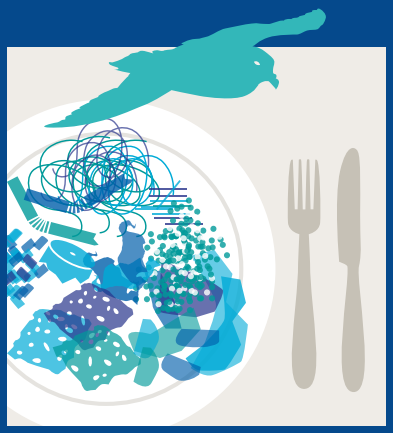

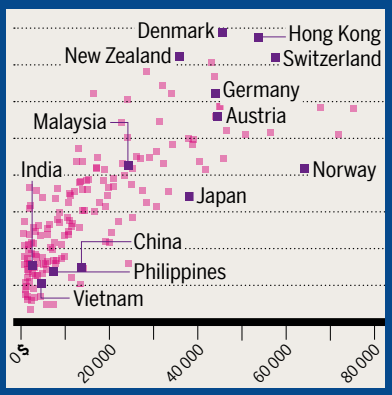

Since 2000, more plastics have been produced than in the 50 years before.
BLESSING AND CURSE, page 14

Just a few major corporations produce most of the world's plastics.
BLAMING THE CONSUMER, page 30

Plastics alone could consume between 10 and 13 percent
of the earth's remaining carbon budget for staying below 1.5 degrees.
NOT GREEN, BUT GREENHOUSE, page 26

Many of the chemicals in plastic have an effect on human health.
The consequences may be both serious and long-term.
FOOD CHEMISTRY, page 16

We only have to start questioning things that we have come to accept as normal.
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