AN INTRODUCTION TO

PLASTICS & TOXIC CHEMICALS

HOW PLASTICS HARM HUMAN HEALTH AND THE ENVIRONMENT AND POISON THE CIRCULAR ECONOMY

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IPEN

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AN INTRODUCTION TO PLASTICS & TOXIC CHEMICALS: HOW PLASTICS HARM HUMAN HEALTH AND THE ENVIRONMENT AND POISON THE CIRCULAR ECONOMY

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IPEN is a network of non-governmental organizations working in more than 125 countries to reduce and eliminate the harm to human health and the environment from toxic chemicals.

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FOREWORD

HAZARDOUS PLASTICS PRODUCTION: EXCEEDING THE PLANETARY BOUNDARIES

By Bethanie Carney Almroth, Patricia Villarubia-Gómez, and Zhanyun Wang

The authors are experts in ecotoxicology, chemical pollution, plastics, and planetary boundaries, and authored the scientific publication describing how plastics and chemicals are exceeding planetary boundaries, destabilizing Earth systems and threatening the safe operating space for humanity: "Outside the Safe Operating Space of the Planetary Boundary for Novel Entities"

Plastics are pervasive in our societies and the environment. We cannot avoid using them, and we cannot avoid being exposed to them. Today, plastics pollution has rapidly become one of the most pressing environmental threats to the people and the planet. To solve plastics pollution, we must first adequately frame the problem in its entirety. However, plastics pollution has been widely presented as a waste problem, resulting in strategies that narrowly target end-of-life waste management and consumer behavior. Addressing the end-of-life of plastics is important, but more importantly, we must address the "avoidable" human exposure to toxic chemicals during the production and use of plastics.

We must first recognize that plastics are not safe, inert materials per se, but rather a complex group of mixtures of tens of thousands of chemicals, many of which are toxic. The massive diversity and quantities of plastics and associated chemicals are produced, largely uncontrolled with minimal transparency from the industry, at rates that outpace societies' ability to conduct safety-related assessments and monitoring. Plastic products are so ubiquitous in our contemporary daily lives – in our food systems, kitchens, children's toys, building materials, electronic devices, infrastructures – that we cannot control them getting into our own bodies, or releasing into the environment, and thus, we cannot prevent harm. Plastics have exceeded the safe operating space for humanity.

The production, use, and pollution by plastics and associated toxic chemicals also exacerbate the other planet crises such as climate change and biodiversity threats, further destabilizing the planet. They are tied to climate change, directly via extraction and use of fossil fuels (99% of plastics are produced from fossil fuels) and other raw materials, but also indirectly via changes in the environment that include release of aerosols and other particles into the atmosphere, changes in albedo affecting polar ice, and changes in land usage and deforestation. Plastics and toxic chemicals impact biodiversity by affecting reproduction, spread of non-indigenous species, and loss of important functions in ecosystems. Impacts on the environment are seen in all ecosystems.

Plastics and many associated chemicals are persistent and, once released, will exist in the environment for decades or longer. Some of the toxic chemicals found in plastics are persistent organic pollutants that are banned globally by the Stockholm Convention but are still present in the environments as well as in in-use plastics and plastic waste due to their longevity (e.g., dioxins, furans, polychlorinated biphenyls (PCBs), organohalogen flame retardants, and many per- and polyfluoroalkyl substances (PFASs)). Their presence in plastics also hampers the transition to a sustainable circular economy, as uncontrolled recycling can result in contamination of recycled plastics by these legacy chemicals, resulting in continued human exposure to them.

While the problems we face are massive, they are not insurmountable. We can make changes, starting from safer and more sustainable materials. We must. Several actions are readily apparent. We must consider the full life cycle of plastics and associated chemicals from extraction of fossil fuels with special attention on production, material and product design, to environmental impacts. We need to move pressures and responsibilities for solving plastics pollution away from the communities that are already impacted by them back to the producers and upstream actors. We need also to frame the problem correctly and utilize media and other communication channels to educate so that the public and decision-makers understand and demand producer responsibility, transparency and circularity. The response should be global and cohesive, with careful consideration of equity, justice and human rights. We are confident that this report by IPEN plays a key role in raising the much-needed awareness around these issues.

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Linn Persson, Bethanie M. Carney Almroth, Christopher D. Collins, Sarah Cornell, Cynthia A. de Wit, Miriam L. Diamond, Peter Fantke, Martin Hassellöv, Matthew MacLeod, Morten W. Ryberg, Peter Søgaard Jørgensen, Patricia Villarrubia-Gómez, Zhanyun Wang, and Michael Zwicky Hauschild. Outside the Safe Operating Space of the Planetary Boundary for Novel Entities. Environmental Science & Technology 2022 56 (3), 1510-1521 DOI: 10.1021/acs.est.1c04158 https://pubs.acs.org/doi/10.1021/acs.est.1c04158


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INTRODUCTION

Many people are concerned about visible plastics pollution: landfills with endless plastic waste and plastics turning the oceans into waste dumps. But just as important are the invisible health and environmental hazards caused by toxic chemicals throughout the plastics lifecycle.

The health and environmental impacts of plastics are a global crisis. Scientific evidence shows that we have broken through the "planetary boundaries"[1] for chemical and plastics pollution, meaning that production and emissions may be threatening the stability of the entire global ecosystem.

To best understand what plastics pollution is, one must understand what plastic is: a material made from carbon (fossil fuels) and chemicals. Plastics do not exist without chemicals, and harmful chemicals are released at every phase of the plastics life cycle – from oil extraction to plastics production, transport, use, and disposal.

Over 10,000 chemicals[2] in plastics have been identified, and data on more than 2,400 of these chemicals has identified them as substances of concern (there is incomplete or no hazard data on hundreds of other plastic chemicals). Toxic chemicals in plastics have been linked to cancers, damage to the immune and reproductive systems, impaired intellectual functions, developmental delays, and other serious health conditions. Evidence suggests that we are already seeing serious health problems from chemical exposures throughout the plastics lifecycle.[3]

There are no regulations to protect human health and the environment from most of the toxic chemicals used in plastics. Often regulations are developed substance by substance only after years or even decades of harm from plastic products being sold. When a chemical is finally regulated, industry simply puts a new, untested chemical (usually one closely related to the regulated version) onto the market, often with similar toxic environmental and health consequences.

Plastics transport chemicals into every nook and cranny of the world – they bring toxic chemicals into our homes and ultimately into our bodies. Plastic waste shipments transport plastics with chemicals across the world. Plastic food containers leach chemicals into our food. Marine plastic litter transports chemicals used in plastics to remote locations via ocean currents. The burning of plastics releases chemicals into the air, spreading chemicals globally as air pollution. In these and many other ways, plastics threaten human health worldwide.

Although chemical pollution from plastics is a global problem, it is most acute in areas near plastics production facilities and in low- and middle-income countries that may have weaker regulations and are used as dumping grounds for plastic wastes. The people in these countries are already disproportionately exposed to toxic chemicals and face greater health risks due to this environmental injustice. Western countries must stop plastic waste exports, and plastics producers must take responsibility for the environmental injustices that their plastics create.

Plastics production has skyrocketed since the 1950s and projections suggest plastics production and wastes may double or even triple in the coming decades[4]. Industry promotes a circular plastics future, but due to the toxic chemicals from plastics, it is clear that plastics poison the circular economy. We need immediate steps to significantly reduce the production of plastics and a fundamental shift in our materials economy to replace them with safer, sustainable materials that promote a healthy, circular economic future.

To avoid responsibility and define solutions for the plastics crisis, industry also promotes plastics recycling and technologies that burn plastic wastes for fuel. Yet despite decades of promoting recycling, a recent study[5] found that, as of 2015, only 9% of all plastic waste ever produced had been recycled. When they are recycled, plastics recycling simply transfers toxic chemicals from used plastics into new products. Burning plastics exacerbates climate change and produces some of the world's most toxic chemicals, known as dioxins, magnifying health threats.

