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Summary

# Everything you (don't) want to know about plastics

# Introduction

Plastics have many benefits and without plastic, modern society would indeed look very different. However, plastics also have numerous disadvantages, such as toxic substances that may leak out and adversely affect humans and other organisms. Plastic degradation in nature is very slow – a piece of plastic may last for several hundred years. This means that almost all plastic ever produced, still exists in some form in our environment. Around the globe, we find plastic in the form of road-side litter, around dumps, in the ocean, and in the starving bellies of birds. Moreover, when a piece of plastic is torn, small plastic fragments are released, known as microplastics. Environmental pollutants may stick to the microplastics and can thereby be led into aquatic organisms mistaken the plastic particle for food. Few environmental problems are as prominent as that of plastic litter. Almost everywhere you travel you can see traces of human presence in the form of plastic debris. This type of pollution also involves a more subtle but clear problematic aspect – the chemicals hiding in the so often handy material.

In a global collaboration funded by the Swedish International Development Cooperation Agency (Sida) and the following environmental organizations: Swedish Society for Nature Conservation (SSNC), EcoWaste Coalition from the Philippines, ESDO from Bangladesh, groundWork from South Africa and ToxicsLink from India, the plastic's presence and influence at all levels of society, based on each individual organization perspective are summarized in this report. In the European Union, the plastic-related problems are mostly related to chemical safety and the migration of chemicals from all of the plastic products in our immediate environment, whereas in the Global South, problems with blocked waterways due to the unabated and unconscious use of plastic bags and inadequate waste disposal are higher on the agenda. All five organizations have been designated one chapter each, in which they give their independent point of view about the plastics issue in their society (appendix 1-5 in the main report).

## Plastic

Plastics and rubber are formed by polymers consisting of smaller units known as monomers, which link up (polymerize) in long chains. At present, the vast majority of monomers is produced from petroleum (crude oil/mineral oil) and is therefore non-renewable. Monomers can also be made from biomass, but generally to a higher cost. Except monomers, various additives are added to the manufacturing process of plastics and rubber. Additives are chemicals that are necessary for the actual polymerization process, or to give the final product its specific desired properties, for example, plasticizers, flame retardants, heat and UV stabilizers, biocides, pigments, extenders, etc. Polymers are large in size, which means that they do not penetrate biological membranes, and are not particularly reactive and are therefore not considered toxic. On the contrary, unreacted monomers, solvents, additives or degradation products, can leak and be exposed to both humans and the environment during the whole life cycle of a product. Several common additives are classified as hazardous according to the EU regulation on Classification, Labelling and Packaging of substances and mixtures (CLP)[1].

[1] CLP (Classification, Labeling and Packaging) is the EU system for hazard labeling of chemical substances and mixtures, founded on the UN System - GHS (Globally Harmonized System).

Examples of hazardous classes for common additives are: carcinogenic, mutagenic, toxic for reproduction, harmful to aquatic life, or having persistent negative environmental impacts. A specific additives chemical and physical properties; the surrounding environment; if the additive is unbound; its molecular size in relation to the cavities between the polymers; etc., will determine how prone an additive is to leak from a product. It is difficult to make generalized statements about the health and environmental effects of plastics and rubber, since thousands of potential additives can be used in plastics and rubber and the amount of remaining monomers varies depending on the polymerization technique.

Given the strong indications that chemical exposures are a global threat to human health, it may seem strange that the chemicals issue is not higher on the political agenda. At least within the EU, the manufacturer is obliged to prove that a chemical is safe to human health and environment before putting it on the market. It is obvious; so far the legislation is proven ineffective.

An organism can only be harmed by a chemical if it is exposed to that chemical. Uptake of the chemical can occur through the skin, lungs or digestive system.

Few people think about the fact that this happens all the time, and that their homes are full of chemicals – not just household chemicals, cosmetics and medicines – but also in products such as building materials, paints and lacquers, rugs and carpets, furniture, toys, electronic equipment, food and more. The diffusion of, and exposure to, chemicals – many of them considered as toxic – from consumer products made from plastic is extra common in specific indoor environments that contain a great deal of plastics and electronics (electronics are to a great part plastic-based), for example, in preschools, cars and offices. Theses indoor environments, constitutes a considerable part of the chemical load that humans and the environment are subjected to, and is an acknowledged problem. Since human beings form part of the ecosystem, we are even indirectly exposed to plastic-related chemicals, for example, through the food we eat.

