Plastic's toxic additives and the circular economy

September 2020

Regional Activity Centre for Sustainable Consumption and Production

UN environment
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Mediterranean Action Plan
Barcelona Convention

BRS CONVENTIONS

IPEN
for a toxics-free future

Acknowledgement

The preparation of this publication was coordinated by the Regional Activity Centre for Sustainable Consumption and Production (SCP/RAC) - Regional Centre under the Stockholm Convention on Persistent Organic Pollutants - with the valuable support of IPEN. Likewise members of the Marine Litter Topic Group (listed in the Annex to this publication) contributed to the preparation of the document, but individual members (and the organisations they represent) are not necessarily committed to every view expressed in it.

September 2020

(Updated and revised version from March 2019)

Preface

This Plastic's Toxic Additives and the Circular Economy publication draws on recent scientific publications and reports, and on the expertise of the members of the Marine Litter Topic Group. It describes a number of general issues concerning the problems associated with plastics and the obstacles to adopting a circular economy approach, and focuses in particular on the problems related to chemical additives. There are a wide variety of chemical additives, noting many have been identified as Persistent Organic Pollutants (POPs) and are now listed under the Stockholm Convention – for example, many of the brominated flame retardants. Yet many chemicals are still used due to exemptions. Other potential POPs have not yet been addressed under the Convention. There is therefore a range of issues that may still need to be addressed as the production or recycling of plastics containing POPs, or potential POPs, will continue to expose ecosystems and people to harmful chemicals.

The Basel and Stockholm Conventions recognise that plastic wastes may contain potentially hazardous substances, including additives such as plasticisers and flame retardants, or may be contaminated by hazardous substances, and as such may pose a risk to human health and the environment, including marine ecosystems. Given the variety of additives used in plastic products and their detection in macro- and microplastic debris collected in surveys, it is only to be expected that they will be found in environment matrices — in water, sediment and biota — and may pose a major environmental concern (1). In addition, the presence of toxic additives is potentially a serious constraint on the recycling of plastics and the move to a circular economy.

The Regional Activity Centre for Sustainable Consumption and Production (SCP/RAC), regional centre of both the Stockholm Convention on Persistent Organic Pollutants (SCRC-Spain) and the Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean prepared this report and originally released it as an Information Document to Delegates for the 2019 Conference of the Parties to the Basel and Stockholm Conventions (UNEP/CHW.14/INF/29/Add.1 and UNEP/POPS/COP.9/INF/28/Add.1). This report was developed with the active involvement of other regional centres of the Basel and Stockholm Conventions, international organisations and experts that joined the Marine Litter Topic Group (See Annex).

In order to increase accessibility of this report to scientific institutions, policy makers, and public interest organisations, the Stockholm Convention Regional Centre in Spain (SCRC-Spain) collaborated with the International Pollutants Elimination Network (IPEN), to format, translate and distribute this report.

The content of the report has not been altered, noting specific detailed text relevant to delegates at the 2019 Basel and Stockholm Conventions meetings. The original information document is available online here.

SCRC-Spain is currently working with UNEP Chemicals and Health Branch to develop further information in relation with the topic of this publication, and new reports will be released in the coming months.

Foreword Barcelona Convention & BRS Secretariat

The pollution generated by plastics and in particular marine plastic litter is a very complex and multi-dimensional issue. It is currently being addressed by an impressive number of stakeholders at all levels. The stocktaking survey for reducing marine plastic litter and microplastics undertaken by United Nations Environment Programme (UNEP) in the framework of the ad hoc open-ended expert group on marine litter and microplastics is illustrating those efforts all around the world. We do recognize, however, that the efforts need to be further intensified and well-coordinated in order to reverse the dramatic trends of the impacts of plastics on the environment and human health.

As it is known today, plastics may remain in the environment for hundreds of years, and can break up into micro- and nanoplastics that could be taken up by organisms and enter into the food chain. There is another aspect of the plastic pollution that is nearly invisible but equally important: toxic chemicals components used in the plastic production could remain in waste streams. We welcome this new publication putting light on this aspect that requires immediate actions if we want to move towards a safer, circular economy.

The three global chemicals and waste conventions, the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade and the Stockholm Convention on Persistent Organic Pollutants (BRS conventions), and a regional sea convention, the Barcelona Convention for the Protection of the Marine and Coastal Environment in the Mediterranean share common concerns and priorities, such as the issue of marine plastic litter and microplastics, the environmentally sound management of plastic wastes and potentially hazardous constituents of plastics. The Memorandum of Understanding for an enhanced cooperative framework between the BRS Secretariat and the Secretariat of the Barcelona Convention, signed in Geneva in December 2018, aims to further these common goals and objectives. The coordination established by the Secretariats constitutes a very good example of articulation between the global and regional levels.

The Mediterranean Sea is considered as one of the most affected areas by marine litter in the world. Marine litter is an urgent concern for the marine and coastal ecosystems with their endangered species in the Mediterranean, with impacts on human health as well as the tourism sector, particularly those concentrated along the shores. Thus, the UNEP/Mediterranean Action Plan (MAP) has long been dedicating efforts to tackle the issue of marine litter in the Mediterranean Region under the Barcelona Convention's mandate and through a dedicated legally binding Regional Action Plan on Marine Litter.

At the regional level, on-going initiatives like the Plastic Busters initiative are currently studying the impact of toxic substances released from plastics on the Mediterranean biota. In addition to the detrimental consequences that ingestion of plastics by marine biota may entail, worrying environmental consequences of marine litter could potentially affect marine biota both from their physical nature if ingested and by transfer of chemicals associated with them, including persistent organic pollutants (POPs) and endocrine disrupting chemicals (EDCs). The Mediterranean basin is considered one of the world's biodiversity hotspots and it is of utmost importance to preserve it.

At the global level, the Basel, Rotterdam and Stockholm conventions provide a framework to protect human health and the environment from hazardous chemicals and wastes through a life cycle approach. At its meeting in 2019, the Conference of the Parties to the Basel Convention amended the Convention to better control plastic waste under its legally-binding framework, which will make global trade in plastic waste more transparent and tightly regulated. The amendments also recognized the harm caused by a range of plastic wastes containing hazardous additives. The new entries added by the amendments become effective as of 1 January 2021. Furthermore, Parties established the "Plastic Waste Partnership", a new multi-stakeholder global partnership to mobilize business, government, academic and civil society actors to tackle plastic pollution.

Echoing those efforts, the Stockholm Convention lists several substances that are used as chemical additives in plastics for elimination, including many of the brominated flame retardants. Those substances are also subject to the prior informed consent procedure under the Rotterdam Convention.

Finally, the Stockholm and Barcelona conventions are supported by an organization, in its capacity as the Stockholm Convention Regional Centre and the Regional Activity Centre for Sustainable Consumption and Production (SCP/RAC), based in Barcelona, that forges connections between the global and regional levels and provides interesting opportunities for actions to beat plastic pollution.

The present report is the result of a collaborative effort led by SCP/RAC to further illustrate a range of potential issues that may arise during the lifecycle of plastics due to the presence of toxic chemicals, and provides recommendations to move forward. The report serves to better grasp the issue in the context of the implementation of a circular economy and to foster action to reduce the toxicity of plastics.

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Foreword IPEN

Increased plastic production is creating massive used plastic landfills in countries across the planet and is turning pristine oceans into plastic waste dumps. Unfortunately, there is another, less visible plastic hazard – the threat to human health from toxic chemicals found in most plastic products, including children's toys, food packaging, kitchen products, clothing, electronics and many, many other everyday consumer products.

Chemicals are added to plastic products for a wide variety of reasons. But their harmful effects on human health can be profound. Even small amounts of these plastic chemical additives can result in damage to immune and reproductive systems, cancers, impaired intellectual functions, and/or developmental delays.

In some cases, the chemicals added to plastics are so dangerous that they have been banned under international and national laws. Their continued use is allowed through exemptions and loopholes won by industry lobbies. In most cases, however, toxic chemical additives are not regulated nor controlled to protect human health and the environment until after the damage is done, at which point the chemical and plastic industry simply puts a new, untested chemical onto the market and the regulatory process starts all over again.

It is almost impossible for families and children to avoid exposure to chemical additives:

Children's toys. "Recycled plastics" – plastics from a variety of sources that have been melted down and re-formed – are used to make children's toys and have been shown to contain many banned, restricted, or otherwise hazardous chemicals. A lack of manufacturer transparency, inadequate recycling regulation, and poor labelling allows this practice to continue.

Food packaging. Most plastic packaging is used once and then thrown away. Toxic chemical additives can be released prior to use, during the cooking process, and when food is hot/heated. These chemicals are also released into the environment when the products are incinerated or landfilled.

Electronics. E-waste handlers and recyclers are unknowingly exposed to a number of dangerous chemicals in plastic electronic components. Broader community exposure occurs when these products are incinerated, landfilled, or turned into other products during the recycling process. For example, there is evidence that "black plastics," widely used to make children's toys and kitchenware, contain dangerous levels of flame-retardant chemicals and dioxins.

Textiles, upholstery and furniture. Polyester, nylon, acrylic and other synthetic fibers are all forms of plastic and comprise more than 60% of the fabric in our clothing. Carpets and furniture are often treated with dangerous flame-retardant and PFAS chemicals. Consumers are rarely aware of the chemicals used to produce these products, as labelling is not required.

Plastic production has doubled over the last 15 years and is expected to double again over the next two decades. Plastics, packaging, and chemical manufacturers argue that waste management and recycling are the solution. These are relevant tools, but do nothing to reduce harm from "invisible" plastic additives.

Four steps must be taken to protect our children and families from exposure to these chemicals:

Material innovation. Investment must be made to develop new, safer materials and systems that avoid the production and use of plastics with hazardous chemical additives. Materials should be designed in accordance with goals of causing no harm to environmental and human health; and achieving zero waste.

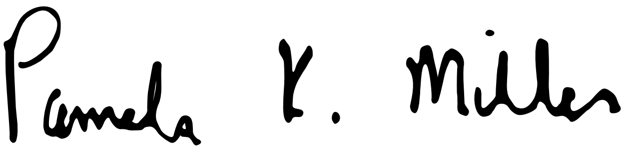
Industry collaboration. Industry must work with civil society to adopt a hazard-based approach to setting standards and regulation, and it must take responsibility for the hazardous materials they produce.