We need real solutions to the global plastics crisis because the toxic legacy of plastics will not only affect those living today but future generations to come. The urgent solutions to address the impact of plastics are to prohibit the use of hazardous chemicals in plastics, and to significantly reduce plastics production while innovating for safer, sustainable materials that truly meet the needs of a toxic-free circular economy.

The beginning and end of the plastics lifecycle: plastics begin as fossil fuels and end as trash in dumps or landfills

HEALTH HARMS FROM PLASTICS

Many harmful chemicals are used during the production of plastics, either as building blocks for the plastic material itself (such as bisphenols) or as additives to provide certain properties such as durability, color, flexibility, or other qualities. These toxic chemicals can harm the environment and our health in a range of ways when plastics are produced, used, and disposed of.

The impact on human health from these chemicals can be profound. Even small exposures can result in disruptions to reproductive systems, impaired intellectual functions, delays in physical development, and cancer. For example, endocrine-disrupting chemicals (EDCs) from some plastics are linked to health problems at very low doses.[6]

PEOPLE ARE EXPOSED TO TOXIC CHEMICALS IN EVERY STAGE OF THE PLASTICS LIFECYCLE

When plastics are made

- Most plastics are made from fossil fuels, and the extraction of oil and gas both use and release toxic pollutants into the environment.
- Workers and communities near plastic production facilities are exposed to toxic chemicals in their air, water, dust, and the food chain.
- Marine animals and fisheries are contaminated when chemicals from plastics and plastic pellets, used as the feedstock for making plastic products, escape into waterways.

In the products people use every day

- Hazardous chemicals are found in children's toys and many other consumer products made from new and recycled plastics; when recycled plastics are used to make new products, toxic chemicals from the used product are transferred to the new product.
- Chemicals can leach out from many common plastic products such as furniture, carpeting, and clothing (since most synthetic clothing (nylon, polyester, etc.) and textiles are plastics).
- Hazardous chemicals can migrate from plastic food packaging into our food and onto our hands while we are eating.

When waste plastics are disposed of

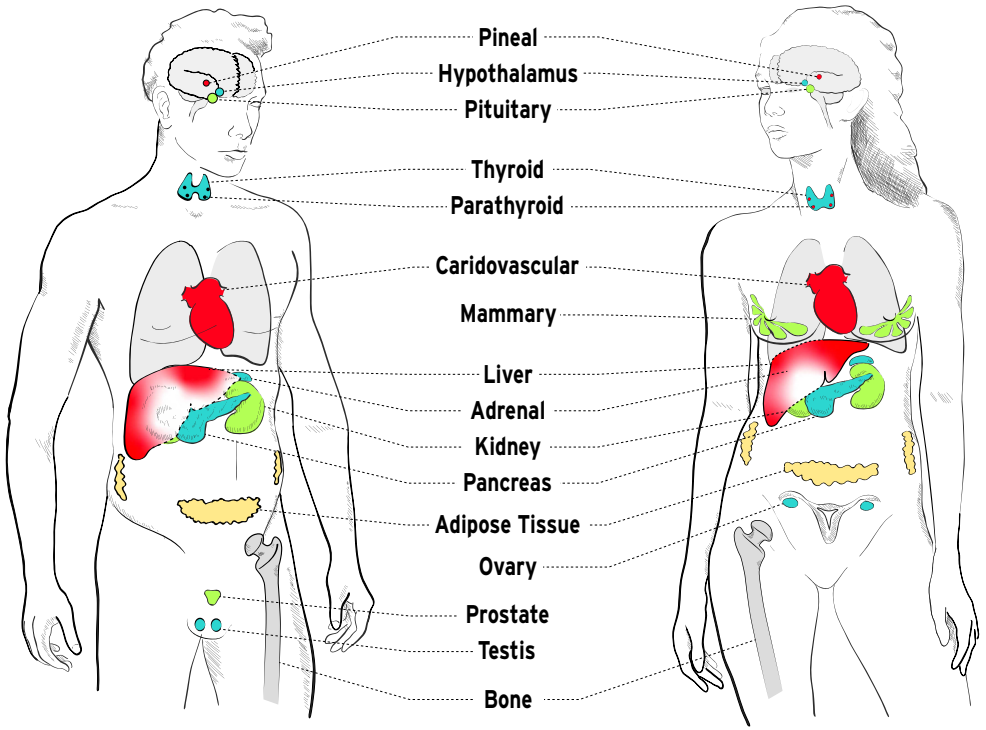
- The vast majority of plastic wastes cannot be recycled into new products. They are either dumped, burned, or landfilled.
    - Open burning and incinerating plastic wastes emits dioxin and other toxic chemicals into the air and generates highly hazardous ash and residues that are typically dumped or landfilled, contributing to the environmental dispersal of highly toxic chemicals.
    - Toxic plastic additives in solid waste leach out and contaminate surrounding food chains and waterways.
    - Plastic wastes in marine environments leach toxic chemicals that compromise aquatic organisms' ability to reproduce, threatening the food chain.
    - Ocean plastic debris can spread toxic chemicals globally, and plastics also attract and carry chemicals. This accumulated chemical load can make plastics even more dangerous to wildlife and the food chain.
    - Plastics that are recycled or burned as fuel create toxic exposures to workers and surrounding communities, and can leave toxic residues, creating large hazardous waste streams. When plastic waste is burned (including as "refuse-derived fuel" or during chemical recycling) it creates toxic ash, dangerous emissions including dioxins, and contributes to climate change.

Plastic particles can also enter the body in a variety of ways. Although the health effects of exposure to plastic particles are not yet fully understood, research has shown that humans are exposed to micro- and nano-plastics through:

- **Consumption:** People may ingest microplastics when we eat and drink food packaged in plastics. Studies have found microplastics in bottled water and other bottled beverages[7], commercial fish and shellfish[8], and other foods and beverages. A 2021 review[9] noted that several studies have found microplastics in beer, wine, energy drinks, bottled tea, milk, honey, sugar, and salt. The review noted one study that found that steeping plastic tea bags in hot water released 2.3 million microplastic particles and 14.7 billion nanoparticles into a cup of tea, and another that found that infants fed milk from sterilized plastic bottles could ingest as many as 3 million microplastic particles per day.
- **Inhalation:** Plastic microfibers are commonly found in indoor air and dust and have been found in high concentrations in outdoor air in major cities and in remote areas like the Arctic and Mount Everest[10]. Microplastics have been detected in human stool, blood[11], placenta[12], and lungs, and

research suggests the particles may persist in the lungs and potentially cause inflammation.[13] One study[14] found that microplastics in pregnant rats can pass through the lungs into the hearts, brains, and other organs of the fetus. Textile workers in the synthetic clothing industry may be most at risk, but clothing can also affect consumers: a 2020 study[15] found that airborne microplastics may be released when we wear synthetic clothing.

- **Skin contact:** While there is a gap in studies on the impacts of direct exposure to plastics via skin contact, a 2020 study[16] noted that people may be exposed to chemicals in microplastics through ingestion or skin contact when we use cosmetics or personal care products such as toothpaste, face wash, scrubs, and soaps. Particles smaller than 100 nanometers (nm) can cross the skin barrier, and nano-plastics as small as 25 nm have been found in cosmetics. A 2021 safety review[17] found that microplastics in cosmetics could be associated with skin damage due to inflammation and cell damage.



Shown are the major endocrine organs in the body. Plastics are often made with chemicals that can disrupt the body's endocrine system.