There are a large number of hazardous chemicals in plastic materials found in consumer products. There are relatively little known for the majority of these chemicals how they affect our health and the environment, but some phthalates, bisphenol A, some brominated flame retardants and poly-fluorinated chemicals, have been relatively well-investigated and are therefore in focus in this report. These chemicals have negative impact on humans and the environment, and investigations have shown that a large proportion of the populations are constantly exposed to them.

When chemicals are released from products or construction materials in a home, dust functions as a chemical sink that reflects all the chemicals one can be exposed to at home. Polluted dust will be inhaled or eaten, given that it ends up on food, accumulates in the mucous membranes in the mouth, or when children put dusty fingers and objects in their mouths.

In the EU, there are restrictions on the use of certain chemicals in certain types of products. The most hazardous phthalates, for example, may not be used in toys, and bisphenol A may not be used to make baby bottles. And yet, since these substances are used in other products, children are often exposed anyway, including, for example, through dust. The exposure level from products is often so low that immediate (acute) effects are rarely observed. However, low level exposure is highly relevant when it comes to endocrine disruptors since the endocrine system can be affected at extremely low concentrations.

Such so-called 'low dose' exposure is often considerably lower than the dosages traditionally used in risk assessments. Since risk assessments constitute the foundation in the regulation of chemicals, it raises concerns regarding the chemicals legislation and its ability to protect human health and the environment. Another important factor regarding safety at low doses is the simultaneous exposure of all the chemicals from all the products surrounding us. Even if exposure to one single chemical from one product is limited, and might not cause any negative impacts per se, the total exposure may do so, especially when the chemicals in a mixture are similar and are affecting the same endpoint. Monitoring studies unambiguously show that humans (and animals) are constantly exposed to mixtures of chemicals, and this, of course, applies to all chemicals, not only those found in plastics.

Exposure to chemicals during manufacturing, use and waste disposal in the life cycle of plastic material can be a direct health problem. There are, however, also indirect health problems, linked to the inappropriate large-scale use of plastics. As described in the chapters from the Philippines, Bangladesh and India (annexes 2, 4 and 5), there is a strong link between the existence of plastic litter in urban waterways and flooding in connection to regular monsoon rains in the region. Beyond the obvious material costs and acute dangers, flooding is also associated with a number of water-borne diseases such as cholera, malaria and typhoid fever.

It is widely known that waste water is a main source of the spread of many chemicals into the environment. Not only industrial production, but also chemicals from households and plastic materials in water and sewage infrastructure, contributes to the spread of plastic monomers, additives and small plastic particles or pellets to the waste water. Potential sources of distribution of plastic chemicals to the environment include the following:

- waste water,
- sludge from sewage treatment plants
- leakage from landfills,
- incineration fumes, and
- local, regional and global transport of chemicals from plastic waste.

A very large amount of the toxic chemicals are not properly broken down in waste water facilities, and are instead passed through the facility and into the environment.

For example, phthalates, nonylphenols and BPA, all of which are commonly found in water that arrives at sewage treatment plants. The insufficient chemical purification for certain plastic-related chemicals means that the chemicals also make their way into sewage sludge during the purification processes. In many countries, sewage sludge is used as plant fertilizers and soil conditioners on arable land. The risks involved with the spread of sewage sludge in the environment are an issue of rising concern in the public debate. In addition to hazardous chemicals that might be found in sludge, there are also plastic and rubber particles.

As a rough estimate, plastic constitutes around 10% of the total weight of municipal waste, based on estimates provided by a large number of countries. Plastics that cannot be recycled are incinerated or sent to a landfill, but where proper waste collection and management systems do not exist, such as in many countries in the Global South, there is a risk of uncontrolled spreading of plastic waste in the environment.