Clean & safer recycling systems. Recyclers need to know the chemical composition of the materials they are handling. Plastic producers should also be charged a fee to fund waste collection and recycling systems.

Transparency. The public and recyclers should have the right to make informed decisions about the products they buy or handle. Plastic materials should be labeled with information about the chemical additives used to produce them.

This new publication, Plastic's Toxic Additives and the Circular Economy, shines a light on the invisible hazards linked to plastics. It is our hope that decision-makers and manufacturers will transform their thinking and practices to take a precautionary approach to the entire lifecycle of plastics, from production to disposal.

Dr. Tadesse Amera
IPEN Co-Chair



Pamela Miller
IPEN Co-Chair

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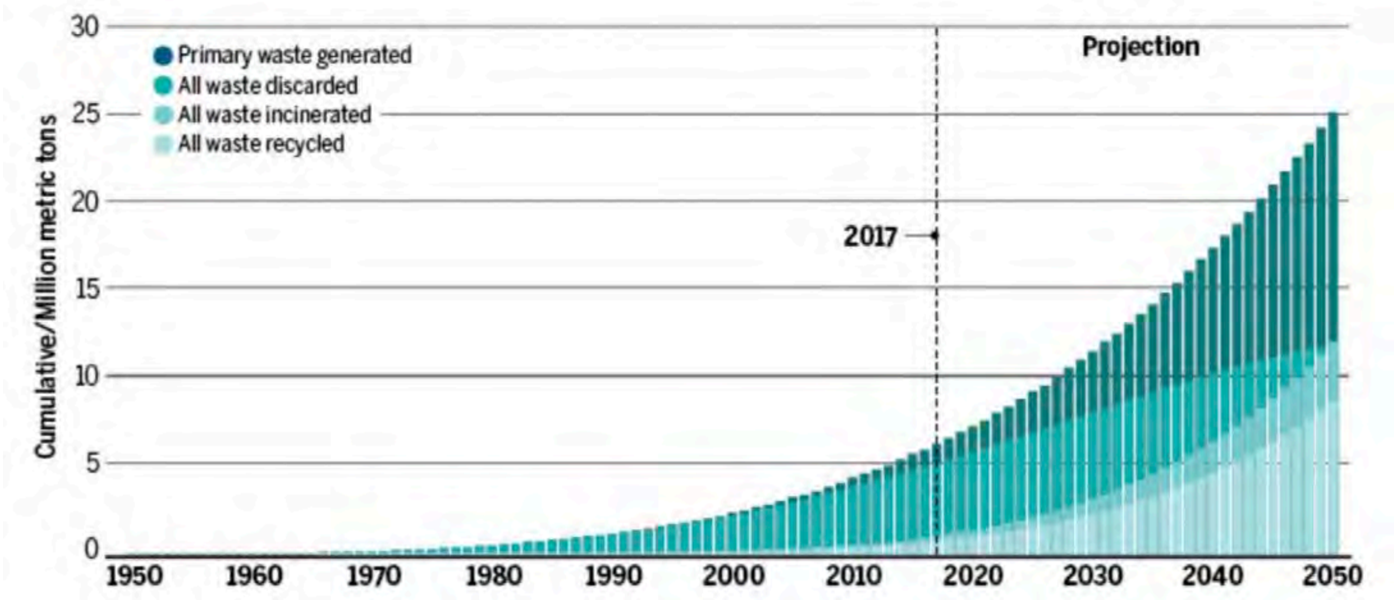
1. Introduction

The increasing growth in the amount of plastic and other polymer waste and the problems it causes in the marine environment have highlighted the pressing need to control this source of pollution on both land and at sea.



Historical data and projections to 2050 of plastic waste production and disposal primary waste is plastic becoming waste for the first time and does not include waste from plastic that has been recycled. Source: (Geyer, Jambeck et al. 2017, Guglielmi 2017)

Photo credit: Brian Yurasits

There is no doubt that there is an urgent need to address the sources of plastic pollution, and in particular the additives used in plastics, to allow a proper implementation of circular economy strategies, to avoid the presence of banned toxic chemicals in products made from of recycled materials, and to reduce the risk to human health and the environment. Recyclers and promoters of a circular economy approach are currently facing multiple environmental and technological challenges in dealing with plastic streams.

The presence of POPs and other toxic or potentially toxic substances in plastic products has a negative impact on the environment and human health, and impacts on all phases of the life cycle of plastic products.

Toxic additives need to be substituted with non-chemical alternatives or non-toxic substances to make recycling easier and to avoid contaminating recycled materials with toxic chemicals, including those which are already banned under the existing chemical agreements, and to reduce the consumption of virgin materials (2).

Photo credit: Martin Holzknecht, Arnika

The presence of POPs and other toxic or potentially toxic substances in plastic products has a negative impact on the environment and human health, and impacts on all phases of the life cycle of plastic products.

POPs are used as additives in large volumes of plastic and other polymers — they are found for example in electronics, vehicle and other transport uses, and buildings and construction. The Stockholm Convention can address the management of the plastics or polymers used in these significant sectors through, for example, BAT/BEP guidance for the recycling and separation of impacted and non-impacted plastic/polymers, and various guidance documents have been developed (3.a) (3.b). As Short-Chain Chlorinated Paraffins (SCCPs) which are used in polyvinyl chloride (PVC) and ethylene-vinyl acetate (EVA), have been listed under the Convention the proportion of polymers within the scope of the Convention will increase significantly. Similarly, the extension of the listing of PFOS and PFOA, which are added to synthetic carpets and textiles or used as polymers in the surface treatment of paper and can contribute to marine litter or pollution by microplastic, will bring a further range of plastic products within scope.

In addition, the second edition of the Global Chemical Outlook (GCO-II), which has been presented to UNEA4, identified cases where emerging evidence indicates risks to human health and the environment that are not yet addressed at the international level. Using as a starting point recent regulatory risk management actions taken by public bodies since 2010 on chemicals or groups of chemicals, "GCO-II identified eleven chemicals or groups of chemicals. Several of these chemicals[ii] (for example, bisphenol A, cadmium, lead, microbeads, polycyclic aromatic hydrocarbons, phthalates) are used as additives or found as contaminants in plastics.

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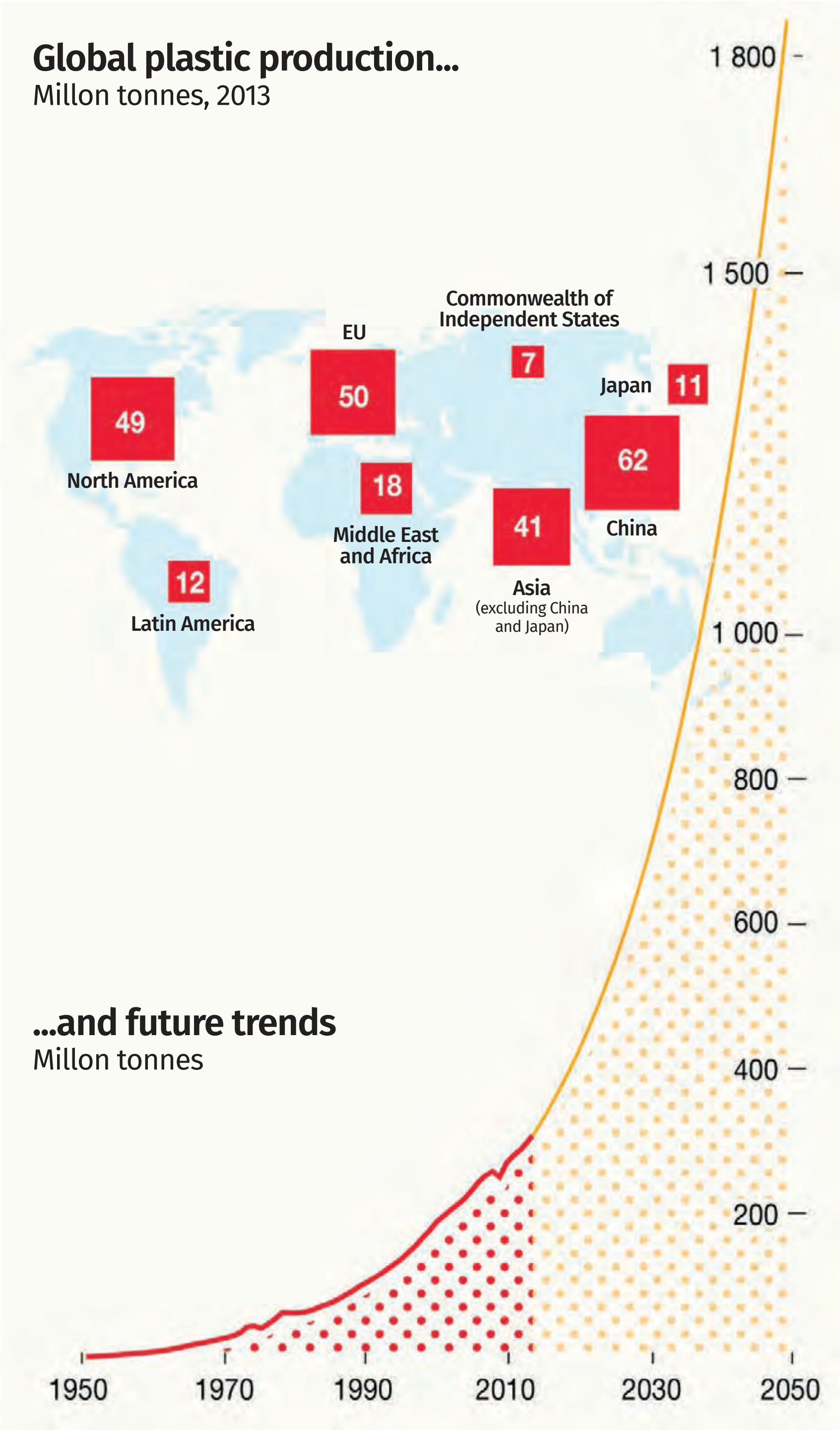
2. Plastic pollution and the circular economy



Source: Ryan, A Brief History of Marine Litter Research in M.Bergmann, L Gutow, M. Klages (Eds.) Marine Anthropogenic Litter, Berline Pringer, 2015; Plastics Europe

During the last 15 years global production of plastics has doubled

During the last 15 years global production of plastics has doubled, reaching about 299 million tonnes per year in 2013 (3). Production is expected to double again over the next two decades (4). This generates large volumes of plastic waste, much of which stems from products that have had only a very short life. This large and diverse waste stream creates serious environmental and management problems (5).

