May: the plastic-free month !

Plastic is everywhere. It is now high time to ban it from our lives. This was the message that was announced in the media.

The action “*Mei Plasticvrij* (a plastic-free month of May)” wants to make the Flemish people aware of the problem. Its aim is to significantly reduce the production and use of plastic. A call to participate in the action appeared in all Flemish newspapers and magazines, and many have already joined the movement.

Granted, there is a problem — a huge and global problem even! Plastics as well as their by-products and derivatives are littering our arable land, cities, motorways, oceans, estuaries and rivers. The ubiquitous presence of plastics in our environment somehow contributes towards making the problem unnoticed, unrecognized, and forgotten. And this is exactly why we all need to start thinking about it with more deliberate attention [Kontrick 2018]. A slogan-like action such as *Mei Plasticvrij* is merely the first step in the right direction. Long-term structural solutions require much more efforts.

The increasing production and disposal of plastic have resulted in the omnipresence of macro- as well as microplastics (MiP)[1] — a situation that causes serious concern among the global population. Most plastics are barely degradable and are easily ingested by a wide range of organisms. They have been found in all forms of marine life from zooplankton to whales. The extent of the pollution and its resulting impact on the environment still remain largely unknown. What we do know, however, is that persistent plastics, with an estimated lifetime for degradation of hundreds of years in marine conditions, can break up into micro- and nanoplastics over shorter timescales, thus facilitating their uptake by marine biota. A crisis of hitherto unimagined proportions is about to occur! First, and most obviously, the physical impact of MiP creates devastating injuries to many forms of marine life. Plastic bezoars[2] in gills and intestines interfere with feeding habits and lead to the unnatural death of many animals. Second, plasticizers in MiP have been linked to abnormal growth and reproductive problems resulting from endocrine disruption in multiple animal models [Auta et al. 2017]. Third, studies have shown how organic contaminants leach into organisms that ingest MiP. Fourth, a study this year described how MiP deliver dangerous metals like lead and cadmium to coastal ecosystems [Munier & Bendell 2018].

There is no room for doubt: plastics pose risks to marine ecosystems, biodiversity and food availability [Gallo et al. 2018]. Recently, scientists in Norway found more than 30 plastic bags and other plastic waste inside the stomach of a whale stranded off the coast. But the marine ecosystems are not the only ones to be affected. Microplastics are everywhere: on land, but also in the air we breathe, in the water we drink and in all the food we eat. It is very disturbing to learn that the food we eat contains microplastics from distant sources, but especially from the immediate environment

[1] Microplastics are small plastic pieces less than five millimeters long that can be harmful to organisms. Microplastics come from a variety of sources, including larger plastic debris that degrades into smaller pieces. In addition, microbeads, a type of microplastic, are very tiny pieces of manufactured polyethylene plastic that are added as exfoliants to health and beauty products, such as some cleansers and toothpastes.

[2] Bezoars are tightly packed collections of ingested material that can become stuck in the stomach or intestines.

and house dust [Catarino et al. 2018]. We are surrounded by invisible pieces of waste and exposed to all kinds of unpleasant consequences. Even the arable land is polluted. Research results published by Awet et al. [2018] showed a pronounced decrease in microbial biomass in treatments of 100 and 1000 ng polystyrene nanoparticles per g dry soil mass throughout the incubation period. Moreover, basal respiration and metabolic quotient increased with increasing polystyrene nanoparticles application rate throughout the incubation period possibly due to increased cell death that caused substrate-induced respiration (cryptic growth). The authors in this way demonstrated the antimicrobial activity of polystyrene nanoparticles in soil.

Although we still need additional scientific research to fill the knowledge gaps about the health impact of plastic litter in both the marine and freshwater ecosystems [Wagner et al. 2014], there is sufficient scientific evidence already to support actions by the scientific, industrial, polical and civil society communities to curb the endless flow of plastic waste into aquatic ecosystems. Continued increases in plastic production and consumption, combined with wasteful uses, inefficient waste collection and insufficient waste management facilities, especially in developing countries, mean that to achieve even current objectives for reducing marine litter represents a huge challenge, and one unlikely to be met without fundamentally rethinking the ways in which we consume plastics.

A plastic-free month of May is therefore a commendable initiative to increase population awareness. The current trend should not be allowed to continue. Some people however may interpret "plastic-free" as meaning "completely without plastic and possibly no more plastic in the future". This to me seems a totally unrealistic objective.