The plastic pollution/littering of our oceans are a serious problem. Certain beaches show an almost absurd litter problem, for example, there are beaches in Hawaii that by 1/3 by weight consist of plastic litter. A rule of thumb is that approximately 15% of all marine plastic garbage washes ashore, an additional 15% floats to the surface and the remaining 70% sinks. This puts into perspective the seriousness of the harm suffered by marine life, foremost in ”hot-spots” such as Hawaii. But it is not just the visible plastic litter that is the problem.

Micro plastics – coming from such diverse things as the fleece sweater or the facial scrub, to degradation products from all types of plastic gadgets we use – are also a complex problem. The problem with microplastic is that it absorbs environmental pollutants such as DDT, PCB, flame retardants, BPA, dioxins, etc. from the ambient water. Research has shown that concentrations of certain environmental pollutants are several thousand times higher in microplastic than in the actual water column. Animals, foremost fish, mussels and other filterers, easily mistake plastic particles for food. When the microplastic enters the body of that organism, there is a risk of environmental pollutants leaving the plastic and being directly stored in the animal’s fatty tissue. From there, there is a risk of the pollutant making its way further along in the food chain.

In spite of some legal improvements regarding management of solid waste, civil society organizations in India, South Africa, the Philippines and Bangladesh witness that the plastic litter related problems persist. One pressing contributory to the problematic wastes are plastic bags, commonly and carelessly disposed by its consumers adding to the increasing volume of waste dumped or burned in dumpsites and landfills, killing of marine animals, clogging of drainage systems worsening already catastrophic flooding situations. A major shortcoming is that existing plastic bag regulations usually is restricted to certain regions and that they are inadequately implemented. In order to gain the full potential positive effects of a ban, EcoWaste Coalition of the Philippines recommends a national plastic bag ban that will phase-out all kinds of plastic bags and promotes the use of locally produced reusable bags using natural fibers. This would help in reducing the country’s over-all waste generation and at the same time boost the local economy. Bangladesh has a similar situation and the environmental organization Environmental and Social Development Organization (ESDO) talks about the three R’n, "reduce", "reuse" and "recycle", i.e. advocated reduced use of plastics in general and instead use natural materials, while the plastic used should be reused many times and then recycled.

Plastic waste is also revealed as a dirty, even downright toxic, source of income prominent in the poorest countries in the Global South. Toxicity and environmental health issues are further compromised by use of recycled plastics for households and children’s product with no or low chemicals safety standards and norms in products. In India for example, approximately 60% of its plastic waste is recycled in the informal sector. However, these people work in very difficult conditions and have no information of the potential hazards of plastics. The Indian NGO ToxicsLink claim there is a critical and urgent need for addressing issues of chemicals in products and demands a higher level of product safety, especially for children. The control over what the plastic industry produces is also a problem. Both in India and South Africa there are many plastic manufacturers, both large and small. At the same time, there is no independent organization or authority checking that what is produced to the market is safe for the consumer. Therefore, groundWork in South Africa advocates a continued increasing legal protection for both workers at plastic factories as well as for consumers.

The great variety in the different types of plastics that exist renders it difficult to make an unambiguously statement which types of plastic should be avoided at home – additives alone, which give different types of plastic their different properties, and which are also prone to leakage, number in the hundreds. It is our opinion that plastic materials, so complex and very common in our homes, should be assessed based on the hazards and inherent properties of the plastic constituents. Parents today are unable to ensure that their children are not exposed to plastic chemicals suspected of being related to for example allergies, asthma, diabetes, obesity or disordered reproduction capacity - that is not acceptable. These are expensive prices to pay, not only at the level of the individual, but also for society.

## Discussion

Clearly, the level of technological development in society can largely be ascribed to plastics and its unique properties. The computer this report was written with would not exist without plastics. At least not with the normal performance requirements of a modern computer – light but yet durable, it should not burn or give the user electric shocks, and last but not least, it should be reasonably cheap. A conclusion to be drawn is that it would be unreasonable to take a categorical stance against all use of plastics. On the other hand, it is important to realize that a great deal of our use of plastic is unnecessary and in many cases may constitute a health risk.