EVERYDAY PLASTICS AND HUMAN HEALTH

EXPOSURE FROM NEW AND RECYCLED PLASTIC PRODUCTS

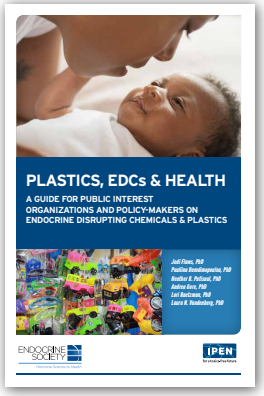
People can be exposed to toxic chemicals when using many common plastic products in their everyday lives. Research suggests that many plastics can leach chemicals and expose people through skin and hand-to-mouth contact, children's teething and mouthing behaviors, and through chemicals leaching into food and beverages. Studies from IPEN and others have shown that children's toys and many consumer products contain toxic chemicals, including some banned or restricted chemicals. Some of IPEN's findings include:

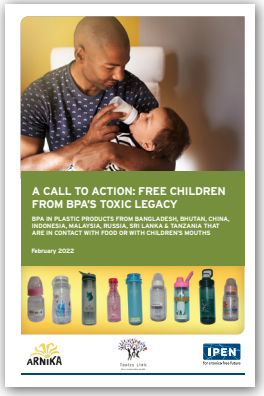
Recycled Plastic Products in African and Arabic Countries. Africa has long been an export destination for waste from rich countries. But the threat from toxic chemicals is not limited to plastic waste disposal. An increasing number of studies show that products available on the African market also contain dangerous levels of toxic chemicals. For example, a 2022 IPEN study found banned BFRs in recycled plastic toys, kitchen utensils, and other consumer products sold in 11 African and Arabic countries.

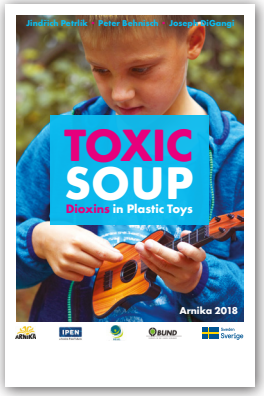
Recycled Plastic Products in Europe. Consumers in low- and middle-income countries are not the only ones at risk from chemicals in recycled plastics. A 2018 IPEN study found that toys, hair accessories, kitchen utensils, and other consumer products from 20 European countries contained flame retardants and other dangerous chemicals originating from recycled waste.

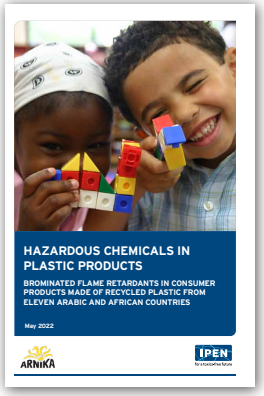
SCCPs in Children's Products, Food Chains, and Breast Milk. A 2017 IPEN study analyzing products in 10 countries found short-chain chlorinated paraffins (SCCPs), often used as UV stabilizers in plastics, in children's products, including Mickey Mouse slippers, jump ropes, balls, and plastic ducks. SCCPs have also been found in fish, seals, walrus, and whales of the Arctic that serve as traditional foods of Indigenous peoples. They have also been detected in the breast milk of Arctic Inuit women.

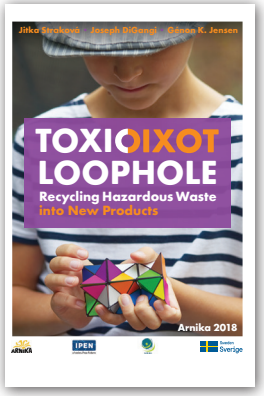
PFAS in Synthetic Textiles in Indonesia, China, and Russia. According to a 2021 IPEN study, synthetic outdoor clothing and sportswear from China, Indonesia, and Russia contained PFAS-based polymers to confer water resistance. The most frequently identified PFAS in the study (fluorotelomer alcohol 8:2 FTOH) can degrade to another highly persistent PFAS, pefluorocarboxylic acid (PFOA), a chemical listed for global elimination under the Stockholm Convention. The use of PFAS in textiles and outdoor wear increases environmental pollution and human exposure, as PFAS are emitted to the environment during production, use, and final disposal.

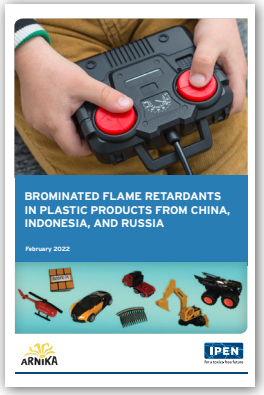












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TOXIC CHEMICALS FROM PLASTICS ARE AMONG THE MOST HARMFUL CHEMICALS IN THE WORLD

Scientific studies show that we are already seeing serious health problems from chemicals found in plastics. People are exposed to chemicals from plastics during their production, transport, use, and disposal – and studies show that these exposures can have harmful health effects.

Yet it is almost impossible to avoid exposure to chemicals from plastics. Plastic materials and products are not labeled, so we can't know what chemicals are in them, making it impossible to avoid chemical threats.

Some toxic chemicals from plastics are endocrine-disrupting chemicals, some are persistent organic pollutants (POPs), and some pose other health threats.

Endocrine Disrupting Chemicals

Many common plastic additives are endocrine disrupting chemicals (EDCs) that can interfere with the body's natural hormone system. Because our hormones are involved throughout all our bodies' systems, EDCs are associated with a wide range of health impacts, including cancer, early puberty in girls, obesity and diabetes, infertility and reproductive disorders, and neurodevelopmental effects such as attention-deficit/hyperactivity disorder (ADHD), autism, learning disabilities, intellectual disabilities, conduct disorders, cerebral palsy, and impairments in vision and hearing. Developing fetuses are particularly vulnerable to EDCs.

These chemicals are so ubiquitous that a variety of EDCs have been found in all people worldwide who have been tested for the presence of EDCs in their blood, fat, urine, and other tissues.

Medical, health, environmental, and scientific bodies have voiced concern about EDC exposure and EDCs in the context of the larger universe of toxic chemicals. These diverse groups include, among others, the Endocrine Society, American Medical Association, The American Public Health Laboratories, The American Chemical Society, the American College of Obstetrics and Gynecology, the American Society of Reproductive Medicine, The British Royal College of Obstetrics and Gynecology, The International Conference on Children's Health and Environment, the International Federation of Gynecology and Obstetrics, the World Health Organization, and the United Nations Environment Programme.

In the environment, EDCs can interfere with the ability of fish and other organisms to reproduce and develop properly. In doing so, they disrupt the aquatic food chains upon which all living things, including humans, depend.

Several products are being marketed as "bioplastics" or "biodegradable" plastics. These products are promoted as more ecological than plastics, but they often contain similar chemical additives[18] as other plastics, including EDCs.

Persistent Organic Pollutants (POPs)

Some persistent organic pollutants (POPs) have been used as chemical additives in plastics; others are unintentionally produced during plastic waste processing. POPs are chemicals that a) persist in the environment for a long time; b) are toxic to humans, wildlife, and plants; c) bioaccumulate and can increase in concentration as they move higher in the food chain; and d) disperse throughout the environment via wind, water, and migratory species.

Some plastic-related POPs have been banned globally under the Stockholm Convention on Persistent Organic Pollutants (SC). However, even these banned POPs are still present in the environment and in plastic waste stockpiles due to their longevity. Thousands of others known to be harmful or suspected of causing harm to human health and the environment remain unregulated. Dioxins, furans, polychlorinated biphenyls (PCBs), certain flame retardants, and per- and polyfluorinated substances (PFAS) are some examples of plastic-related POPs.