Since the dawn of the synthetic materials era, advances have been unparallelled in the history of materials. Chemists have discovered new catalysts and developed new synthesis routes to join small molecules into long polymer macromolecules with the appropriate properties for particular uses. Physicists and engineers have designed new processing methods and new technologies to enhance performances. Naturally, consumers are becoming increasingly more demanding. And, quite rightly, we expect products that will further enhance the quality of our lives and we want materials and technologies that are increasingly energy efficient, sustainable and capable of reducing global pollution. Our dream is an open and accessible world with a healthy living environment for all. It is also our challenge for the future.

The World Economic Forum (https://www.weforum.org/) published "*5 synthetic materials that will shape the future*", a highly fascinating and relevant paper on unexpected innovations and developments. Ignoring these opportunities would be very foolish. The World Economic Forum emphasized innovations of unmistakable importance.

Bioplastics are becoming steadily more important [Arikan & Oszoy 2017]. As we are all too often reminded, "common" plastics do not degrade and are a very visible source of environmental pollution. To complicate things further, the raw materials of these polymers, which we call the monomers, are historically derived from crude oil, which is not renewable. But things are changing! Thanks to research and development using enzymes and catalysts, it is becoming increasingly possible to convert renewable resources into the major building blocks needed for manufacturing plastics and synthetic rubbers. And when the reaction products are also biodegradable[3], they no longer constitute a huge problem for the environment. Currently, the global bioplastics market is thought to be growing at a rate of 20% to 25% per year. Their major advantages are a lower carbon footprint, independence, energy efficiency, and better eco-safety.

Plastic composites are reinforced by different types of fibre to make them stronger or more elastic. More recent high-performance developments within this field are nanocomposites, whereby plastics are reinforced using tiny particles of substances such as graphene[4]. These have any number of potential uses [Chen et al. 2018], ranging from lightweight sensors on wind turbine blades to more powerful batteries to internal body scaffolds that speed up the healing process of broken bones.

No matter how carefully we select materials for engineering applications based on their ability to withstand mechanical stresses and environmental conditions, at a given time they will inevitably fail. Ageing, degradation and loss of mechanical integrity due to impact or fatigue are all contributing factors. Inspired by biological systems, new materials are now developed which are able to heal in response to what would be traditionally considered irreversible damage. Polymers are not the only materials with the potential for self-healing, but they seem to be very good at it [Pang et al. 2018]. A series of novel techniques dedicated to polymerized products with features such as properties regulation, self-healing, reprocessing, solid state recycling, and controllable degradation are now being developed, heralding the opportunity of upgrading traditional polymer engineering. Although the exploration of this emerging topic is still in its infancy, the advances so far are encouraging and clearly directed to large scale applications.

Most polymers are insulators and therefore do not conduct electricity. However, a substantial upsurge in this field of polymer research emerged in 2000 after the award of a Nobel Prize to Alan MacDiarmid, Alan Heeger and Hideki Shirakawa for their contribution in discovering that a polymer named polyacetylene became conductive when impurities were introduced through a process known as doping. Not only does the same process make other similar polymers conductive, but some can even be converted into light-emitting diodes (LEDs). This is an area where polymers still face considerable challenge since they are a class of exciting materials combining the advantages of both metals and plastics [Ouyang 2018].

Gels and synthetic rubbers can easily adjust their shape in response to external stimuli, which means they are able to respond to changes in their surroundings. The external stimulus would usually be a change in temperature or acidity/alkalinity transition; but it could equally be light, ultrasound or chemical agents. This turns out to be incredibly useful in designing smart materials for sensors, drug delivery devices and many other applications. Other possibilities for smart polymers include products like window coatings that can wash the windows when they are dirty, and medical stitches that disappear when an injury has healed.

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[3] Whether a plastic is biomass- or petroleum-based is a different question than whether it will biodegrade (a process by which microbes break down material if conditions are suitable). Technically, all materials are biodegradable, but for practical purposes, only those that degrade within a relatively short period of time are considered biodegradable.

[4] The simplest way to describe graphene is that it is a single, thin layer of graphite — the soft, flaky material used in pencil lead. Graphite is an allotrope of the element carbon, meaning it possesses the same atoms, but they are arranged differently, which gives different properties to the material.

In today's society there is need for bioplastics, nanocomposites, self-healing polymers, plastic electronics as well as smart polymers. Let us be careful not to throw out the baby with the bathwater!

From this perspective plastic-free is pure nonsense. I would have preferred “litter-free” or “waste-free”. I would very much appreciate clean cities, clean motorways. And, yes, I would love a natural, plastic-free, and productive ocean.

Hopefully, consumers will no longer throw their rubbish on the streets. Hopefully, the industry will increasingly consider waste as a raw material. And, hopefully, decision makers will seriously and financially encourage the research we still need to warrant necessary innovations.

I know, being hopeful can sometimes be disheartening!

Plastic free ??? [source: Caroline Rutgeerts 16.05.2018]

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Leo Goeyens

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