The persistence of plastic materials, in combination with its extensive use and inadequate handling, are the cause of long-reaching negative environmental impacts, both locally and globally. The current situation involves considerable challenges for our future society, which will involve both decreasing plastic consumption and reducing the variety of plastic types, as well as phasing out our current unsustainable linear from cradle-to-grave flow of products. The aim should be to mimic the logic of our natural never-ending cycles containing only products. That is, a transition from today's system, which deems products as waste some stage, to a system where waste is a valuable product, for example as raw material to build new products.

A major goal with this report was to highlight the enormous complexity surrounding the plastic issue. We wanted to describe the social, economic and, last but not least, environmental and health-related problems associated with our current trends in the use of plastic. The report also looks at the complexity of the actual material. Regarding the latter, the conclusion to be drawn is that the chemistry behind plastic and rubber materials, and the associated additives, is so complex that these materials are very difficult, but not impossible, to classify according to hazard from a consumer and environmental perspective.

Our review has indicated that a number of hazardous chemicals are used to produce plastics and still to exist in the final product (see Annex 6). Furthermore, it is also very difficult to quantify the consumer exposure to these hazardous substances. For example, the use of plastics containing hazardous monomers is potentially harmful, since unreacted monomers may remain in the final product. Unfortunately, it is impossible for the average consumer to know if and how much of such monomers can be found in a given plastic item.

However, what ultimately determines how hazardous a plastic material is, will largely depend on the additives contained in it, which will vary enormously among products. The additives are often not bound to the plastic polymer and are therefore prone to leak, and the additives constitute up to 70% of the plastic weight. A plastic material composed of non-hazardous monomers can therefore, because of the additives, be more hazardous than a plastic material made from hazardous monomers. As a common consumer, it is not possible to know the quantity or type of additive within a plastic material. One way to limit the risk is to decrease the use of plastics containing the substances of high concern (SVHC), in particular if the material is in contact with food, skin, and the mouth or if it is used as a medical implant.

> Within the EU, the consumer has the right to ask, and demand an answer within 45 days, in the store, if a product contains any of the substances found on the candidate list. However, all substances of highest concern are not included on the list, so this is only a start.

The complexity of plastics has an impact on how chemicals and their application in products are assessed in terms of risk, and the great uncertainties related to that. It is complicated enough to assess the risks just for one chemical, but could be considered relatively uncomplicated in comparison to the nearly impossible task to quantify the risks of a complex product/item, in a scientific and credible way. Plastic materials constitute a good example this problem.

Within the EU, chemicals are assessed one by one despite the fact that humans and the environment are exposed to a mixture of chemicals, such as pesticides, industrial chemicals, biocides and chemicals in cosmetic products. In recent years, both researchers and authorities have perceived how unreasonable it is to ignore the fact that chemicals do interact with one another, and thereby, also may exert a greater negative impact on biological life than one chemical would. The European Chemicals Agency, ECHA, has compiled a long list of around 145,000 chemicals – and of these, tens of thousands are believed to exist on the market today, which in theory yields an immense number of combinations difficult to comprehend. As a consequence, it becomes more and more evident that the traditional way of assessing chemical risks is increasingly becoming more averted from the complex exposure situations that constitute reality.

Current risk assessments are based on the supposition that cut-off values can be established, below which exposure is deemed safe. However, endocrine disrupting chemicals is often argued in the scientific debate, since effects are observed at such low dose ranges it is inapplicable to define a cut-off value, also referred to as threshold. Thereby the fundament for risk assessment is flawed for this type of chemicals.

Within the EU, efforts are currently underway to generate criteria for endocrine-disrupting chemicals. Promising proposals for credible and scientifically robust criteria exist, both within political and scientific circles, as well as by independent non-governmental organizations. The outcome of the criteria proposals will be decisive of how endocrine disrupting chemicals will be dealt with in the future, and will likely influence the work on endocrine disrupting chemicals also beyond EU borders. Moreover, endocrine disruptors have been identified as an ”emerging issue” within the SAICM . WHO and UNEP released a report about endocrine disrupting chemicals, which helped to put the issue even higher on the agenda and hopefully moved things in the right direction.

