Microplastics waste is a valuable resource, it is just in the wrong place

The negative image of plastic persists and is not getting any better in the face of the ongoing debate about microplastics which are basically everywhere. Plastic pollutes the environment. Produced from petroleum, plastic contributes to climate change through carbon dioxide (CO_2) that is emitted during the extraction of crude oil. The globe is littered with huge quantities of plastic; we have known this for years, but have not done anything about it. The situation has to change, and we have to modify the production and utilisation of macroplastics as well as fundamentally rethink the way we dispose of them. 'Out of sight, out of mind' mentality must become a thing of the past.

Single-use plastic products are still part of our everyday lives. Global manufacturing and use of plastic products continue to increase, and, along with inadequate disposal and the long shelf life of plastics, the quantities of plastic waste are increasing everywhere in the world. We are making efforts to collect, separate and recycle plastic waste, but the plastic problem seems nevertheless to be out of control. Plastic can already be found on our dinner plates. While the EU is paving the way for a ban on single-use plastics like drinking straws and plastic bags, that will come into force by 2021 in all EU member states, the German plastics industry is pleased about its plastic sales performance: in 2018 alone, the German plastics industry generated sales worth 65.7 billion euros[1]. More than a third of all plastics processing companies indicated that the microplastics debate did not negatively affect their business[2]. In 2015, every German used 117 kilogrammes of plastic, of which packaging material made up the greatest proportion[3]. In 2016, the demand for plastics in all of Europe was around 50 million tonnes; polyethylene accounted for the largest proportion (30%), followed by polypropylene (19%), i.e. packaging material; polyethylene terephthalate (PET) (7.4%) and polystyrene (6.7%), another packaging material[4]. 1.5 million tonnes of plastic were produced worldwide in 1950; 65 years later in 2015, as many as 322 million tonnes of plastic were produced[5].

Versatile, cheap, durable

Plastic accounts for three quarters of all garbage that ends up in the sea and 80 percent of this plastic waste comes from land sources.

Plastics are very popular because of their properties: low weight, elasticity, hardness, moldability and thermal and chemical resistance. These features can be optimised by adding specific substances during production. Plastics have long supplanted natural substances such as glass, wood, metal and cotton in the medical and electrical engineering sectors, in sports and in the textile and automotive industries where they have led to decisive advances. But problems arise when plastic products are no longer needed. How can plastics be disposed of? What can we do with plastic waste? Plastics become waste that does not decompose. Plastic waste starts off as macroplastics (with a diameter > 25 mm), is then crushed by friction, UV radiation and salt water and becomes mesoplastics (with a diameter of between 5 and 25 mm) and eventually microplastics (<5 mm)[6] which end up in a wide variety of places. Plastic packaging pollutants also end up in our food and organs[7]. Plastic particles that are smaller than five millimetres in diameter are called microplastics. Primary microplastic granules are 0.5 mm in size or less before entering the environment and are used as microbeads in cosmetics products, shower gels and detergents due to their emery effect. The plastics industry produces special granules that can be used to produce larger objects using a method known as injection moulding. Paints and waxy dispersions may also contain plastic components.

Data about the origin of microplastics that are found in the environment are partly contradictory. This is because the methods used for detecting and quantifying plastics are not yet standardised. However, there is general agreement that as much as almost one third of the emitted microplastic particles is due to tire abrasion and about the same proportion to fibres from synthetic textiles that are released from clothing during washing[8]. As they do not remain in place and need to be refilled regularly, the plastic granules on the artificial turf of sports fields also play a bigger role than previously thought. Cosmetic microplastics and lost plastic pellets used in plastics production constitute a relatively small proportion. Plastic particles that are found are analysed using spectroscopic methods to determine their type, size, shape as well as elementary composition.

Fishing nets need 600 years to rot

Every year, 30 million tonnes of plastic enter the world's oceans, five million in Europe alone. One percent of all this plastic reappears. 99 percent of plastic waste does not reappear and is referred to as "missing plastic". Every year up until 2018, China disposed of up to 3.5 million tonnes of plastic waste either into landfills or into the Pacific, dumping it directly into the sea. The Slovak plankton expert Gaby Gorsky once said that we use the sea as a huge carpet under which we sweep all our plastic waste. Marine vessels also find it easier to dump their garbage overboard, rather than taking it with them and disposing of it on land. There are five huge offshore garbage patches in the oceans. The Great Pacific Garbage Patch is the largest of the five and estimated to be five times larger than Germany. Plastic accounts for 75 percent of all waste found on European beaches. There are places in Corsica where more microplastic than plankton is found. A study on microplastics in inland waters in Germany carried out by the State Institutes for the Environment from Bavaria, Baden-Württemberg, Hesse, North Rhine-Westphalia and Rhineland-Palatinate found microplastics in all lakes and rivers examined. The study calls the omnipresence of microplastics a "civilisational base load" and pointed out that 80 percent of the plastic waste found in waters stems from land sources. There is no way to prevent the generation of microplastics that result from the breakdown of larger plastic items. Basically, the only way to reduce the environmental impact of plastics is to refrain from using single-use plastic products.