Dioxins affect brain development, disrupt thyroid and immune system functions, and are associated with an increased risk of multiple cancers. Chlorinated dioxins (PCDD/Fs) are a family of chemicals considered among the world's most toxic substances and were among the first 12 "dirty dozen" POPs listed under the Stockholm Convention. They are not produced intentionally but are known to be created through many industrial production and disposal practices, including the
burning of PVC. Their counterparts, brominated dioxins, are POPs formed when plastics are produced with brominated flame retardants (BFRs) and when these BFR-containing plastics are incinerated or heated for plastics recycling or disposal. Despite having similar properties as chlorinated dioxins, brominated dioxins are not yet listed under the Stockholm Convention.

Some of the toxic chemical additives described below are EDCs, and some are POPs, including some listed or under consideration for listing as POPs under the Stockholm Convention. Some chemicals in plastics may not meet the criteria as POPs but are toxic substances to humans.

Toxic Plastic Chemical Additives

Flame Retardants. The widespread use of plastics since the mid-twentieth century was accompanied by a rise in fire-safety concerns because plastics in many consumer products are inherently flammable. This gave rise to the production of a new class of toxic chemicals, flame retardants. Flame retardants are added to a wide variety of plastic products, particularly for automotive plastics and plastics used in electronics, to reduce flammability.

Some examples of flame retardants include:

- *Brominated flame retardants (BFRs).* BFRs are linked with infertility and can disrupt male and female reproductive development, alter thyroid development, and affect neurodevelopment. BRF exposure is also associated with psychomotor and attention-related IQ declines in children. There are many types of BFRs. As of 2020, five specific groups of BFRs had been listed in the SC for elimination: Hexabromobiphenyl (HBB);

Hexabromocyclododecane (HBCDD); Octa-BDE; Penta-BDE; and Deca-BDE. Penta- and Octa- BDE were listed in 2004; Deca-BDE was widely used as a replacement until it was listed in 2019. Because there are some exemptions from the listing for recycling of plastic wastes that contain some of these chemicals, people can still be exposed to these toxic flame retardants from consumer products that are made from recycled plastics.

- *Short, medium, and long-chained chlorinated paraffins (SCCPs/ MCCPs/LCCPs).* These chemicals are used as flame retardants in some plastics. They are also added for other properties, such as to make some plastics more flexible. SCCPs were banned in 2017 under the Stockholm Convention (with a 5-year phase out period), but use of MCCPs has increased as a result, despite studies suggesting that all chlorinated paraffins have similar harmful properties. Biomonitoring of polar animals and studies of Arctic fish have demonstrated long-range transport of chlorinated paraffins, and other studies have shown that they are persistent in the environment. Studies indicate that chlorinated paraffins adversely affect the liver, kidney, and thyroid gland in humans. A recent study found that MCCPs were the most abundant of the CP groups measured in human breast milk.

Bisphenols: Bisphenols are used as chemical building blocks in hard polycarbonate plastics and in some epoxy resins. They are found in many common plastic products, including reusable food and beverage containers, water bottles, the linings of food cans, medical and sports equipment, thermal paper receipts, and plastic water pipes.

Bisphenol-A (BPA) is a common and controversial bisphenol used widely in plastics. Exposure to BPA has been associated with breast, prostate, ovarian, and endometrial cancers, as well as infertility and increased anxiety, depression, hyperactivity, inattention, and behavioral problems. BPA can also affect genes' expression, and the effects of BPA exposure can be carried down from generation to generation. Studies show that BPA can migrate into food and beverages from plastic bottles, packaging, and canned food coatings.

BPA has been banned in some places but is still used in many regions. Some food packaging containers are labeled "BPA-free," but testing has shown that even some products labeled this way may contain BPA. Further, studies suggest that other bisphenols used to replace BPA, such as BPS, may pose similar health risks.

Phthalates: Phthalates, sometimes called "everywhere chemicals" due to their widespread use, are used as plasticizers, additives that make plastic products

flexible. Studies suggest that, like BPA, phthalates can leach from plastic into food and liquids. Children can also ingest phthalates when they suck on flexible plastics like pacifiers or teethers.

Exposure to phthalates is associated with a variety of health issues. Phthalates are known reproductive toxicants and are linked to decreased pregnancy and high miscarriage rates, anemia, toxemia, pre-eclampsia, early menopause, and abnormal sex hormone levels. Phthalate exposures are associated with reduced fertility and studies suggest that exposure may impede fertility across multiple generations. Phthalates are also associated with elevated blood pressure and obesity.

Ultraviolet (UV) Stabilizers: UV stabilizers are used to prevent the degradation of plastic products in sunlight. UV stabilizers can leach from food packaging materials into our food. The chemicals have also been found in household dust. Several studies demonstrate that UV stabilizers are EDCs and can impede fertility and development. UV stabilizers common in plastics include:

- Phenolic benzotriazoles (BT) are used as UV stabilizers in plastics for a wide range of products, such as disposable drink bottles, toys, and building materials. BTs are often transported long distances in plastic resin pellets and fragments, especially in aquatic environments, and have been detected in plastics on remote islands. BT is toxic to mammals, potentially damaging the liver and kidneys through prolonged exposures.

- UV-328 is a type of BT chemical produced in high volumes and used in a wide variety of applications, including in paints and coatings, plastic outdoor furniture, epoxy and construction materials, and food packaging. It does not degrade in soil and water and can be found many decades after use. Multiple studies have found it in aquatic life, foodstuffs, and human adipose tissue. Studies have also shown that it can leach from plastics that have been ingested by birds.[19]
- Alkylphenols are used in many plastics as UV stabilizers and to spread substances like paints and coatings over plastic surfaces. Some alkylphenols are used as indirect food contact substances. They are EDCs that can mimic estrogen and disrupt reproductive systems, with links to infertility, low sperm count, and disrupted prostate development. Studies have shown that occupational exposure is associated with a heightened risk of breast cancer.

Per- and Polyfluoroalkyl Substances (PFAS): PFAS are known as "forever chemicals" because they persist in the environment and accumulate in the bodies of wildlife and people. They are widely used in food contact wrappers, carpets, cookware, and firefighting foams. 2021 reports found that PFAS can be created through fluorination of plastics, including potentially for plastics used as food containers.[20]

PFAS contaminate local water sources primarily due to their use in firefighting foam, so most people are exposed to PFAS from drinking water. In addition, PFAS leach from food containers, wrappers, and cookware into food.

PFAS are metabolism-disrupting chemicals affecting the immune systems, liver, and thyroid function. They can alter puberty, raise breast cancer risk, and are associated with non-Hodgkin's lymphoma and cancers of the kidneys, testicles, prostate, and ovaries.

There are thousands of chemicals in the PFAS family, but only three have been listed for restriction and elimination under the Stockholm Convention: perfluorooctanesulfonic acid (PFOS), perfluorooctanoic acid (PFOA), and perfluorohexane sulfonic acid (PFHxS). Based on the scientific evidence[21] and because PFAS all pose similar health and environmental hazards, IPEN has called for a global ban on all PFAS rather than continuing to address them one by one.

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PLASTIC PRODUCTION

PLASTICS ARE MADE FROM CARBON AND CHEMICALS

Plastic Manufacture

Plastics are made with refined and processed fossil fuels. Chemical engineering of petrochemicals allows manufacturers to produce a vast number of different types of plastic polymers on an industrial scale. This production process can be dangerous for both the people who work in these operations and the people who live in surrounding communities. Extraction of raw materials (fossil fuels) and the plastics manufacturing process release toxic chemicals:

- Conventional and unconventional (e.g., fracking) oil and gas extraction methods use toxic chemicals and release toxic pollutants into the environment.
- Oil refineries, natural gas processing facilities, and petrochemical plants release enormous amounts of toxic pollutants, and they are often located in or near communities who experience multiple health disparities and toxic exposures.

The oil and chemical industries also massively contribute to climate change. At every phase of the plastics life cycle, greenhouse gases and toxic chemicals are released – from oil extraction to plastics production, transport, use, and disposal.