Given the considerable uncertainties with respect to current risk assessment, and awaiting improved methodological circumstances, a rapid phasing out of the most hazardous chemicals through substitution is the most credible approach to handle the undesired risks associated with chemicals. Though, substitution must be made with well-studied chemicals that are known to exhibit less hazardous properties. There is a risk that a chemical identified as hazardous is exchanged by a similar chemical in the same group, obtaining same technical product properties as the original chemical.

However, and this is indeed unfortunate since toxicity profiles are often similar for substances in the same group. One way to avoid unnecessary and demanding (in terms of required resources) substitution is to avoid all substances from the same chemical group, in which one or more substances have proven to be problematical. For example, there are at least 15 different bisphenols, among which bisphenol A and bisphenol S are perhaps the most commonly known. The remaining bisphenols have been poorly studied and it would be inappropriate to replace bisphenol A with another bisphenol without knowing the consequences. Another example is that of flame retardants in the group polybrominated diphenyl ethers (PBDE), of which all more or less meet the PBT criteria in REACH[2].

## Recommendations

This report tries to answer the somewhat theoretical question: ”Is the current use of plastic sustainable, and if not, what can be done to make it sustainable?” Obviously, the answer to the first part of this question is no: the current use – rather, misuse – of plastics is not sustainable, but there is great potential to improve the current situation. Two main problems that have been identified and been made the focus of our report are: toxic effects of plastic chemicals and plastic litter.

[2] REACH (Registration, Evaluation, Authorisation and restriction of Chemicals) is the EU regulation of chemicals, adopted to improve the protection of human health and the environment from the risks that can be posed by chemicals, while enhancing the competitiveness of the EU chemicals industry. It also promotes alternative methods for the hazard assessment of substances in order to reduce the number of tests on animals.

## Polymers and monomers

Plastic is a polymer, which is built up of monomers. If the monomers are classified as hazardous under the CLP[3] Regulation or according to SIN[4] 2.1 , the plastic becomes potentially problematic throughout its life cycle and should be substituted, i.e. either to be built up of harmless monomers or substituted for another type of polymer.

## Problematic plastics and rubbers:

As problematic plastics, SSNC count those which monomers are classified as hazards according to SVHC or CLP (selected hazard statement codes are found in Table 1 of this Annex), or included in the SIN List 2.1.

- Acrylonitrile butadiene styrene (ABS)
- Acrylonitrile-Butadiene rubber
- Amino plastics and amino resins (e.g. melamine, UF and MF plastic resin)
- Butyl rubber
- Epoxy plastics and epoxy resins (e.g. DGEBA with BPA as a monomer)
- Phenolic plastics and phenolic resins
- Fluorinated ethylene plastic (FEP)
- Fluoro-polymer rubber
- Nitrile rubber
- Unsaturated polyester - if styrene is used
- Polycarbonate (PC)
- Polyether ether ketone (PEEK)
- Polypropenecarbonate (PPC)
- Polystyrene (PS)
- Polytetrafluoroethylene (PTFE)
- Polyurethane (PUR)
- Polyvinyl chloride (PVC)

A more complete list, with hazard statement classes of the monomers is found in appendix 6. If harmful additives are added, the plastic immediately becomes problematic.

## Additive

Additives classified as hazards according to CLP or SIN 2.1, are problematically and needs to be substituted. Since the additives are usually not bound to the polymer, they can migrate to the surface and be released to the surroundings. Therefore, it is often more problematic, at least for the health, if the plastic contains hazard additives then hazard monomers. The most hazardous additives known today are:

- phthalates,
- bisphenols,
- brominated flame retardants and
- perfluorinated chemicals.

Representatives from each of these four groups of endocrine disrupting substances are in all likelihood found in every home, airborne and bound to dust. A good start for consumers is to, as far as possible; avoid products that contain these substances.

## Plastic litter

The plastic problem is multi-faceted, ranging from sea birds dying of starvation because they have mistaken plastic garbage for food, to the diffuse spread of endocrine disrupting chemicals from consumer products. The problem is mainly due to unconscious use, and insufficient waste management systems of plastic bags and other types of single-use plastic packaging.