Plastic that ends up in the environment decomposes very slowly because synthetic polymers are difficult to break down by microbes because of their long linear chains and high molecular weight. On the other hand, up to 90 percent of all biodegradable material can be broken down into water, CO_2 and biomass by microorganisms in the presence of oxygen. In the absence of oxygen, microorganisms convert biodegradable material into methane, CO_2 and biomass. While an apple needs two months, bananas and cigarette butts three to five years to decompose, a soda can needs 200, a plastic bag 300 and a single-use diaper 450 years before it is completely broken down. It is estimated that fishing nets that consist of a mix of different polymers remain in the environment for about 600 years. Lost and abandoned fishing nets become a huge ecological problem for all marine life.

Waste industry relies on consumers

Microplastic particles do not only contain toxic additives, they can, just like magnets, also attract additional pollutants and form biofilms with pathogens.

Our soils store huge quantities of microplastics. The most direct entry is via compost and sewage sludge that are applied to fields for fertilisation. Sewage treatment plants are able to extract up to 97 percent of the microplastic, but the rest remains in the sludge that is applied to agricultural areas. In addition to providing them with sewage sludge, sewage sludge treatment plants pay farmers 100 euros per hectare onto which the sewage sludge is applied. This is quite a cheap way of getting rid of waste. Sewage sludge contains up to 24,000 microplastic particles per kilogramme of dry matter[10]. Sewage sludge can be used as fertiliser if it contains less than 0.5 percent foreign matter. Due to the high concentration of pollutants and plastics in sewage sludge, this practice is receiving increasing criticism. Baden-Württemberg is therefore trying, on a voluntary basis, to channel sewage sludge into thermal recycling. This was 97 percent successful in 2017[11], although the application of sewage sludge to agricultural soils was not previously prohibited as is the case in Switzerland or in some Austrian states.

Nevertheless, up to 400,000 tonnes of microplastics enter agricultural soils in Europe every year[12]. Earthworms eat the plastic particles and work them deep into the earth. The path of plastics begins in the compost that accumulates in supermarkets as well as in private households. Plastic bags and packaging material end up in compost. Last year, each tonne of household compost contained up to 440,000 microplastic particles[13]. Hundreds of thousands of tonnes of spoiled food, including from supermarkets, are shredded along with the packaging material wrapped around the food as the mechanical removal of plastics from compost material functions insufficiently or because unpacking the food products is too time-consuming and therefore "not profitable." The municipal waste management companies receive the shredded waste from the disposal companies and add it to the sewage sludge as biomass. It goes without saying that it is crucial to make sure that only biological material enters the sewage sludge: if packaged food is disposed of, it needs to be unpacked by supermarkets and private consumers as the mechanical removal of the plastics material is never 100 percent effective.

One of the biggest environmental problems worldwide

Large or small pieces of plastic can be absorbed by animals and cause injury to the animals' digestive tract or block hunger, leading to starvation. The progressive size reduction of microplastics probably facilitates their uptake into organisms. Plastic has been shown to enter cells and to accumulate in tissue. Microplastic poses other dangers too, as it is mixed with additives such as toxic plasticisers or flame retardants. Some of these additives are known to be carcinogenic, that they accumulate in the body, or have hormone-like effects. In addition, plastic particles also bind toxic substances or hormones from the environment and potentially release them again in the altered environment of an animal or human body. Last but not least, biofilms can also form around individual plastic particles, which then become transport vehicles for bacteria and viruses. Animal studies have already found microplastics in the liver, lymph nodes and blood of animals. Earthworms that have plastic particles in their intestines grow slower and die earlier than earthworms without ingested plastic particles. Earthworms are

consumed by chickens and chickens are eaten by humans. But microplastic particles also accumulate in fish, seafood, beer and honey. Viennese researchers found around 200 particles per bowel movement in human faeces. Interestingly, most of these microplastic particles come from plastic packaging. Most of the plastic is excreted, but some nevertheless remains in the body. Whether this smaller part accumulates in our organs or what it does there exactly is not yet known.

Refuse, reduce, recycle!

The dual system of waste collection has existed in Germany since 1991. The initial requirement to label packing material that can be recycled with the Green Dot has been abolished because now all packaging must be part of Germany's dual system.
© Stephanie Heyl

EU politicians and industry have already adopted action plans to reduce and avoid plastic waste. The Vice President of the European Commission, Frans Timmermanns, calls for the exclusive use of recyclable plastics by the end of 2030. Research into replacement materials such as bioplastics is also in full swing. Bioplastics are often seen as a sustainable alternative to petroleum-based plastics. However, it is not clear whether these are plastics that are completely biodegradable or produced on the basis of biobased renewable raw materials. Researchers from Bonn have investigated the carbon footprint of biobased plastics using computer simulations and found that more forest areas would have to be converted into arable land in order to increase the production of bioplastics. This would lead to the release of higher levels of CO_2 into the atmosphere. This would lead to a more negative carbon balance in the short term though the balance looks much more positive when plant waste is used as the raw material. Another negative factor is the fact that biodegradable plastic remains in the environment for months or years and is difficult to recycle. The entire waste management processes would first have to be adapted to the new material. Biodegradation is advantageous only when an added benefit arises. Otherwise, a circular economy in the form of recycling is ecologically and economically more useful.