Landfill is the predominant disposal route for plastic waste around the world, with illegal dumping not fully eradicated.

Landfill currently is the predominant disposal route for plastic waste around the world, with illegal dumping not fully eradicated in developing nations and many dumpsites being illegal or badly managed. More worrying still are the number of households not covered by any municipal waste collection system, a situation where plastic waste is under no control, increasing the likelihood of lightweight plastic (and its toxic load) reaching water bodies and finding its way to the sea (6).

The consequences of a linear economic model (extract, make, use, dispose) are evident: loss of resources, waste generation, persistent environmental contamination and ecosystem degradation. Even if there might still be a need to understand better the full impact of plastic pollution, numerous reports and scientific articles provide clear evidence of the dramatic situation and the need for change.

It is in this context that the circular economy concept has gained increased interest as an alternative to a traditional linear economy (7) (8) (9). A circular economy keeps resources in use for as long as possible. It extracts the maximum value from them whilst in use, then recovers and regenerates products and materials at the end of their service life. The principles of a circular economy are to design out the concept of waste; to rebuild natural capital and to keep products, materials, and molecules flowing effectively through the economy at their highest value (10).

> *This requires life cycle thinking and the adoption of circular design principles — making appropriate choices of materials when designing products*

This requires life cycle thinking and the adoption of circular design principles — making appropriate choices of materials when designing products — and establishing appropriate recovery systems. Both are a major challenges across industries today. Some materials should be avoided since they contain substances which have been identified as being of concern[iii]. In other cases, the way materials are combined in a product inhibits their separation and capture after use, limiting their recovery and recyclability.

In large part, industry's efforts have been focused only on addressing waste and/or increasing the use of recycled content with the intention of keeping materials in the value chain longer (10). But in practice industry is currently cycling materials that were never optimised for human and environmental health. For example, polymeric materials such as foam, plastic food packaging, paper, rubber and textiles can contain flame retardants, softeners, plasticisers, coatings, modifiers, catalysts, other performance enhancing additives and residuals. When they are recycled into new products, the output tends to be highly contaminated, non-homogeneous, and impure even for toys and food contact materials (11) (12) (13) (14) (15). The problem is that currently it is not feasible to obtain full information about the formulation of mixed waste streams, and it would be impractical to attempt to reverse engineer a contaminated lot of material to identify all the chemical constituents (10). The output is complex to assess thoroughly for toxicological impacts; hence inadvertently humans and the environment are increasingly exposed to risk through a number of recycled products and materials.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Both developed and developing countries have realised not only the challenges but also the opportunities arising from better management and prevention of plastic waste, such as the potential to improve competitiveness and create new economic activities and jobs. This has given rise to a number of measures by both private and public actors. A number of countries have agreed targets for the recycling of plastic, for the use of recycled plastic in products, or for the ban of single-use plastics. The 2018 UN Environment report on Legal Limits on Single-Use Plastics and Microplastics, A Global Review of National Laws Regulations highlights numerous examples (16). As a specific example, the European Union (EU) published in 2018 an EU strategy for plastics in the circular economy (Find out more here).

The New Plastic Economy initiative of the Ellen Mac Arthur Foundation is also relevant, demonstrating the commitment of major actors in the plastic economy. It emphasises the need to tackle the flood of plastics at their source, to eliminate the unnecessary use of plastics, and to innovate and circulate everything. It also stresses the importance of the extended producer responsibility (17).

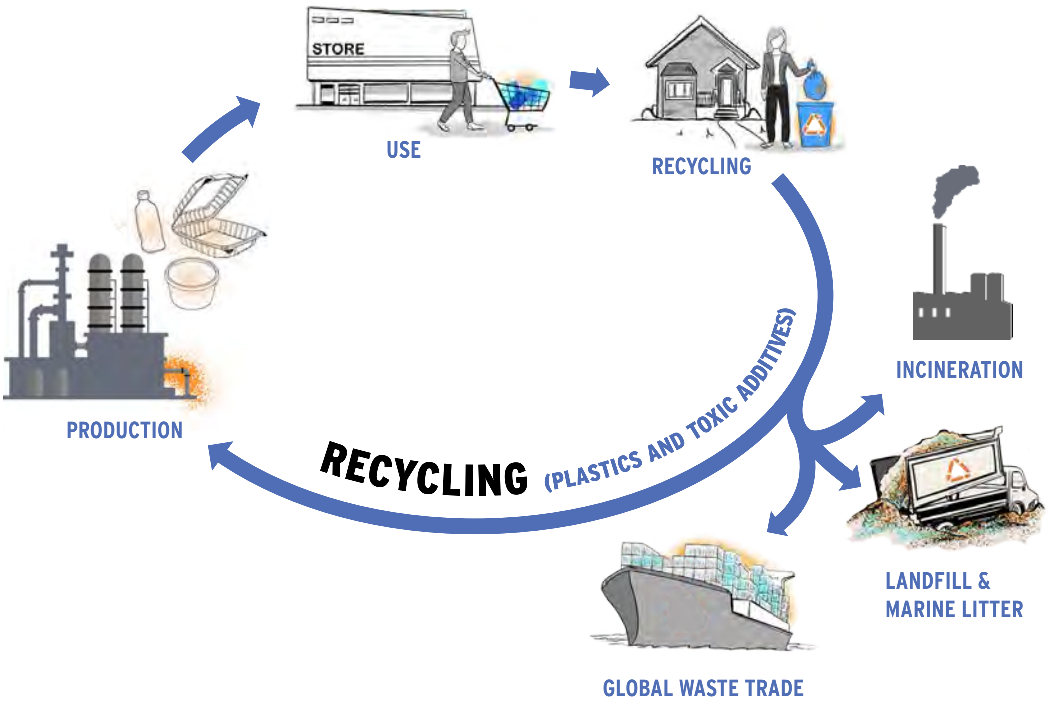
The international movement of plastic waste poses several challenges. A country may promote a circular economy via plastic collection for recycling and where recycled plastic is defined as a resource, but then export that plastic waste to another country for recycling. In Asia, customs officers have had to impound imports registered as “recyclable plastics” because they contained an undefined mixture of plastic types and other municipal and industrial waste. Many countries have now banned, or are proposing to ban, plastic waste imports.

In summary, there is growing awareness of the need for change, and the circular economy model is gaining momentum as the next best viable solution (18). However, there are many issues that need to be addressed.

Basel Plastic Waste Amendment

During the Basel Conference of the Parties from 29 April to 10 May 2019, Governments amended the Basel Convention to include plastic waste in a legally-binding framework which will make global trade in plastic waste more transparent and better regulated, whilst also ensuring that its management is safer for human health and the environment. At the same time, a new Partnership on Plastic Waste was established to mobilise business, government, academic and civil society resources, interests and expertise to assist in implementing the new measures, to provide a set of practical supports – including tools, best practices, technical and financial assistance.

2.1. Challenges of the life cycle management of plastics in the circular economy, and the issue of POPs and other toxic chemical additives



Many challenges have been found when trying to “close the loop”, arising at every stage in the life of plastics from the initial design to the end of life. The following paragraphs identify some of these challenges and possible solutions.

2.1.1. Design and production phase: Phase-out and substitution with non-toxic alternatives

Currently there is still a wide range of toxic chemicals used as plastic or polymer additives – for example, chemicals that have not yet been subject to international controls (such as many endocrine-disrupting chemicals) or recognised POPs which are allowed under exemptions. These substances will impact on the future recycling of the products in which they have been used. They should be phased out and substituted with non-toxic alternatives in order to encourage a circular economy.

To keep ‘safe’ molecules in recycling for a long time, industry needs to create safe materials and build the systems, infrastructure and technology. This requires the use of chemical hazard evaluation tools to assess and then optimise material chemistry for human and environmental health so that better decisions can be made in the design phase. Chemicals must be assessed across a comprehensive set of human and environmental health criteria, so that lower hazard chemistries can be selected (10).

However, scientific reports describe the difficulty of obtaining high-quality data on chemical toxicity and environmental impacts, due to both the complexity of the supply chain and the fact that manufacturers limit visibility of the chemicals going into their products. There are often barriers to sharing information within the industry due to claims that information is commercially confidential (19).

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There is however concern whether an approach based solely on a list of restricted substances is adequate, since it does not identify what is safe or preferred for use (10). Circular economy strategies need to focus on proactively assessing and screening material chemistries to avoid regrettable substitutions and reduce the toxicity of the materials that are going to be circulating in commerce. Broader application and further development of effect-based testing approaches are also desirable to guide the substitution efforts and ensure the toxicological safety of plastics in the circular economy (20).

Chemicals Strategy for Sustainability (toxic-free EU environment)

As announced in the European Green Deal and in the context of its zero pollution ambition for a toxic-free environment, the Commission will present a Chemicals Strategy for Sustainability. The Strategy will build on recent policy evaluations and initiatives associated with the EU chemicals legislation — in particular the second REACH Review, the Fitness Check of the most relevant chemicals legislation (excluding REACH) and the Communication on options to address the interface between chemical, product and waste legislation — but also on specific policy evaluations carried out in the area of environmental and health protection, products, food and workers' protection. This strategy aims to reduce the risks associated with producing and using chemicals. It will simplify and strengthen EU rules on chemicals, and review how EU agencies and scientific bodies can work together towards a process where substances are only reviewed by one agency.

