1.8 Going beyond - Plastic, harmful chemicals and the environment

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Plastic and the environment

The invention of plastic was a revolution in the history of mankind and many products in current modern life rely on plastic. Between 1950 and 2017 an estimated 9 200 tons of plastic have been manufactured and this number is projected to increase to 34 billion tons by 2050 (UNEP 2021). Therefore, releases of plastic waste to the environment are expected to increase as well.

A large proportion of the plastic waste ends up as litter in the marine and terrestrial ecosystems, which has various environmental, economic and social implications (Hahladakis *et al.* 2017). In this section, only environmental impacts are discussed with a special focus on water bodies and climate change but impacts on terrestrial ecosystems are also relevant.

Plastic and the oceans and other water bodies

The downside of the widespread production and use of plastic is that an enormous quantity of plastic ends up in rivers, seas and oceans. It is estimated that approximately one garbage truckload of plastic reaches oceans and other water bodies every minute (Heinrich Böll Foundation 2019). In the environment, macro- and meso plastics (> 5 mm) decompose through mechanical, chemical and biological processes into micro- (50 µm to 5 mm) and eventually nanoplastics (< 0,1 µm). Together with microplastics from other sources, such as from wear of vehicle tyres or leaching of fibres from textiles, microplastic particles accumulate in the oceans. Plastic has already been proven to be present in all oceans: from the poles to the equator, at the water surface, in deep sea sediments and in coastal regions (Lucht and Weber 2018). Marine organisms ingest plastic through their diet, and this leads to the large-scale contamination of fish and seafood stocks with microplastic. The plastic can eventually end up back on our plates via the food chain. Plastic can contain numerous chemicals, including some that are harmful, such as endocrine disrupting chemicals (Lucht and Weber 2018; Heinrich Böll Foundation 2019). Through migration, chemicals contained in plastic can be released into the immediate environment, where they may cause harmful impacts on human health, animals and ecosystems (UNEP 2021). Plastic in the oceans may not only contain hazardous chemicals that were initially and intentionally added to it, but during its journey in the oceans, it can also adsorb persistent organic pollutants (POPs) such as polycyclic aromatic hydrocarbons (PAH) or pesticide residues such as dichlorodiphenyltrichloroethane (DDT).

The uptake of (micro-)plastic can damage aquatic life in three different ways: (1) by mechanical injury and blockage of the digestive tract, (2) by release of plastic pollutants, and (3) by adhesion and subsequent release of environmental pollutants. Various studies have detected several reactions to microplastic uptake in mussels and fish: changes in the digestive tract, severe inflammatory reactions in other tissues, decreased reproductive success and altered feeding behaviour. This indicates a migration of micro- and nano-plastic particles as well as associated pollutants from the digestive tract to other regions of the body and a by-passing of cell barriers (Umweltbundesamt 2013; Lucht and Weber 2018).

Plastic and climate change

Plastics and synthetic fibres are derived from oil and gas and more than 99 % of plastics are based on fossil raw materials. Worldwide, manufacturing of petrochemicals products (i.e. the production of chemical products from natural gas and crude oil) is the sector with the steepest increase in oil consumption (Heinrich Böll Foundation 2019). Carbon dioxide, methane and other greenhouse gases are released at many stages of the plastic life cycle, from the extraction of fossil raw materials, refining and processing in energy-intensive processes, until disposal or incineration. This has a huge impact on the global climate. The greenhouse gas emissions associated with the production, use and disposal of conventional fossil fuel-based plastics are predicted to grow to approximately 6.5 gigatons of carbon dioxide equivalents by 2050 (UNEP 2021). In other words: making plastics could cost 10-13 % of the remaining carbon budget to keep global warming below the 1.5 degrees celsius goal of the Paris Agreement (Heinrich Böll Foundation 2019).

In addition, the production and incineration of plastics can release harmful substances into the environment. For example, if the plastic type "PVC" is burned at high temperatures (> 400°C), highly toxic dioxins can be formed (Polcher *et al.* 2020). Furthermore, polycyclic aromatic hydrocarbons (PAHs), hydrochloric acid and furans can be released if PVC is burned (UNEP 2021).