Toxic Chemical Additives

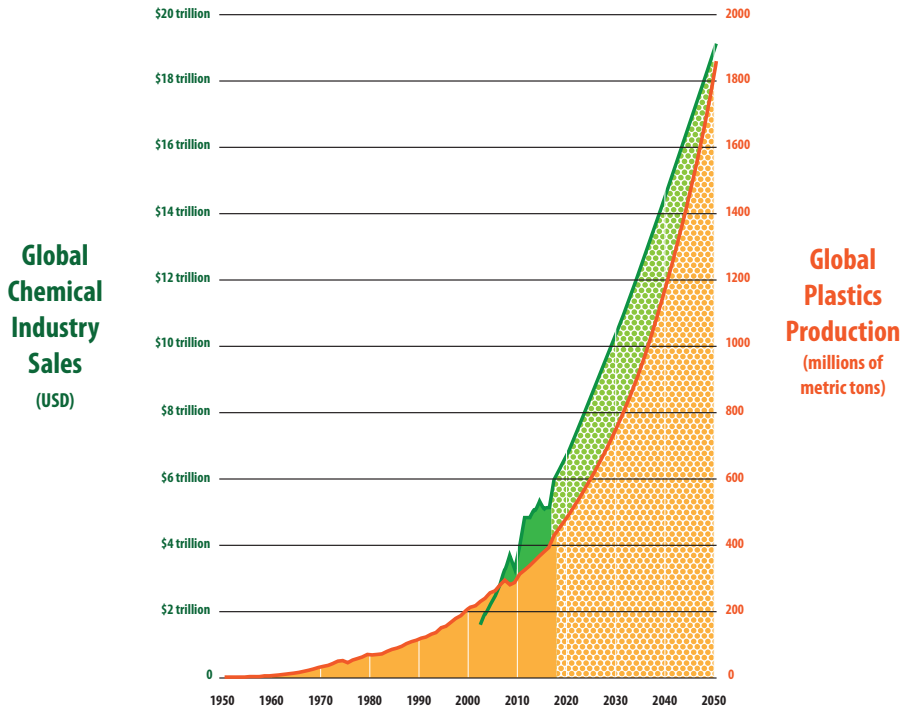
Chemicals are added to plastics to give them certain qualities, such as inflammability (flame retardants), flexibility (plasticizers), grease-resistance (PFAS), sterility (biocides), and other properties. Industry analysts estimate that the global plastic additives market will grow from USD 43.82 billion in 2018 to USD 61.25 billion by 2025.[22]

Plastic Pellets

Plastic pellets are small plastic particles about the size of a lentil (2-5 mm) made from different plastic polymers. They are used as raw materials to make plastic products.

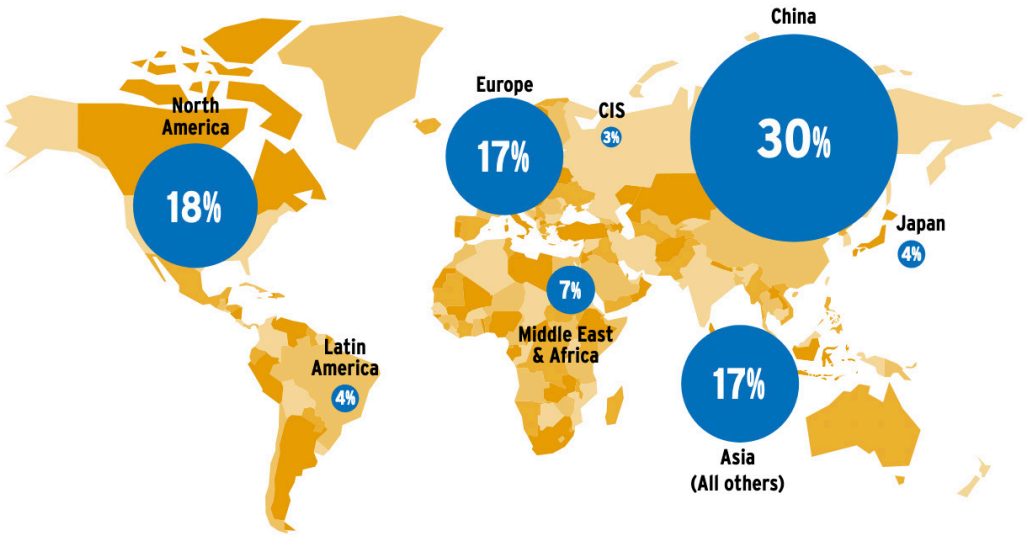
Toxic additives are found in pre-production pellets that often wash up on beaches after being lost during transport or during the manufacturing process. They are also in pellets made with recycled plastics. Though the number of plastic pellets entering the environment is unknown, it is thought to be tens of thousands of tonnes each year.[23] An IPEN study of beach pellets found UV stabilizers and PCBs in all samples taken from twenty-two locations around the world. The Stockholm Convention banned PCBs in 2001, but they are still found in the environment because of their widespread use.

A second IPEN study assessed chemicals in pellets made from recycled plastics. This study found flame retardants, BPA, and UV stabilizers. All of these chemicals are present in plastic waste and have associated human health impacts, including disruption to the endocrine, immune, and reproductive systems.

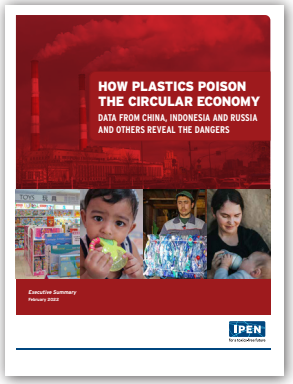


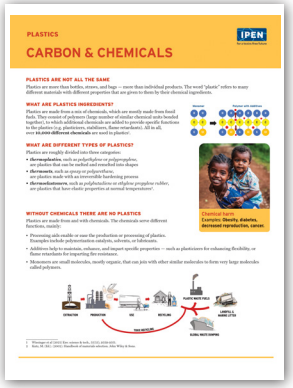
Global Plastic Production

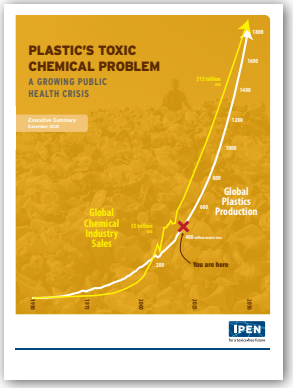
Regional Production 2018



Includes thermoplastics, polyurethanes, thermosets, elastomers, adhesives, coatings and sealants, and PP-fibers. Not included: PET-fibers, PA-fibers, and polyacryl-fibers. Source: Plastics Europe Market Research Group and Conversio Market and Strategy GmbH







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PLASTICS WASTES

PLASTIC RECYCLING IS AN INDUSTRY FAIRYTALE

Packaging, textiles, consumer products, transport, construction, and electronics are the sectors that dominate the generation of plastic wastes. The packaging sector is by far the greatest generator of plastic wastes; much of it as single-use packaging.

Before 2015, 90% of all the plastic waste ever produced had been dumped in landfills or incinerated, with only 9% recycled.[24]

In fact, most plastics are not designed to be recycled. Plastics' chemical composition and additives used in plastics make it almost impossible to safely dispose of or recycle them into new products.

Nevertheless, as the production of plastics ramps up, the petrochemical companies that make plastics and the industries that depend on plastic packaging have teamed up to promote plastic recycling as the model solution to the growing problem of plastics pollution around the world.

But industry's plastic recycling proposals are fairy tales. No recycling scheme currently in use or proposed has the ability to absorb the millions of tonnes of plastic scrap expected to be produced over the next twenty years. And all recycling schemes, in use now or proposed, expose people and their communities to toxic chemicals released into the air, land, and water.