2.1.2. Use phase: migration and release potential of various additives present in plastic

Chemicals present in plastics can potentially migrate from plastic products to the medium in contact with them, and can also slowly migrate within the plastic to the surface. For example, scientific studies have reviewed the migration of various chemical substances from plastic packaging materials during microwave and conventional heating, under various storage conditions. They found that there is unwanted migration and release of additives such as plasticisers (e.g. short-chained chlorinated paraffins (SCCPs) from PVC toys or shower curtains) or of flame retardants (e.g. from plastic casings of televisions or computers). Some of the migrating substances may be toxic. Other additives can give an unpleasant taste to food, or can enhance the degradation of active substances in medicines. The initial concentration of the chemical substance present in the plastic, the thickness, crystallinity and the surface structure of the plastic are all factors that influence the migration rate (21).

Photo credit: IPEN

Specific examples of toxic substances studied for potential release from various plastic products include brominated flame retardants (BFRs) (22), SCCPs/MCCPs (23) (24), phthalates (25), bisphenol-A (26), bisphenol-A dimethacrylate, lead, tin and cadmium formaldehyde and acetaldehyde, 4-nonylphenol, methyl tert-butyl ether (MTBE), benzene and many other volatile organic compounds. Although several of these studies report released concentrations that are lower than the established legal limit values, there are also occasions where they are considerably higher. It has also been highlighted that the guideline values do not take into account of the low levels at which endocrine-disrupting chemicals may be in effect nor do they consider the toxicity of mixtures (21).

2.1.3. End-of-life phase: difficulty in performing exposure-based risk assessments of products for recycling

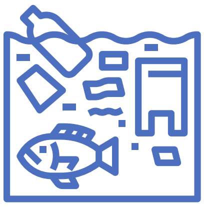
When articles containing plastics reach the end of their lives recycling is one of the options, but this can be problematic if the plastic contains toxic additives – for example, a large share of plastic products currently produced have been found to contained polybrominated diphenyl esters (PBDEs) and other BFRs from recycling (27).

Chemical risk assessments are the basis for assessing impacts on human health and the environment. This reflects the precautionary approach embedded in the Stockholm Convention. To ensure that human health and the environment can be effectively protected, risk assessments should be based on actual data and not on estimates or assumptions. A recent review however reported this is an issue in scientific studies where, for example, there is a substantial shortage of and lack of access to information on how specific chemicals are used, or which chemicals are used in what application and in what quantities, and at which levels they are present in finished plastic packaging. Because of the limited ability to conduct accurate exposure assessments, one conclusion of the review is that hazard-based assessment remains the approach of choice when dealing with large numbers of chemicals potentially present in consumer products. (20).

> *There is an urgent need for publicly available information on the use of chemicals in plastics, on the exact chemical composition of finished articles, and on the impact of POPs and other toxic additives from recycling.*

There is therefore an urgent need for publicly available information on the use of chemicals in plastics, on the exact chemical composition of finished articles, and on the impact of POPs and other toxic additives from recycling Second, harmonised toxicological information, such as hazard classifications under the UN Globally Harmonised System of Classification and Labelling of Chemicals, is currently not available for many chemicals that are associated with plastic packaging, even for substances for which hazards have been identified and characterised in academic studies. The lack of harmonised classifications for many chemicals affects the hazard ranking. For some of the key hazardous chemicals identified in scientific studies more detailed analyses should be performed, including an assessment of the availability of alternative systems or products, and of the hazards throughout life. Insufficient information on chemicals' use patterns prevents exposure-based assessments, since filling data gaps using a systematic, scientific approach is nearly impossible for anyone outside the industry (20).

2.1.4. End-of-life phase: emission and leaching of potentially toxic substances



79%

of plastics end up in landfills or the environment

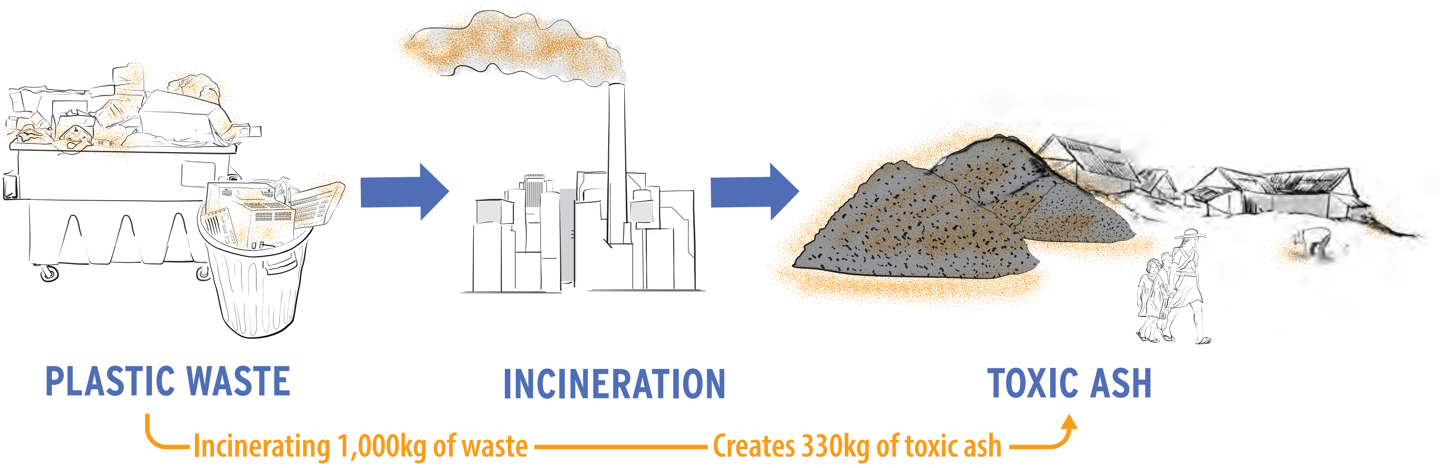
9%

of discarded plastics are recycled

Globally, 79% of plastics end up in landfills or are discarded into the environment, whereas only 9% are recycled (112). In industrial countries a large share of plastic waste is used for energy recovery. In Europe, more is destined for energy recovery (39.5%) than for recycling (29.7%) (28). However, uncontrolled combustion of plastic waste and, in particular of plastics containing halogens such as PVC, polytetrafluorethylene, teflon, or brominated flame retardants, can cause emissions of hazardous substances, for example unintentional POPs such as dioxins (29). Also pyrolysis or combustion of fluorinated polymers or fluoropolymer dispersion can result in the unintentional formation and release of fluorinated POPs (e.g. PFOA), other PFAS, other toxic substances, ozone depleting substances and greenhouse gases (30) (31) (32) (33).

Halogens emitted from the combustion of plastic waste can also cause corrosion in incinerators and other thermal facilities. Chlorine and bromine may accumulate in cement kiln systems limiting their capacity for the thermal recovery of plastic (34). Furthermore, since most plastics are fossil fuel based, incineration may also contribute to global warming and the depletion of petrochemical resources. Controlled combustion in Energy-from-waste[iv] plants and cement kilns equipped with state of the art air pollution control (APC) technologies may be the best way available to limit the dispersion of POPs (2). However, improvements in APC technology to reduce POPs emissions to air has led to their transfer to residues such as fly ash and to a lesser extent bottom ash. This requires that there should strict regulation and control of the ash, to avoid further dispersion of POPs and to avoid food chain contamination (35)

Air pollution control technology to reduce POPs emissions to air has led to their transfer to residues such as fly ash and to a lesser extent bottom ash. This requires that there should be strict regulation and control of the ash, to avoid further dispersion of POPs and to avoid food chain contamination



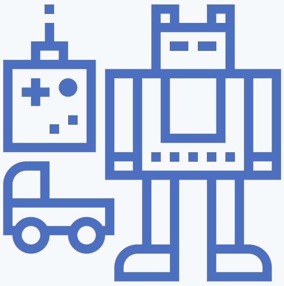
Non-combustion techniques might also be used for the destruction or irreversible transformation of POPs-impacted plastics. However, none of these technologies have demonstrated proven full-scale performance, and the CreaSolv process has been included as an emerging technology in the Stockholm Convention guidance on BAT/BEP for the treatment of PBDE-containing plastics. Mechano-chemical treatment (ball milling) has been shown to destroy PFAS and PBDE in impacted plastics (36) (37), and the CreaSolv is capable of separating brominated POPs from expanded polystyrenes allowing recycling of the clean styrene recovered (38). The process can also be applied to e-waste plastics containing brominated POPs.

The global trade in waste plastics has seen the movement of significant volumes of plastic waste from developed countries to developing countries, where environmentally unsound recycling and disposal practices can exacerbate exposure to toxic compounds. It was estimated that in 2016 that 70% of all plastic waste exports were from OECD members, largely to lower-income countries in East Asia and the Pacific (39). China's decision to ban the import of contaminated plastic waste is predicted to result in a 111 million metric tonnes displacement of plastic waste by 2030.

A recent case of human POPs exposure increasing due to poor management of imported plastics was noted in Ghana with sampling at a 'recycling site' revealing some of the highest levels of dioxins ever recorded (40)

Photo credit: BaliFokus/Nexus3

It is also important to recognise that in many countries the informal recycling economy is a fundamental element of plastic waste management. But little is known of the fate of plastic additives within these informal 'recycling' practices.



Detection of high PBDD/Fs levels and dioxin-like activity in toys

PBDDs and dibenzofurans are increasingly reported at significant levels in various matrices, including consumer goods that are manufactured from plastics containing certain brominated flame retardants. A study determined that PBDD/Fs levels present in plastic constituents of toys could pose a threat to children's health. PBDD/Fs, unlike their chlorinated counterparts (PCDD/Fs), have not been officially assigned toxic equivalence factors (TEFs) by the WHO. An estimate was made of the daily ingestion of TEQs from PBDD/Fs-contaminated plastic toys by child mouthing habits. It is observed that the daily ingestion of PBDD/Fs from contaminated plastic toys may significantly contribute to the total dioxin daily intake of young children.