***Table 1*: Overview of commonly used plastic types and their potential impacts related to chemicals**
(references to information sources are provided at the end of the page)

Types of plastic	Associated health concerns	Chemical-related environmental impacts during production and/or disposal
Polyvinyl chloride **where to find:** Hard PVC: Drains, window profiles, oil/vinegar bottles Soft PVC: Floor coverings, hoses, synthetic leather, vinyl carpets, swimming rings, toys (e.g. dolls, balls)	PVC can contain a variety of hazardous chemicals (e.g. bisphenol A, lead, mercury, cadmium, flame retardants and plasticizers (phthalates)) which may leach from the material throughout the product life cycle and can cause serious health and environmental problems. The raw material vinyl chloride is a known carcinogen [3, 7, 4].	Incineration and disposal of PVC can lead to the formation of numerous harmful chemicals (e.g. dioxine), including carcinogens and persistent organic pollutants (POPs) [3, 7, 4].
Polypropylene **where to find:** Food containers, straws, baby	Relatively stable and heat resistant. Over longer periods, stabilizers can leach from the material[3].	There are no critical impacts known.

bottles, microwave dishes, toys		
Polystyrene **where to find:** Styrofoam for transporting meals, disposable cups/lids/cutlery, bicycle helmets, clothes hangers, toy figures, plastic model kits, crafting utensils, insulation boards	In the manufacturing process, benzene, a known carcinogen, is used. Polystyrene may contain endocrine-disrupting phthalates which can be also found in toys[7]. Unreacted styrene, the precursor to polystyrene, is a harmful substance which can migrate from food packaging into food, especially when the food is greasy, hot or acidic[2].	Foamed polystyrene is highly combustible, which is why it often contains flame retardants. For example, the flame retardant hexabromocyclododecane (HBCD) was commonly used for polystyrene insulation boards before it was banned by the Stockholm Convention in May 2013 due to its persistence, toxicity and potential to accumulate in living organisms [2].
Thermoplastic polyurethane (TPU) / Polyurethane (PUR) **where to find:** soft plastic toys, electronic devices	In some cases, the hazardous chemical isocyanate is used in production and during production processes, harmful gaseous substances, such as chlorine and phosgene (highly toxic), or ethylene oxide (carcinogenic and mutagenic) may be formed. In addition, plasticizers and flame retardants are added to PUR which can be harmful to health[6,5].	During production, harmful gaseous substances, such as chlorine and phosgene (highly toxic) may be formed. Disposal can also be problematic when PUR is incinerated, numerous hazardous chemicals such as isocyanates, hydrocyanic acid and dioxins may be released into the environment. In landfills TPU degradation can release greenhouse gases (methane, CO2)[5].
Acrylonitrile butadiene styrene (ABS) **where to find:** e.g. building blocks for children, sports equipment, safety helmets, luggage, furniture, medical equipment, tubes, caps, telephone sets, and cameras	There are no health concerns associated with chemicals known[1].	There are no critical impacts known.
Polycarbonate (PC) **where to find:** toys, bottles, CDs, DVDs,	Bisphenol A is often used for its production. Bisphenol A is considered as "substances of very high concern" under REACH and is considered as an endocrine disruptor[7].	There are no known critical impacts known

For further information on that topic, please access:

- *United Nations Environment Programme (2021). From Pollution to Solution: A global assessment of marine litter and plastic pollution. Nairobi. https://www.unep.org/resources/pollution-solution-global-assessment-marine-litter-and-plastic-pollution.*
- UNEP (2021): *Impacts of plastic pollution on freshwater aquatic, terrestrial and avian migratory species in the asia and pacific region.* Accessed 14 December 2021. *https://www.cms.int/sites/default/files/publication/cms_report_migratory_species_and_plastic_pollution_31AUG2021.pdf*
- Böll Foundation (2019): *Plastic Atlas. Facts and figures about the world of synthetic polymers*. Accessed 14 December 2021. https://www.boell.de/sites/default/files/2020-01/Plastic%20Atlas%202019%202nd%20Edition.pdf?dimension1=ds_plastikatlas

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References for table 1

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2. Hagenau, M. (2020). Polystyrol: Wissenswerte Informationen über den Kunststoff, 26 May. https://utopia.de/ratgeber/polystyrol-wissenswerte-informationen-ueber-den-kunststoff/. Accessed 16 December 2021.
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6. Verbraucherzentrale (2021a). Spielzeug ohne Schadstoffe: Das sollten Sie beim Spielzeugkauf beachten, 04 March. https://www.verbraucherzentrale.de/wissen/umwelt-haushalt/spielzeug/spielzeug-ohne-schadstoffe-das-sollten-sie-beim-spielzeugkauf-beachten-6911#. Accessed 16 December 2021.
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