So-called "advanced" or chemical plastic recycling schemes will generate high volumes of hazardous chemicals and contribute to climate change

So-called "advanced recycling" uses heat to turn plastic waste into fuel or into reclaimed resin to make new plastic. This combustion process requires vast amounts of energy, generates dangerous dioxin emissions, and produces crude, contaminated hydrocarbon fuels. In addition, plastics produced using this approach cannot compete with virgin plastics on price, and so the output will most likely end up being burned as crude fuels.

Chemical recycling has a lot of hype, but not much reality

Industry's "advanced" and chemical recycling processes are actually old, outdated technologies that for decades have proven to be uneconomical and unsafe. Chemical recycling creates massive hazardous waste streams, and fuels generated from this process release hazardous chemicals into the air when

burned. In short, these are not environmentally sound nor commercially viable technologies.

"Plastics to fuels" masquerades as renewable energy

Plastic-based fuels are simply an extension of fossil fuel burning and release a variety of toxic pollutants, carbon, and particulates. The most common version involves converting plastic waste to hydrocarbon fuel which is then generally sold and burned in industrial boilers as a cheap, low-grade fuel. This process is highly inefficient and requires a great deal of energy.

The oil produced is often contaminated with toxic additives from the plastic, which are released into the atmosphere when burned. By masquerading as renewable energy, both producers and users of the fuel can access a range of renewable energy credits, tax breaks, and subsidies that should be directed to real renewable energy projects. Similarly, burning plastic waste in incinerators and cement kilns as "alternate fuels" or "refuse-derived fuels" squanders resources and results in toxic emissions, toxic ash, and high-intensity carbon releases.

Most plastics in mechanical recycling end up being burned or landfilled

Many of the chemical additives in plastics are very toxic and can have serious impacts on human health. The additives also interfere with and degrade the quality of the plastic flakes and pellets produced in mechanical recycling and make them unsuitable for re-use in new plastic products. As a result, the vast majority of plastics that can be mechanically recycled are still exported to developing countries, where they are burned or landfilled. When plastic scrap is burned in the open, some of the most toxic chemicals known, such as dioxins and furans, are released and contaminate the soil and food chain.

Plastics poison the circular economy

A circular economy aims to change the economic "take-make-waste" approach. The new approach looks to minimize the extraction of natural resources and waste creation, designing for sustainability. This favors products that last longer, that are easier to use, recycle, and repair, that incorporate more recycled materials, that limits single-use, and that maximize an item's lifespan.

But many toxic chemicals are used in plastics and they cannot be tracked. This means that when plastics are reused, repurposed, or recycled into household products, toys, bricks, roads, or other applications, the toxic chemicals in the used product end up in the new products. This continues to expose people and the environment to harm.

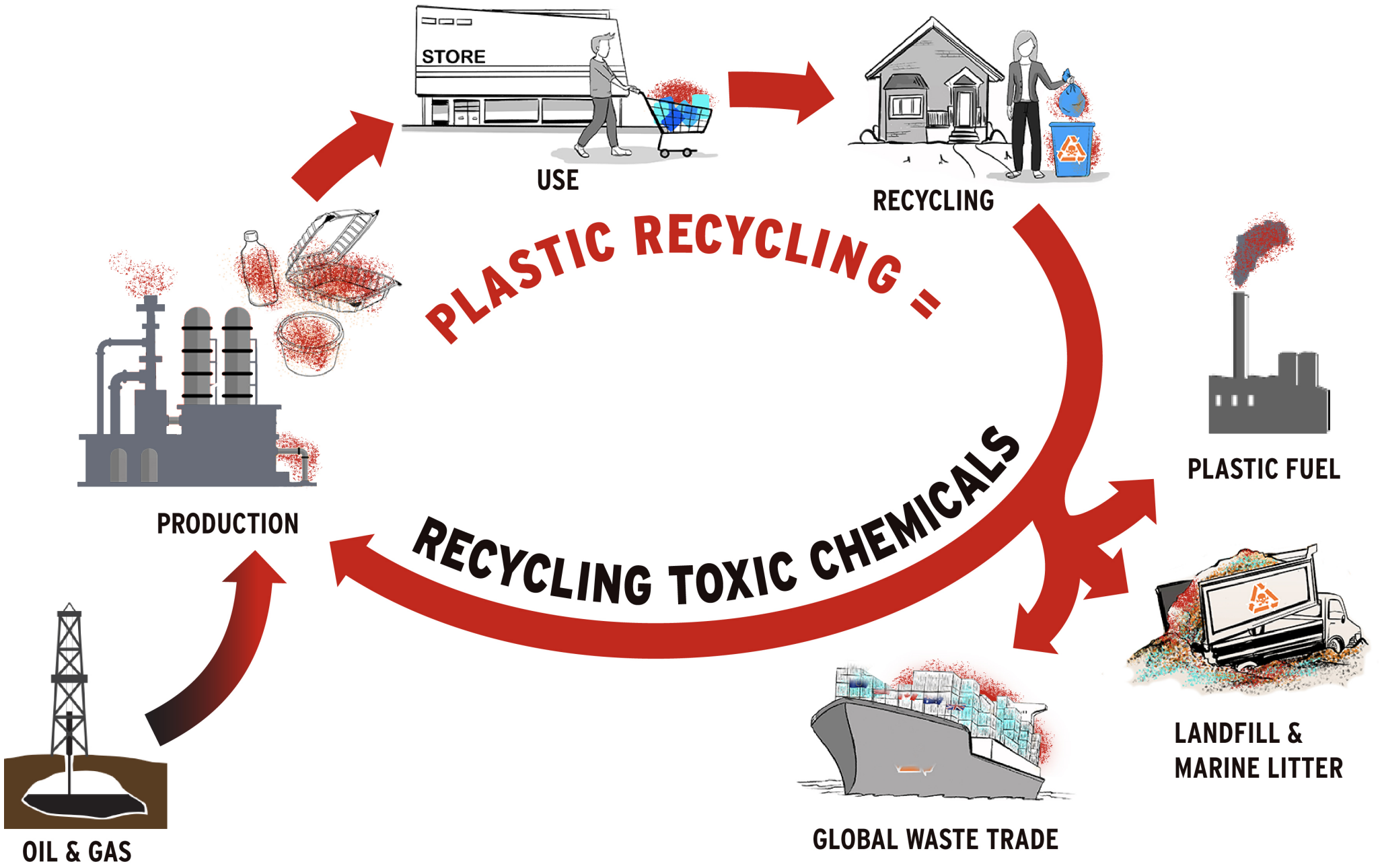
IPEN studies have found toxic chemicals in new products made from recycled plastics, including in items purchased in low- and middle-income countries, such as toys, kitchenware, and other common products.