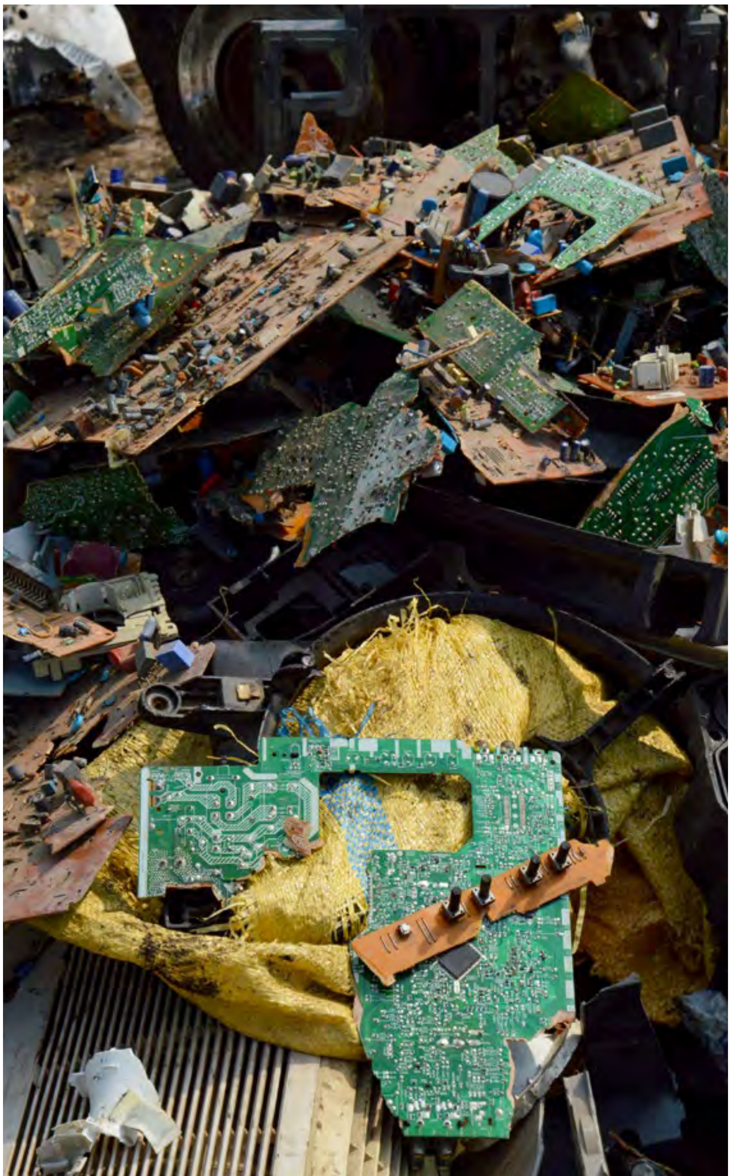


Photo credit: Martin Holzknecht, Arnika

2.2. Substances of concern

The following section describes the most concerning groups of chemicals used in plastic production due to their presence in consumer goods and their known impacts on human health. It deals with groups of chemicals rather than individual substances, to focus on reducing the use of entire classes rather than phasing out individual problematic chemicals one at a time. This approach helps develop coordinated strategies for reducing the production and use of chemicals of concern and prevent regrettable substitutions.

Tackling entire groups of chemicals can prove more effective, because there are a great number of chemicals in use, most of which have not been well studied and their impacts on human and environmental health are not sufficiently understood. Moreover, when a harmful chemical is phased out, often only after years of research and negotiation, the replacement is likely to be a "chemical cousin" with similar structure and potential for harm. (41) (42). Grouping strategies have been proposed by institutions and environmental organisations such as Greenpeace and the European Commission (43) and also by the Green Science Policy Institute[v]. While many of the following chemicals do not meet the POPs criteria under the Stockholm convention, many can persist for a long time and travel long distances with related exposure and toxicity from plastic and microplastics ingestion, and are therefore of equivalent concern. (44).

2.2.1. Flame retardants

Flame retardants are a class of additives used in plastic and other polymer products to reduce flammability and to prevent the spread of fire. They are used in many consumer products ranging from electronic devices to insulation foams. The main retardants used in plastics include brominated flame retardants (BFRs) with antimony (Sb) as synergist (e.g. polybrominated diphenyl ethers (PBDEs), decabromodiphenylethane; tetrabromobisphenol A (TBBPA), phosphorous flame retardants — e.g. Tris(2-chloroethyl)phosphate (TCEP) and Tris(2-chlorisopropyl) phosphate (TCPP) — and short, medium and long chain chlorinated paraffins (SCCP/MCCP/LCCP), boric acid, hexabromocyclohexane (HBCD) (2) and the series of compounds known as Dechloranes in all its forms such as Dechloranes 602, Dechlorane 603, Dechlorane 604 and Dechlorane Plus (45).

PBDEs are hydrophobic substances that were produced as three commercial formulations (commercial penta-BDE, commercial octa-DBE and commercial deca-BDE). They are ubiquitous, toxic, and persistent, they bioaccumulate, and they are of great concern for human health (46). Tetra- to hepta-BDEs and hexabromobiphenyl (HBB) were listed in Annex A of the Stockholm Convention in 2009 for elimination with exemption for recycling, and decaBDE was listed in 2017 with several exemptions[vi] for use (47). In 2013 HBCD was listed for elimination in the Annex A of the Convention with specific exemption for use and production in extended polystyrene (EPS) and extruded polystyrene (XPS), where it is mainly used (113).

Lately, attention has been given to other emerging brominated flame retardants such as 1,2-bis (2,4,6- tribromophenoxy) ethane (BTBPE), decabromodiphenylethane (DBDPE) and hexabromobenzene (HBBz) as these have been identified in many environmental compartments, in organisms, in food, and in humans (118). As they are not chemically bound to the polymer matrix, they can leach into the surrounding environment (48) (49) — the exception is TBBPA which is normally chemically bound to the polymer (50). TBBPA is produced by brominating bisphenol A and is the most commonly produced BFR in the world, representing 60% of the BFR market (51).

2.2.2. Perflourinated chemicals

PFOS and related substances have been listed under the Stockholm Convention since 2009, and PFOA and related substances are suggested for listing in the current COP. PFHxS has been acknowledged to meet the POPs criteria. All per- and polyfluorinated[vii] substances (PFAS) are an issue of concern under the Strategic Approach of Chemical Management Strategic Approach to International Chemicals Management (SAICM). PFOS and PFOA do not follow the pattern of a classic POP — they do not accumulate in fatty tissues but instead binds to proteins. They therefore accumulate mainly in organs such as the liver, kidney, brain and spleen. In animal studies PFOS causes cancer, neonatal mortality, delays in physical development, and endocrine disruption. Higher maternal levels of PFOS and PFOA are associated with delayed pregnancy (52). Higher PFOS/PFOA levels are associated with reduced human semen quality and penis size (53) (54). For most other PFAS toxicity data are insufficient (55).

A major use of PFOS related substances (PFOS precursors) was in side-chain fluorinated polymers such as fluorinated (met)acylate polymers, fluorinated urethane polymers or fluorinated oxetane polymers (56) (57). PFOA related substances have also been included. These polymers are used for surface treatment on carpets, textiles or furniture and can be released as particles and possibly microplastics. Degradation of side-chain fluorinated polymers can release PFAS including PFOA or PFOS depending on their former synthesis (58) (57).

2.2.3. Phthalates

Phthalic acid esters or phthalates are a family of additives used as plasticisers, mainly in PVC production (59). They add fragrance to products and make them more pliable. But some phthalates have been defined as endocrine disruptors, even at low concentrations (60). Phthalates interfere with the production of androgen (testosterone), a hormone critical in male development and relevant to females as well.

PVC can contain 10%-60% phthalates

PVC can contain 10%-60% phthalates by weight (61). They can easily leach into the environment during manufacturing, use and disposal (61). They are of great concern, since they have been found in a wide range of environments. In 2015, 8.4 million tons of plasticisers were used around the world. Di(2-ethylexyl) phthalate (DEHP) was the most commonly used, representing 37% of the global plasticiser market. The European Parliament targets DEHP plasticizer in recycled PVC, (117). However, DEHP has gradually been replaced by diisononyl phthalate (DiNP), diisodecyl phthalate (DiDP) and di(2-Propyl Heptyl) phthalate (DPHP), which represented 57% of plasticiser consumption in Europe in 2015 (59).

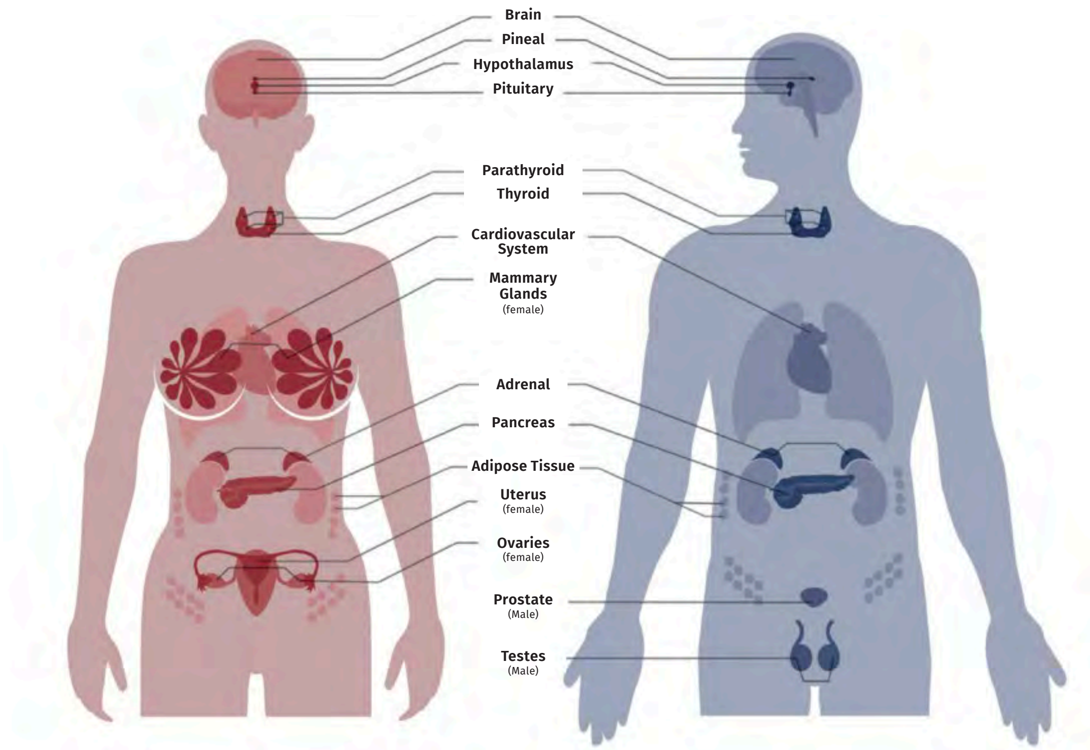


Illustration: Endocrine Society

The European Union has restricted some phthalates since 1999, and the United States and Canada has similarly restricted their use since 2008, particularly in children's toys or articles which young children may put in their mouths. DEHP has been classified as a reprotoxin (category 1B) in the EU.