China stopped the import of waste from Germany at the beginning of 2018. Since then, we have had to develop new ideas about what to do with our plastic waste. Some companies see plastic waste as a new raw material to be recycled. Plastic recycling is particularly useful because oil, the raw material from which plastic is made, is becoming increasingly scarce. Every year, we collect eight million tonnes of plastic in yellow bags. According to the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, the recycling rate was 46 percent in 2017, 49.7 percent in 2018 and is currently 58.5 percent. The plan is to reach a recycling rate of 63 percent in 2022, helped by a new packaging law. The remainder is either burned, or exported to Vietnam or Malaysia. However, material recovery is always preferable to burning because this does not lose the energy that was put into it during manufacture. Due to elaborate plastic bottle tops and the variety of materials used, plastic is difficult to separate and recycle. These products are often produced from composite materials in which different plastics are combined. Available separation methods are very expensive and fail in separating plastic composites in which plastics of similar density have been processed.

Solutions in Baden-Württemberg

Numerous efforts and activities have been initiated in Baden-Württemberg with the goal to reduce the flood of plastic packaging, increase recycling rates and reduce the input of plastic into the environment. For example, the company J. RETTENMAIER & SÖHNE GmbH + Co. KG (JRS) from Rosenberg won 3rd place in Baden-Württemberg's Environmental Technology Award 2019 in the Material Efficiency category. JRS developed VIVAPUR®CS SENSORY 15S, a microplastic replacement made of plant fibres for use in cosmetic products. The motto of the company is "from cradle to cradle", which describes a consistent circular economy, in which all products can be returned to the biological cycle.

Jochen Mößlein from Freiburg developed a system for a company called Polysecure, that seeks to find out how more plastic can be recycled. The company works closely with wholesalers and packaging manufacturers to develop special markers that are applied to packaging to help separate the various plastics in the sorting plants.

The CreaSolv® process is able to produce new products from old plastic packaging or insulation material.
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The Fraunhofer Institute for Process Engineering and Packaging IVV in the city of Freising has developed a solvent-based approach to produce recycled plastics of used packaging in virgin material quality. They are expected to be suitable for re-use as high quality packaging materials. The CreaSolv® process is not a chemical but a physical recycling process because the polymer chains are retained and only the solid state is converted to a liquid state. The target plastic is dissolved with a specific solvent and impurities such as additives are removed from the polymer solution. The pure polymer can then be precipitated and processed into granules, which has virgin properties. It can then be fed into a new production cycle. The solvent can also be cleaned and reused.

In November 2018, a CreaSolv® pilot plant was put into operation in Indonesia. The aim is now to set up a large-scale pilot plant with a capacity of 5m3 plastic waste per day on the premises of Lober GmbH Abfallentsorgung KG as part of the "Circular

Packaging" project in order to prove the economic viability and raw-material efficiency of the process. From 2021 onwards, Lober will be operating the first commercial plant for recovering high-value material from plastic waste streams (corporate and household waste) in Europe. The project includes simultaneous cost-effectiveness tests with potential buyers of the product samples and has received 3.2 million euros in funding from the BMBF. In the longer term, the technology will also be transferred to other types of waste, e.g. plastic waste from the sea.

Plastic as sustainable material

In the sense of a circular economy: high-quality granules of virgin material quality produced with the CreaSolv® process.
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Since January 2019, the German Packaging Act has made it compulsory for manufacturers and entrepreneurs in Germany to register plastics packaging. The Green Dot for the labelling of recyclable materials has been dropped since all packaging now has to go into the dual system. The Central Agency Packaging Register Foundation (KSVR), which was established in May 2017, has been endowed with sovereign tasks such as laid down in § 24 of the German Packaging Act and acts as a federal authority. The German Packaging Act now requires all plastics producers to register the type and quantity of plastics packaging materials which would typically reach private households and accumulate there as waste, into the KSVR's LUCID database. The LUCID database, which has an ecological steering effect, comes under the legal supervision of the German Federal Environment Agency and is open to the public.

Cross-border approaches to reducing plastic entries into the environment could make a significant contribution to the improvement of the current situation. Politicians must create incentives for recycling and deposit systems and ban products that often end up in nature. Scientists must optimise the degradability of polymers and increase the recyclability of products. All of us can avoid littering and buy goods without packaging. In the future, waste prevention must come first and durable, reusable products must replace disposable products. The plastics association PlasticsEurope says: "Plastics are sustainable materials in all phases of their life cycle. They help conserve resources by insulating buildings and making cars lightweight." If they're recycled, they're doubling their contribution!

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Further information:

J. RETTENMAIER & SÖHNE GmbH + Co KG

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