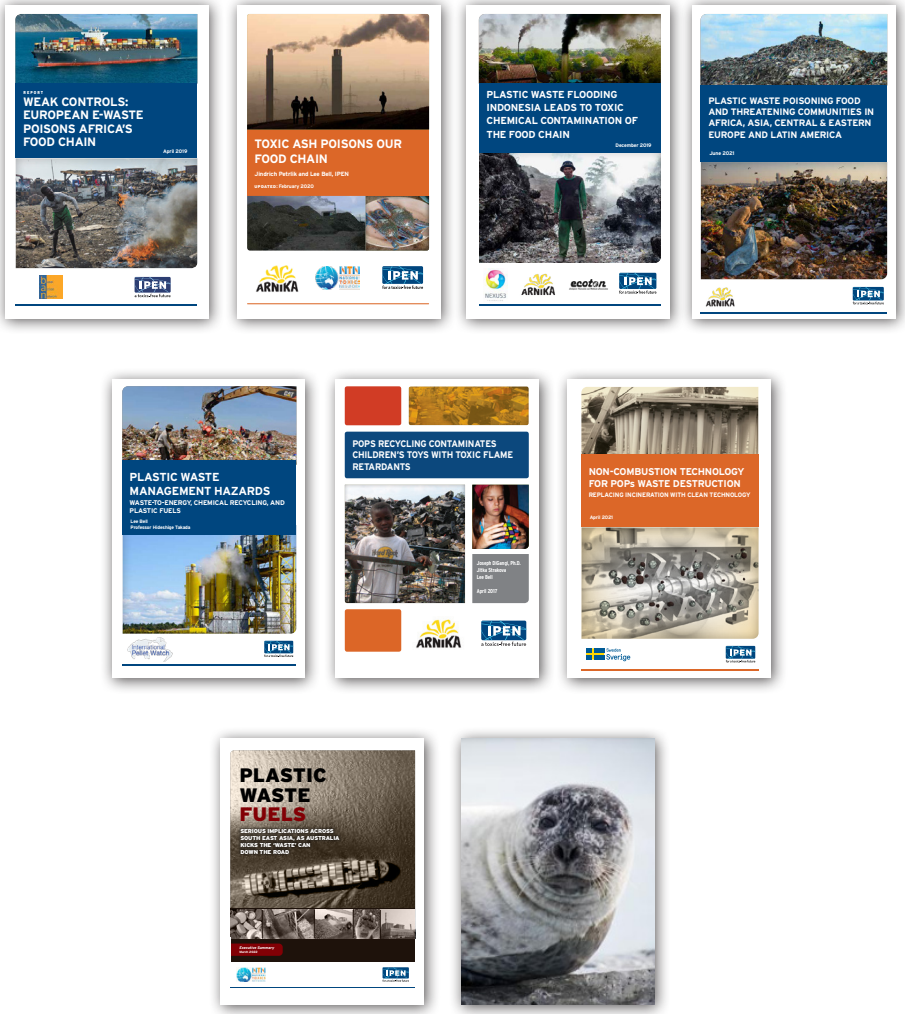
Follow the Money

Petrochemical companies and plastics packagers need a recycling solution to convince the public that a massive expansion in plastic won't harm the environment or their health. The oil and chemical companies that make the petrochemicals used to manufacture plastics and the major global consumer brands that buy plastic packaging have teamed up to sell these schemes to the public and governments around the world. Some of the biggest names in chemical, oil, and plastics production, including Exxon Mobil, Royal Dutch Shell, and Proctor and Gamble are involved. Cement companies that want to use plastics as fuel have also partnered with many of the world's largest users of plastic packaging, including Coca-Cola, Unilever, Colgate, and Nestlé.

But this is all a marketing ploy designed to sell more products, fend off plastics regulation, and convince the public that escalating plastic production can proceed without any harmful consequences.

PLASTICS POISON THE CIRCULAR ECONOMY





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PLASTICS IN THE OCEANS

TOXIC CHEMICALS IN PLASTICS ARE POLLUTING OCEANS, EXPOSING PEOPLE TO DANGEROUS CHEMICALS, AND DISRUPTING THE FOOD CHAIN

Most people are familiar with images of the crisis from plastics pollution in the oceans. However, there is also an equally critical but invisible problem from ocean plastic waste: many of the chemicals used in plastics are toxic to water-living organisms. A 2018 review[25] found that "...more than a hundred million tonnes of plastics are estimated to have been dumped already to the oceans, and projections in plastic production and consumption indicate that plastic waste inputs in the sea may have an exponential increase if no urgent actions are taken."

Toxic chemicals in plastics enter marine environments and create exposure pathways for people and marine animals in several ways. Toxic chemicals leach out from plastic waste or plastic pellets as these materials degrade on beaches or in the water. Marine animals consume the chemicals when they mistake microplastics for food. Toxic chemicals also are deposited in oceans and other waterways when plastic products are burned or used for fuel. Plastics containing toxic chemicals often travel long distances, and plastics also pick up chemicals in the water, adding to the global dispersal of hazardous chemicals. Once chemicals enter a stream, river, or ocean, they can travel all around the world.

SOURCES OF CHEMICALS FROM MARINE PLASTICS

Plastics are both a source of toxic chemicals in oceans and a transport mechanism that spreads chemical contamination across the world. Chemicals found in marine plastics are from:

- Chemicals intentionally added during the plastics production process (additives such as flame retardants, plasticizers, and UV stabilizers).
- Chemicals in water from environmental pollution that stick to the plastics (through adsorption/absorption) and are then carried by plastics globally.

Microplastics

Microplastics are plastics that are smaller than 5 mm. They can either be produced intentionally (for example, as plastic pellets or microbeads) or fragment from larger plastics. Microplastics have been found in commercial fish species around the world, including (among others) from the English Channel, the North Sea, the Baltic Sea, the Indo-Pacific Ocean, the Mediterranean Sea, the Adriatic Sea, and the north-eastern Atlantic Ocean. Many commercially relevant fish and shellfish species have been reported to be contaminated with microplastics. In one study, all samples of deep-sea fish tested from the South China Sea were contaminated by microplastics.[26] In another, microplastics were found in fish and tiger prawns in the Persian Gulf.[27]

Exposure to microplastics has been associated with negative health effects in aquatic organisms, such as increased immune response, decreased food consumption, weight loss and energy depletion, decreased growth rate, and decreased fertility.

Plastic pellets

Plastic pellets end up in the oceans due to spills during their production, transport, and storage. They have been found on beaches and in open waters all over the world since the early 1970s. Testing has shown that these pellets contain banned POPs (including PCBs) and other toxic chemicals.

Common Toxic Chemicals in Plastics Found in Marine Environments

Many of the toxic chemicals from plastics found in marine environments are endocrine disruptors that can impact aquatic organism's ability to develop and reproduce normally:

Phthalates are used as plasticizers in many plastics. In one study, over half of surface plankton samples analyzed contained micro-plastic particles with high concentrations of phthalates. The study warned that concentrations of phthalates in the blubber of stranded fin whales may indicate an emerging threat from microplastics and their contaminants to baleen whales.[28]

Bisphenol A (BPA) is a high-volume chemical produced worldwide. It is released to the marine environment from plastic wastes and via sewage effluents, rivers, and coastal waters. Relatively high concentrations of BPA have been detected in plastic fragment samples from remote beaches and from the open ocean.

PBDEs are used as flame retardant chemicals in computer and TV plastic housings. Burning plastic e-waste is a significant source of PBDEs to the aquatic and marine environment.

UV stabilizers such as benzotriazole ultraviolet stabilizers (BUVs) are commonly found in seafood, river sediment, marine sediment, wastewater, and beached plastic. BUVs are toxic to marine life, persistent, and bioaccumulating. They have also been shown to leach from ingested plastics into birds. Additionally, BUVs have been found in humans, for example in breast milk.

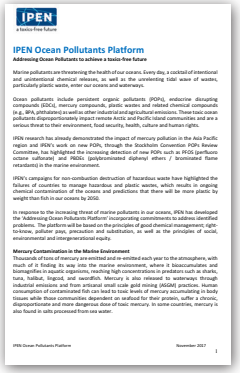
Plastic Waste Attracts Other Toxic Chemicals

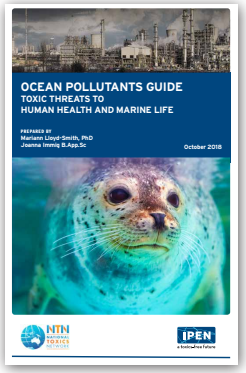
Plastic wastes and pellets have been found to attract and carry chemicals, including PCBs, across the world. PCBs are classified as carcinogens and have been banned for many years. However, PCBs continue to be present in the environment due to leaking electrical transformers and contaminated sites, and from the disposal and recycling of e-wastes.