2.2.4. Bisphenols

Bisphenols are a group of chemical compounds with two hydroxyphenyl functionalities. They are present in many polycarbonate plastic products (including water bottles, food storage containers and packaging, sports equipment and compact discs), epoxy resin liners of aluminium cans, and also bisphenols are frequently used as a developer in thermal paper such as cash register receipts.

They are present in many polycarbonate plastic products (including water bottles, food storage containers and packaging, sports equipment and compact discs)

Bisphenol A (BPA) is the most representative chemical of the bisphenol group and is one of the most commonly produced chemicals worldwide, with over three million tons produced annually (62). In humans, it is linked to reduced egg quality and other aspects of egg viability in female patients seeking fertility treatment.

BPA is mainly used as a monomer for polycarbonate (PC) plastics (65% of the volume used) and epoxy resins (30% of the volume used), which are the main components of the lining layer of aluminium cans (63). BPA can also be used as an antioxidant or as a plasticiser in other polymers (PP, PE and PVC) (64). Leaching of BPA can occur (65), leading to release from food and drink packaging, a source of exposure for humans (66). Studies of human exposure to bisphenol A and 4-tertiary-octylphenol carried out in the United States show a correlation between concentration and population in selected demographic and income groups: females had statistically higher concentrations than males; children had higher concentrations than adolescents, who in turn had higher concentrations than adults. Concentrations were lowest for participants with the higests household incomes (67).

PFOA listed in the Stockholm Convention and PFHxS in POPRC process

The Stockholm Convention on Persistent Organic Pollutants unanimously voted to add perfluorooctanoic acid (PFOA) to the list of substances to be eliminated under the 2004 agreement dedicated to reducing POPs.The flouropolymers intermediate was linked to various types of cancer, along with thyroid disease, ulcerative colitis and birth defects.

At its fourteenth meeting, the Chemical Review Committee of the Rotterdam Convention adopted the risk profile on perfluorohexane sulfonic acid (PFHxS), its salts and PFHxS-related compounds moving the chemical to the next review stage requiring a risk management evaluation.

Other bisphenol analogues, such as bisphenol B, bisphenol F and bisphenol S are used in plastics and may also represent a threat to the environment. (Find out more here). The hormonal pathways disrupted by BPS manifest in many different ways in animal studies: in changed uterine growth, shifts in both male and female sex hormone concentrations, reproductive disruptions including changes to egg production and sperm count (68) as well as statistically significant weight gain and altered hormone metabolic profiles (69). A recent study (70) demonstrated that BPS alters maternal behaviour and brain function in mice exposed during pregnancy/lactation, as well as in their female offspring. A summary of the effects of BPS on hormonal activity can be found in a comprehensive review article published in Environmental Health Perspectives. (71)

Although less well-studied than BPA or BPS, BPF appears to have BPA-like effects. Recent receptor-binding studies indicate that it is about as potent as BPA when acting through at least one of the nuclear estrogen receptors (72). These studies are complemented by animal tests that show the effects of BPF on uterine growth and testes weights, demonstrating impacts on the estrogen and androgen pathways respectively (73). BPF, like BPA, also appears to disrupt thyroid pathways (74).

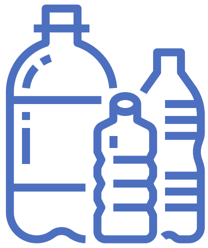
2.2.5. Nonylphenols

NP and NPE are used for many applications such as paints, pesticides, detergents and personal care products

Nonylphenols (NP) are intermediate products of the degradation of a widely used class of surfactants and antioxidants: nonylphenol ethoxylates (NPE) (114). NP and NPE are used for many applications such as paints, pesticides, detergents and personal care products and can also be used as antioxidants and plasticisers in plastics (115).

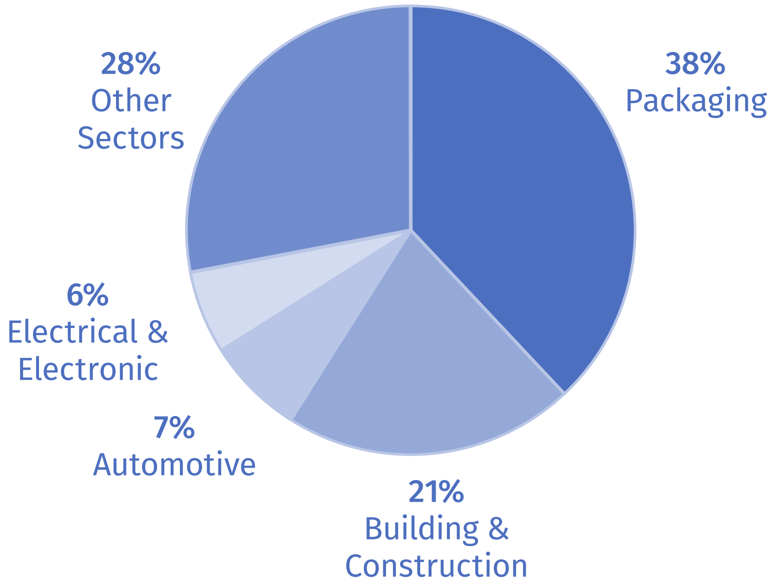
NPs have been found to leach from plastic bottles into their water (116). Moreover, effluents from wastewater treatment plants are the major source of NP and NPE in the environment. The impacts of NP in the environment include feminisation of aquatic organisms, decrease in male fertility and the survival of juveniles even at low concentrations. (75). NP are considered as endocrine disruptors and their use is prohibited in the European Union for example due to their effects on the environment and human health (115).

2.3. Priority sectors



26%

Globally plastic packaging represents 26% of the total volume of plastics used



Polymers and their additives are extensively used in consumer products and to make synthetic fibres, foams, coatings, adhesives and sealants. Globally, plastic packaging represents 26% of the total volume of plastics used (4). In Europe, their use is dominated by the packaging sector (38%), followed by building and construction (21%), automotive (7%), electrical and electronic (6%), and other sectors (28%), such as medical and leisure (76).

Plastics, and the consumer goods made from them, can contain POPs such as SCCPs, PBDEs, PCBs, PCNs and PFOS/PFOA related chemicals, and other toxic substances. Plastic containing POPs are also extensively used in building and construction, automotive and electrical and electronic sectors, compromising more than one third of plastic use. During the recycling process, other plastic is also impacted by toxic substances where they were originally not used even in food contact materials (77) (78) (79) (80). A review prepared by the Secretariat for the Stockholm Convention noted that the low levels of PBDEs in articles, including toys indicate that their presence is not the result of intentional use — they most probably appear in new products made out of recycled plastic that contained PBDEs (See figure above) (UNEP/POPS/COP.8/INF/12) (Find out more here).

During the recycling process, other plastic is also impacted by toxic substances where they were originally not used even in food contact materials

The sectors discussed in the following section are believed to be the most concerning based on the evidence of the presence of endocrine-disrupting chemicals (EDCs) and their repercussions on human health (Find out more here).

2.3.1. Children's products

Children's toys often contain EDCs. Some EDCs are being regulated and banned in children's toys, games, and accessories such as baby bottles in some jurisdictions, but many problems remain. Products that are older, manufactured outside of countries with regulation, or battery-operated may be of particular concern. (Find out more here).

POPs are detected in toys made from recycled plastics containing POP-BFRs (81) and from the abundant use of SCCPs in soft PVC toys (82) (83). The exposure of POP-PBDEs and other plastic additives in recycled plastic has shown relevant exposure to children by toys (84) (85). A new study conducted by IPEN in 2017 reveals elevated concentrations of PBDEs (polybrominated diphenyl ethers) such as octabromodiphenyl ether (OctaBDE), decabromodiphenyl ether (DecaBDE); and SCCPs (short chain chlorinated paraffins) in toys made out of recycled materials and purchased in different stores in 26 countries globally. (Find out more in these links: 1, 2 and 3). Levels of some chemicals were more than five times higher than recommended international limits. They are listed under the Stockholm Convention. However, their presence in new products, although they are banned or restricted, opens up the discussion of a problem regarding inadequate recycling regulations in a circular economy.

Labelling phthalates can be seen in developed countries, but not in developing countries or countries in transition. Recent projects in Nepal, the Philippines, Armenia, Serbia and Belarus clearly showed that phthalates are not labelled on toys thus information on product labels does not help consumers choose a toxic free toy, leaving them unaware of the product toxic health effect. (Find out more here).

Labelling phthalates can be seen in developed countries, but not in developing countries or countries in transition.

Other EDC's such as metals and their salts have also been long acknowledged, studies by the International Pollutants Elimination Network (IPEN) (Find out more here) reported lead in 18% of children's products in Russia and surrounding nations, 15% in the Philippines, and 10% in five cities in China. Cadmium is a natural element used in batteries, pigments, plastic stabilisers, alloys, and coatings. It has in recent years fallen under increased regulation as a carcinogen and pollutant. Cadmium may also be an EDC; research suggests a link to a wide range of detrimental effects on the reproductive system.