Plastic consumption must decrease. This will save resources as it would decrease the use of raw materials and the load on waste management systems, and can be stimulated through legal regulations.

Recycling systems must be further developed to favor reuse before landfilling and incineration. This would decrease the waste amounts and, as such, have an impact on the litter problem. In order for this to be possible, comprehensive substitution plans must be drawn up for a large number of hazardous substances frequently present in plastic, as to avoid toxic substances to be transmitted to the recycled plastics products. Also, the waste management systems needs to be further developed, for example, there must be increased labelling of plastic products to facilitate sorting, as well as improved technology for material recycling. These measures can be stimulated both through legislative and market-oriented instruments.

Also, research within the area of microplastics must be stimulated. It is of particular importance to determine the significance of microplastics as a carrier of environmental pollutants into the food chain, and also to investigate its main sources, in order to be able to undertake the most effective measures.

[3] CLP (Classification, Labeling and Packaging) is the EU system for hazard labeling of chemical substances and mixtures, founded on the UN System - GHS (Globally Harmonized System).

[4] SIN stands for "Substitute It Now" and is a database where ChemSec (The International Chemical Secretariat) has listed substances prone to be regulated according to REACH.

# Conclusions

More and more scientists are becoming concerned at the negative effects on humans and the environment as a result of exposure to toxic chemicals used in the production of plastics. In light of that, the SSNC (Sweden), ESDO (Bangladesh), groundWork (South Africa), EcoWaste (the Philippines) and Toxics Link (India) have made the following conclusions:

- the precautionary principle should be applied. This means that adequate knowledge of hazard is a precondition for plastics use and that the burden of proof is moved to the proposer/manufacturer,
- phasing-out of hazardous additives and monomers used in the production of plastic must occur, in favor of safer and more sustainable alternatives from a health and environmental standpoint,
- all chemicals in a group with similar properties should be regulated, even if only one of the substances in the group is defined as hazardous of high concern,
- chemicals listed in Annex 6 to this report should be phased out as soon as possible, in accordance with the substitution principles,
- a ban on phthalates of high concern should be implemented, primary in consumer products or product in contact with children,
- bisphenols should be banned from use in materials that come into contact with food and beverages and children, and in the long term in other consumer products like thermal cash receipt,
- companies must accept their responsibility in terms of the reduction of unnecessary plastic consumption, since this can reduce exposure to potentially hazardous chemicals. Above all, there is a potential to decrease the consumption of disposable packaging material,
- the recycling of plastics must be made more effective. The recyclable component of plastics would increase if plastics did not contain hazardous chemicals,
- full information about all existing chemicals in consumer products must be required.

Apart from the aesthetic aspects related to the problem of plastic litter, plastic waste is also a problem in the nature on a global scale, from the individual level to the level of populations.

- plastic consumption must decrease, foremost as regards to disposable plastic packaging. This will save resources as it would decrease the use of raw materials and the load on waste management systems, and can be stimulated through legal regulation,
- recycling systems must be further developed so that the reuse of plastics is favored before landfilling and incineration, something which would decrease waste amounts and, as such, have an impact on the litter problem. In order for this to be possible, comprehensive substitution plans must be drawn up for a large number of hazardous substances frequently present in plastic. Our waste management systems need further development, for example, there must be increased labelling of plastic products to facilitate sorting, as well as improved technology for material recycling. These measures can be stimulated both through legislative and market-oriented instruments,
- a reduction in the number of mixed materials used in plastic would increase the volume of recyclable plastic. Clean fractions of the various polymers are necessary for effective recycling without any negative impact on the quality of the material. This can be stimulated through legislative instruments,
- finally, research within the area of microplastics must be stimulated. It is of particular importance to determine the significance of microplastics as a carrier of environmental pollutants into the food chain, and also to investigate its main sources, in order to be able to undertake the most effective measures.

A third current major problem with plastics is that the main resource used in its fabrication is fossil crude oil. Therefore:

- is it necessary to increase the proportion of plastic made from renewable resources, since this would reduce the climate impact of plastic materials, given that a large portion of plastic waste is currently incinerated. The potential health impacts of chemicals contained therein are, however, the same as for conventionally produced plastic.