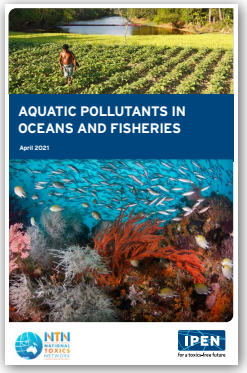
Food Safety and Security

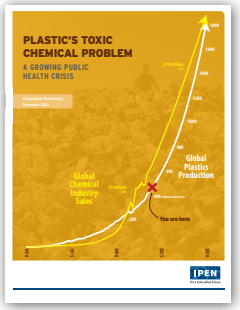
Chemicals in plastics that contaminate food sources from waterways may affect food safety and availability. Plastic impacts on food security have the potential for devastating global consequences: fish and seafood provide more than 3.2 billion people with almost 20% of their average per capita intake of animal protein and 5.1 billion people with 10% of such protein.

A 2020 study[29] noted the significant threats to aquatic life from the leaching of toxic chemicals from microplastics to marine food sources. Furthermore, it indicated that the potential reduction of seafood species populations from chemicals in microplastics could threaten seafood availability, especially in regions dependent on fishing for food.









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KEY ACTIONS TO PROTECT PEOPLE AND THE PLANET FROM PLASTICS AND PROMOTE A NON-TOXIC CIRCULAR ECONOMY

When plastics are produced

- Eliminate chemical wastes during extraction
- Eliminate chemical wastes in the production of plastics
- Prohibit the use of toxic chemicals in plastics
- Prevent toxic chemical releases during the production process and eliminate occupational exposures
- Design essential plastics for durability and reuse
- Eliminate non-essential uses of plastics

When plastics with toxic chemicals are recycled

- Prohibit recycling of plastics made with toxic chemicals
- Promote segregation and safe destruction of plastic wastes containing toxic chemicals

When plastics are disposed of

- Segregate and safely dispose of plastic wastes containing toxic chemicals
- Recycle only those materials that do not contain toxic chemicals
- Ban the export of plastic wastes, with limited exemptions for small island states, and make producers accountable for the environmentally sound disposal of plastic materials throughout their lifecycle
- Prohibit the burning of plastic wastes and associated plastic/refuse-derived fuels

Producer Responsibility

- Plastic producers must take full financial responsibility for their products and their impact through production, use, and disposal, and must ensure the safe handling of wastes to eliminate chemical exposures
- Plastic producers must make all data on chemicals used and added to plastics publicly available, through labeling, materials safety data sheets, and databases
- Fund effective waste management using "producer pays" principles, which require that the costs of all impacts on human health, society, and the environment caused by plastics are recovered through policies such as extended producers' responsibility

IPEN'S WORK: ELIMINATING THREATS FROM CHEMICALS IN PLASTICS

IPEN's Toxic Plastics Campaign works to expose and end the toxic threats to health and the environment from every stage of plastics' lifecycle. We aim to:

- Curb the production of oil, natural gas, and petrochemicals.
- Eliminate toxic chemicals used in the production of plastic.
- Strengthen global policies related to plastic waste controls and incineration.
- End the export of plastic wastes and promote environmental justice and human rights.
- Ensure the public's right to know what toxic chemicals are in plastic products.
- Provide scientific evidence of the plastics industry's impact on public health and the environment.
- Educate media, communities, and policy makers about the harm caused by toxic chemicals from plastics.
- Promote policies for the sustainable management of hazardous plastic wastes that protect human health and the environment (including through eliminating toxic recycling, plastic waste fuels, and incineration).
- Hold the plastic and chemical producers financially responsible for the social, economic, and environmental harm caused by their products.

PLASTICS TREATY

Adoption of an International Plastics Treaty. IPEN promotes the adoption of an international plastics treaty to address the growing problem of plastics pollution, including pollution from toxic chemicals. IPEN believes that an understanding of the following three principles is foundational for a treaty that addresses the human health and climate threats from plastics throughout their lifecycle and for promoting alternatives that truly meet the needs of a circular economy.

- **Principle 1: Understanding plastics as carbon and chemicals**
  Plastics are made from fossil fuels (oil and gas) with a mix of chemicals. To solve the plastics problem, we must address all plastics and put the responsibility for reducing production on the source of the problem, the fossil fuel industry, not on consumers.
- **Principle 2: Addressing the harmful health effects from chemicals in plastics**
  Chemicals in plastics have been linked to cancer, brain damage, infertility, and other serious conditions. When plastics pollute our bodies and our communities, we lose the opportunity to live healthy, productive lives.
- **Principle 3: Recognizing that toxic chemicals make plastics incompatible with a circular economy**
  The toxic chemicals in plastics make them inherently incompatible with non-toxic, circular economic approaches. We need immediate steps to significantly reduce the production of plastics and a fundamental shift in our materials economy to replace them with safer, sustainable materials that promote a healthy, circular economic future.

IPEN calls for a Plastics Treaty that:

- Protects health and the environment
- Ends the production and use of toxic chemicals in plastics
- Removes toxic impacts at all stages of the lifecycle of plastics
- Bans recycling of plastics containing hazardous chemicals
- Protects the public's right to know about chemicals in plastics and information on plastic production and waste exports
- Charges plastic producers to finance the treaty
- Promotes safer sustainable materials for a non-toxic circular economy
- Curbs toxic and climate pollutants

Stockholm Convention on Persistent Organic Pollutants. The objective of the Stockholm Convention is to protect human health and the environment from persistent organic pollutants (POPs). Within the Stockholm Convention, IPEN promotes and provides scientific evidence in support of a ban on all toxic chemical additives to plastics that are presumed to be POPs, including:

Banning PFAS as a class rather than by individual chemicals. There are thousands of PFAS chemicals. They are found in many different consumer, commercial, and industrial products everywhere in the world and are largely used as a flame retardant.

Banning chlorinated paraffins as a class rather than subclasses of different chain-lengths. Research shows that chlorinated paraffins, regardless of chain length, have similar harmful effects and concerns.

Strengthened regulations to reduce dioxin and POPs waste derived from plastic waste management. The Stockholm Convention bans the recycling of wastes contaminated with POPs; this creates a need to define what constitutes POPs-contaminated waste. The POPs limit values, also known as Low POPs Content Levels (LPCLs), are set by the Basel Convention and are a crucial tool to control potential releases of POPs due to improper handling of POPs wastes.

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal. The objective of the Basel Convention is to protect human health and the environment from the adverse effects of hazardous human waste. Under the Convention, countries have a right to refuse the importation of hazardous waste and certain types of other waste, including plastic waste. IPEN supports proposals that will make it easier for countries to restrict imports of plastic waste, including:

- Labeling and transparency measures that allow countries to refuse the import of plastic wastes containing hazardous substances
- Categorizing plastic waste containing hazardous chemicals as hazardous waste
- Ending all exemptions to the Prior Informed Consent procedure for plastic wastes

Contributing to Global Data: IPEN collects data and conducts research to inform policy makers and the public on issues around the threats from chemicals in plastics. Our work includes studies of chemicals in plastic pellets collected from 23 countries, chemicals found in recycled plastics purchased from 24 recyclers in 23 countries, chemicals in toys and other products made from recycled plastics purchased in 11 African and Arabic countries, and many other studies.

Supporting a Global Movement: IPEN's network of 600+ NGOs in more than 125 countries (primarily developing and transitioning countries) works to focus on elevating the issues around chemicals in plastics, providing essential participation and insights from those who are most affected by chemicals in plastics for the development of the Plastics Treaty and other global and national regulatory processes.

IPEN collected plastic pellets from beaches in 23 countries and sent them to an independent lab for testing. Results showed plastics from all locations contained toxic chemicals.

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