2.3.2. Packaging: food and beverage contact materials

Plastic is mostly used in packaging as a low-cost single-use product that is most often not reusable or not foreseen for reuse. Today 95% of the plastic packaging value is lost to the economy after a short, single use (4). Plastic packaging is diverse and made of multiple polymers and numerous additives, along with other components, such as adhesives or coatings, and most worryingly it can contain residues from substances used during manufacturing such as solvents, along with non-intentionally added substances such as impurities, oligomers, or degradation products (20). Fluorinated POPs such as PFOA and formerly PFOS are used in food packaging in fluorinated polymer coatings (86) (87).

Phthalates are used in hundreds of products, including many food and beverage containers and plastic wraps. Concern has risen about packaging since people are exposed to phthalates when they leach into foods or are released when containers are microwaved. Some companies have voluntarily removed them from their products and advertise them as "phthalate-free". Among the phenol class of compounds considered to be EDCs, bisphenol A (BPA) is one of the best known and most pervasive. Although BPA has been banned in children's products such as baby bottles in some countries, it is still used in many water bottles and plastic containers and in the epoxy resins that protect canned foods from contamination[viii].

2.3.3. Electrical and electronic equipment (EEE) and related waste (WEEE/E-waste)

POP-BFRs (tetra-hepta-BDE, deca-BDE, HBB, HBCD) are or have been used as flame retardants in plastic in electronics. Deca-BDE was very extensively used, and still has an exemption for the use in EEE housing.

In 2009 the Strategic Approach to International Chemicals Management (SAICM) agreed that hazardous chemicals in electronics is an issue of global concern and in 2011, the United Nations Industrial Development Organisation (UNIDO), and the Secretariats of the Basel and Stockholm Conventions hosted an expert group meeting to develop recommendations to address hazardous chemicals in electronics that were subsequently endorsed by more than 100 governments at SAICM meetings in 2012 and 2015.

"Hazardous chemicals in electronics is an issue of global concern"

There is mounting evidence that the demand for black plastics in consumer products is partly met by sourcing material from the plastic housings of end-of-life waste electronic and electrical equipment (WEEE) with related POPs contamination (78) (79) (84) (85) (14). Inefficiently sorted WEEE plastic has the potential to introduce restricted and hazardous substances into the recyclate. In addition to POP-BFRs, antimony, which is a flame-retardant synergist, and the heavy metals cadmium, chromium, mercury, and lead are reintroduced by recycling. (88)

It is important to note that these chemicals are not labelled on EEE and related e-waste. Lack of information about their presence in products and waste complicates the recycling process, undermines the circular economy approach, denies consumers their right to know and endangers waste handlers.

2.3.4. Textile, upholstery and furniture

"These chemicals are not labelled on textile products, which makes it impossible for consumers to make an informed decision or for recyclers to proceed with safe recycling. As a result, consumers will have no information about their content in products they purchase, while governments will not know whether they are in compliance with the Stockholm Convention's requirement, which does not allow recycling of products containing Deca-BDE"

Polyester, nylon, acrylic, and other synthetic fibres are all different forms of plastic and currently constitute over 60% of the material that makes up our clothes worldwide (89). Synthetic plastic fibres are cheap and extremely versatile, providing for stretch, breathability, warmth and sturdiness. These fibres contribute to ocean plastic pollution in a subtle but pervasive way since the fabrics they make, along with synthetic-natural blends, leach into the environment just by being washed. Estimates vary, but it is possible that a single load of laundry could release hundreds of thousands of fibres and microfibers from clothes into the wastewater collection system. Textiles also find their way to rivers and oceans from landfills.

Several POPs are used in textiles for clothes and in particular for upholstery in transport and furniture and other flame-retarded or surface-treated textiles or carpets (e.g. commercial penta-BDEs, deca-DBE, HBCD, SCCPs, PFOS, and PFOA). Deca-BDE and SCCPs have received exemptions (Find out more) for the use in textiles. These chemicals are not labelled on textile products, which makes it impossible for consumers to make an informed decision or for recyclers to proceed with safe recycling. As a result, consumers will have no information about their content in products they purchase, while governments will not know whether they are in compliance with the Stockholm Convention's requirement, which does not allow recycling of products containing Deca-BDE.

2.3.5. Construction sector

A major use of plastic and polymers is in construction. Large volumes of polymer foams are used as insulation in buildings and other areas of construction. Most polymer foams used are polystyrenes, including expanded polystyrene (EPS) and extruded polystyrene (XPS), polyurethane (PUR) and polyisocyanurate (PIR). The foams are often flame retarded with brominated or other flame retardants in order to meet flammability standards. HBCD listed as a POP in 2013 is still used in EPS/XPS with a specific exemption for the use in insulation in construction. DecaBDE listed a POP in 2017 is still used in PUR foam in construction as specific exemption. These foams have a long service life of decades and possibly up to a century with challenges in developing countries in managing insulation foam at its end of life (90).

Other polymers in construction treated with decaBDE or other flame retardants are PE insulating foam, PE plastic sheeting and PP plastic sheeting. Also SCCPs are still used and PCNs and PCBs have been used in the past in polymers in construction in particular in sealants and paints (91) (92). SCCPs are also used in construction, in PVC, sealants/adhesives, and rubber, and therefore in a variety of polymers (93). DecaBDE and HBCD are also used in intumescent paints/coatings in construction. These plastics have a long service life of decades. For paints and sealants, which often contain coating plasticisers such as PCBs or SCCPs and are often PVC based, it has been shown their removal via sand blasting has contaminated the environment, including several hundred kilometres of river sediments or fjords with PCBs from single bridges (94) (95).

2.4. Microplastics, persistent pollutants with transporting capacity hindering the implementation of the circular economy

Better understand the toxicity of microplastics

Plastics contain additives (including endocrine disruptors) that can be absorbed by the tissues of animals that swallow them. This research will contribute to identifying the most toxic plastics according to their composition, in order to eliminate them as a priority from our consumption.

Plastic at sea: the solutions are on land!

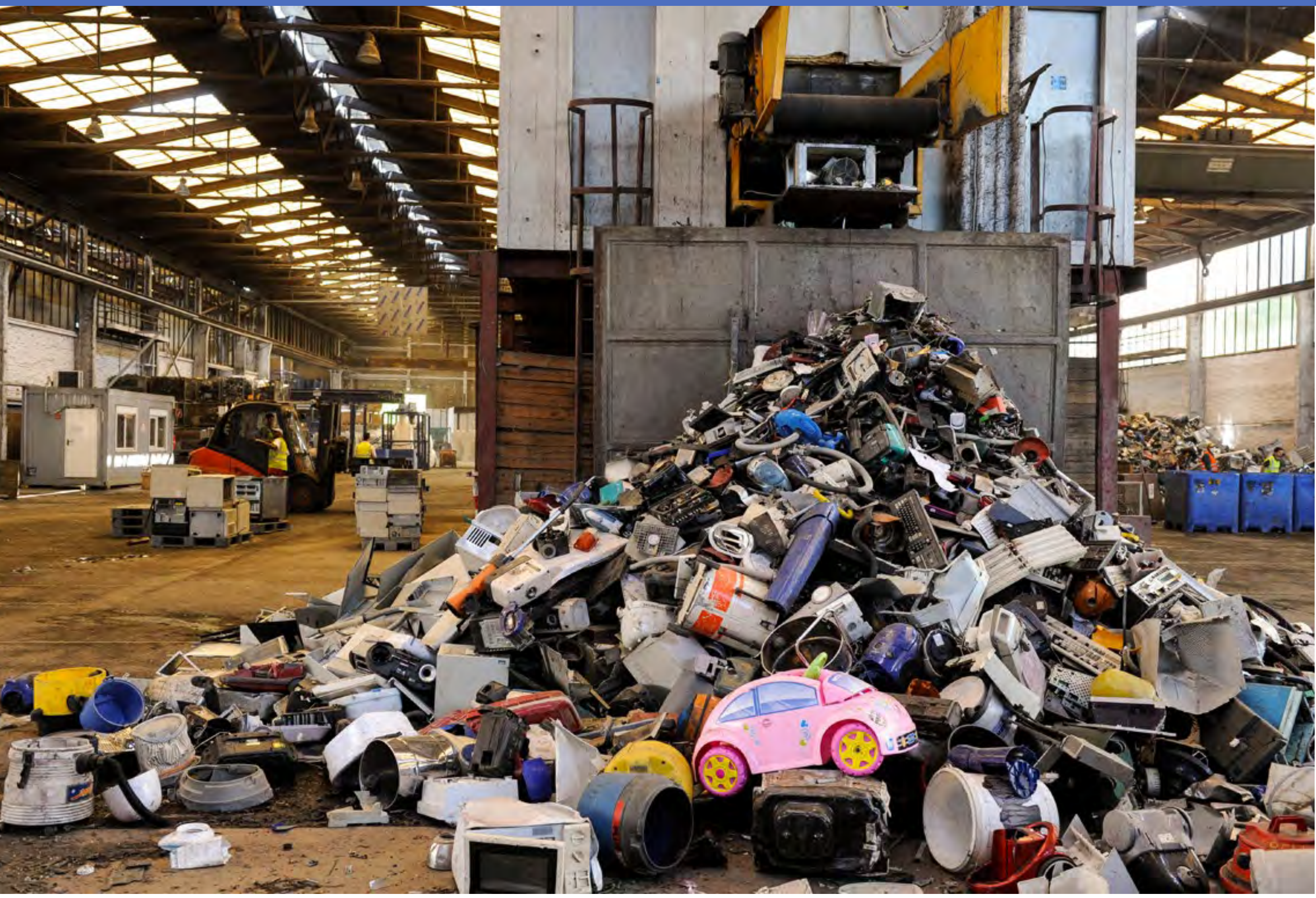
It would be impossible to collect the enormous quantity of microplastics at sea. The most effective solution is to stop the flow of waste coming from the continents.

Microplastics are very small particles of plastic material, typically smaller than 5mm, that can be unintentionally formed through the wear and tear of larger pieces of plastic, including synthetic textiles, or are manufactured and intentionally added to products for a specific purpose — for example as exfoliating beads in facial or body scrubs. Once released to the environment they accumulate in fish and shellfish, consequently entering the food chain.

Prompted by concerns for the environment and human health, several countries have enacted or proposed national bans on the intentional use of microplastics (Find out more) in certain consumer products, principally uses of 'microbeads' in 'rinse-off' cosmetic products, or are considering further restrictions on intentionally added microplastics in products from which they will inevitably be released. The scope of these restrictions covers the use of microplastics in a wide range of consumer and professional products in multiple sectors, including cosmetic products, detergents and maintenance products, paints and coatings, construction materials, medicinal products, and various products used in agriculture and horticulture, and in the oil and gas sectors. (Find out more).

Various consequences from ingestion of macro-, micro- and nano- plastics or entanglement of macroplastics have been reported for various species (96) (97), including suffocation or blocking of the digestive tract causing death (96). Moreover, the ability of plastics to absorb POPs is also known to cause additional problems (2), with plastic additives detected at concentrations up to six orders of magnitude higher than in the surrounding water (98). Additionally, EDCs in microplastics may be as harmful as listed POPs in terms of behaviour and consequences in the marine environment, since they may have an activity level, widespread distribution, toxic risk and bioaccumulation comparable to that of POPs.

Plastics in the marine environment play an important role in the global transport of toxic chemical contaminants encapsulated in the polymer matrix or adsorbed from the polluted environment. Their persistence in marine environment conditions is estimated in decades or even centuries, and thus can be transported long distances via ocean currents or by the migration of ocean life, thus representing a direct threat to fish populations, marine biodiversity richness and potentially to human health (99) (100) (101).



3. Key approaches to tackle the issue

There are a number of general approaches that can contribute to reducing the harm associated with plastics and the toxic additives they may contain in order to ‘close the loop’ safely. There is increasing recognition of the need to address the issues of pollution “upstream” to reduce the final generation of hazardous and other wastes. Boosting recycling may however have negative side effects if eco-toxicity and the risk to health are not properly addressed at an early stage.

Waste management and recycling are essential aspects of the safe circular economy approach, but it is not only limited to those two aspects. The concept also includes many other aspects such as eco-design, development of new business models, product-service systems, extension of product lifetimes, lifetime warranties, reuse, remanufacturing, refurbishing strategies, right-to-repair regulations, a move to full producer responsibility with high performance targets, and outcomes supported by strict enforcement.

Some of the points below may potentially be relevant to work being undertaken by the UNEP or under the framework of SAICM, and may also inform specific work under the Basel and Stockholm Conventions:

(a) Accelerate safer material innovation:

There is an obvious and increasing need for innovation to develop safer materials, and to increase the availability of safer, non-toxic alternatives on the market (e.g. alternatives for SCCPs and decaBDE, Secretariat of the Stockholm Convention 2019a,b) (102) (103). It is often the case that harmful substances are replaced with chemicals of a similar structure and potential for harm (42), so there need to be systems in place to avoid such regrettable chemical substitutions.

Recent initiatives, such as the mapping exercise carried out by the European Chemicals Agency (ECHA) (Find out more) can serve as a first step towards this effort. The joint project by ECHA and industry representatives has put together a list of over 400 functional additives or pigments used in plastics, including information on the polymers most commonly found in and their typical concentration ranges. The mapping considered substances registered under REACH at above 100 tonnes per year, and focuses on plasticisers, flame retardants, pigments, antioxidants, antistatic agents, nucleating agents and various types of stabilisers.

(b) Promote industry collaboration:

Common tools and approaches provide focus and accelerate change. It has been recognised that when industries coordinate and agree on standards, certifications and regulations that are aligned with a common vision for safe chemistry, this can accelerate progress towards optimised products. Extended Producer Responsibility schemes, if well designed can also support the closing of the loop. These approaches should be promoted through the Conventions and the other global instruments promoting the sound management of chemicals and wastes, as well as by providing guidance to syndicates and companies consortia, sending stronger demand signals to the entire industry, in order to achieve cost reductions and make healthy materials competitive with established products. Collaborative platforms allow the industry to test new business models that align incentives among various stakeholders.

(c) Innovation in recycling systems:

Although this area has been the focus of most efforts in circular economy strategies, much improvement can still be made. Materials containing hazardous substances should not be processed with materials that do not contain hazardous substances. Recycling targets for materials and products free from hazardous substances should be significantly higher than material categories that contain hazardous substances which need to be separated in the recycling process. Promoting improved separation and collection at the source to avoid hazardous streams that mix with safely recyclable material is highly recommended.

Additionally, research is needed into indiscriminate depolymerisation, deconstruction and dissociation of the chemical makeup of materials so that the resulting by-products and constituents can be up-cycled into higher value feedstocks for new and existing industrial processes. Controlled and efficient recycling and recovery would give rise to new job opportunities and opportunities for reintegration of the currently discarded materials into the economic cycle.

Moreover, there is a need to drive innovation in recycling technology and infrastructure. The POP-PBDE BAT/BEP guidance compiled technologies for separation and recycling of plastics and foams (Secretariat of the Stockholm Convention 2017a). Other possibly emerging technologies include harnessing the use of catalysts, bacteria (enzymes), ionic liquids, and other techniques to convert molecular composition of plastics, like polyester terephthalate (PET), polyethylene (PE), and polycarbonate (PC) into useful feedstocks (10).

(d) Access information on chemicals in plastic:

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 articles. This could be helped by increasing cross-sector access to high-quality data on chemical hazard assessments and promoting transparency of data on chemical ingredients and their impacts.

Knowing what additives are in plastic products is a global issue. It requires collaboration on a worldwide scale, across stakeholder lines and through entire product life cycles. Sharing information on chemicals in plastics between all stakeholders involved in product life cycles is crucial for protecting human health and the environment. The lack of information on chemicals in products is a significant obstacle to achieving a reduction in risks from hazardous chemicals. Access to information on what chemicals are in plastic products is a necessary condition as well as a prerequisite to enable sound management of chemicals in everyday articles, not only within manufacturing but also throughout product life cycles. Mandatory reporting and labelling of hazardous substances contained in plastic products will provide vital information for consumers, handlers, processors and regulators.

The SAICM Chemicals in Products Programme is a unique global initiative that promotes different options for disclosing information about chemicals in products that could be used for toxic additives in plastic.

It may be necessary to challenge unjustified claims to commercial confidentiality. Information on chemicals relating to the health and safety of humans and the environment should not be regarded as confidential, as outlined in SAICM Chemicals in Products Programme in accordance with SAICM Overarching Policy Strategy, (para.15).

Photo credit: Prigi Arisandi, Ecoton

4. Conclusions

Plastic production and the volume of chemical additives used in making plastics are growing exponentially. About 311 million tonnes of plastics were produced globally in 2014 (Plastics-Europe 2015): if current production and use trends continue unabated then production is estimated to approach 2 000 million tonnes by 2050.

There is growing awareness of the problem of marine plastics litter and microplastics, leading to calls for urgent global action to reduce and prevent plastic pollution. UNEA4 concluded that with a Ministerial Declaration that commits to significantly reduce single-use plastic products by 2030 along with 26 resolutions and decisions. The Basel and Stockholm Conventions clearly have a significant potential role, and indeed the Conference of the Parties to the Basel Convention will consider a number of specific actions.

While the general issue of pollution by plastics has received growing attention, there has so far been less attention given to the additives. They are very widely used and no plastic is produced without some additives. They are found in many products, including many used in the home, but the information is rarely available outside the supply chain. Many of the additives are potentially toxic, and some meet the definition of being POPs. They pose a risk to the environment AND to human health when they leach out of plastic debris. Additives are also problematic in recycling, and their use is a potential barrier to making progress towards a circular economy.

The Basel and Stockholm Conventions have taken action on a number of substances, through listing or through issuing technical guidance. But there are still many chemicals that are not yet subject to adequate control at the international level, and for which further action could make a significant contribution toward reducing the risks associated with plastics use and promoting life-cycle approaches and the circular economy.

The Conference of the Parties to the Basel Convention has several opportunities to ensure that the issue of additives is addressed when it considers the recommendations from the Open-ended Working Group, for example, in the review of Annexes I and III, and in commissioning work to revise the technical guidance on the management of plastic wastes. The proposed new Basel Convention Partnership on Plastic Waste also offers a further important opportunity. Equally, the Stockholm Convention has an important part to play. The Marine Litter Topic Group of the regional and coordinating centres will continue to work on this issue, and hopes to have the opportunity to contribute fully to the work on these issues.

September 2020

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Notes

(i) Research has shown that chemicals added during the manufacturing process of various plastic products, such as flame retardants, stabilisers, Bisphenol A (BPA) and Polybrominated diphenyl ethers (PBDE), may leach from ingested plastics and bioaccumulate within organisms. Microplastics present similar concerns of ingestion, chemical absorption and leaching.

(ii) UNEP/EA.4/21, Global Chemicals Outlook II: Summary for policymakers, paragraph 20.

(iii) For example, in the EU a substance of very high concern is a chemical substance (or part of a group of chemical substances) for has been proposed should subject to authorisation under the REACH Regulation.

(iv) Waste-to-energy (WtE) or energy-from-waste (EfW) is the process of generating energy in the form of electricity and/or heat from the primary treatment of waste, or the processing of waste into a fuel source.

(v) Green Science Policy Institute which has developed the Six Classes program (http://www.sixclasses.org/).

(vi) Specific exemption for recycling of products containing decaBDE was not granted. However , it is difficult to identify and analyse products containing this flame retardant, it is not clear who would be responsible for analysing for these chemicals either. As a result all PBDEs and SCCPs originally used in plastic appear in new products made out of recycled plastic, including toys despite the relevant restrictions of the Stockholm Convention.

(vii) Polyfluorinated alkylated substances are degraded partly to perfluorinated PFAS considered by SAICM.

(viii) Directive 94/62/EC of 20 December 1994 on packaging and packaging waste.

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http://www.cprac.org

UN environment

United Nations
Environment Programme

MAP

Mediterranean Action Plan
Barcelona Convention

https://www.unenvironment.org/unepmap/

BRS
CONVENTIONS

http://www.brsmeas.org

IPEN
for a toxics-free future

https://ipen.org