

Health and environment: A closer look at plastics

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Rolf Halden directs the Center for Environmental Security at Arizona State University -- a new effort to protect human health and critical ecosystems. Credit: The Biodesign Institute at Arizona State University

Plastics have transformed modern society, providing attractive benefits but also befouling waterways and aquifers, depleting petroleum supplies and disrupting human health.

Rolf Halden, a researcher at Arizona State University's Biodesign Institute has been following the chemical trail of [plastics](#), quantifying

their impact on human health and the environment. In a new overview appearing in the journal *Reviews on Environmental Health*, Halden and his co-author, ASU student Emily North, detail the risks and societal rewards of plastics and describe strategies to mitigate their negative impacts, through reconsideration of plastic composition, use and disposal.

"We are in need of a second plastic revolution. The first one brought us the age of plastics, changing human society and enabling the birth and explosive growth of many industries. But the materials used to make plastics weren't chosen judiciously and we see the adverse consequences in widespread [environmental pollution](#) and unnecessary human exposure to [harmful substances](#). Smart plastics of the future will be equally versatile but also non-toxic, biodegradable and made from [renewable energy sources](#)," says Halden.

Plastics are made up of a network of molecular [monomers](#) linked to form [macromolecules](#). These versatile [chemical structures](#) come in enormous varieties and today over 20 major forms of plastics exist. Plastics are typically lightweight and biocompatible. Along with their myriad uses in everyday life, plastics fulfill many needs in the public health arena, where they are found in items including absorbable sutures, prosthetics and engineered tissues.

Further, plastics may be manufactured at low cost using little energy and their adaptable composition allows them to be synthesized in soft, transparent or flexible forms suitable for a broad range of [medical applications](#). Because they can be readily disposed of, items like latex gloves, dialysis tubes, intravenous bags and plastic syringes eliminate the need for repeated sterilization, which is often costly and inefficient. Such single-use items have had a marked effect on reducing blood-borne infections, including hepatitis B and HIV.

Many varieties of polymers are produced to meet the expanding needs of modern medicine. Polymer chemistry is used to produce sophisticated drug delivery systems for the pharmaceutical industry; material to cement bone for hip replacements is made with polymer polymethylmethacrylate and polymer scaffolds are revolutionizing the practice of tissue engineering.

Researchers like Halden have shown, however, that the benefits of global plastics use can come at a steep price in terms of both human and environmental health. Continuous contact with plastic products, from the beginning to the end of life has caused chemical ingredients—some with potentially harmful effects—to form steady-state concentrations in the human body.

In recent years, two plastic-associated compounds have been singled out for particular scrutiny, due to their endocrine-disrupting properties: Bisphenol A (BPA) and di-(2-ethylhexyl)phthalate (DEHP). Studies of bioaccumulation have shown that detectable levels of BPA in urine have been identified in 95 percent of the adult population in the U.S. and both BPA and DEHP have been associated, through epidemiological and animal studies, with adverse effects on health and reproduction. These include early sexual maturation, decreased male fertility, aggressive behavior and other effects. Concern over BPA exposure, particularly for highly vulnerable members of the population, has recently led the Food and Drug Administration to place a ban on BPA use in infant bottles, spill proof cups and other products intended for infants and toddlers.

Similar issues exist with DEHP, a plasticizer found in polyvinyl chloride (PVC). Because this additive is not tightly bound to the plastics in which it is used, the potential exists for DEHP to leach out and enter the body, causing unwanted exposure and affecting health. Both animal and human studies suggest DEHP may produce harmful effects, including insulin resistance, increased waist circumference and changes to male and

female reproductive systems.

A variety of other plastic-related chemicals are currently under evaluation by Halden's group for their adverse effects on health and the environment. These include polyhalogenated flame retardants, polyfluorinated compounds and antimicrobials containing plastic additives such as triclosan and triclocarban.

While researchers are still at the early stages of assessing the risks to human health posed by plastics use, negative impacts on the environment have been a growing concern for many years. Over 300 million metric tons of plastics are produced worldwide each year. Roughly 50 percent of this volume is made up of products disposed of within one year of purchase.

Plastics today represent 15-25 percent of all hospital waste in the U.S. Some newer plastics are biodegradable, but the rest must be incinerated, disposed of in landfills, or recycled. All of these methods have drawbacks and carry environmental risk, as the new study explains.

Biodegradable plastics may break down in the environment into smaller polymer constituents, which may still pose a risk to the environment. Incineration liberates greenhouse gases associated with climate change. Landfilling of plastics, particularly in the enormous volumes now produced, may be an impractical use of land resources and a danger exists of plastics constituents entering the ground water. Finally, recycling of plastics requires careful sorting of plastic material, which is difficult. Recycled plastics tend to be of lower quality and may not be practical for health care and other applications.

As Halden explains, the problems posed by plastics need to be addressed on several fronts, and current research offers significant hope for improvements to human and environmental health. Better

biodegradable plastics are now being developed using carbon dioxide and carbon monoxide compounds and applying metal complexes as catalysts.

The technique provides a double benefit, binding unwanted greenhouse gases, while avoiding the competition with the human food supply. (Conventional bioplastics are made with plant sources like corn and molasses.) One application would be to replace BPA-containing epoxy resins lining metal food cans, thereby dramatically reducing BPA exposure while also sequestering 180 million metric tons of carbon dioxide (greenhouse) emissions.

The use of disposable items is also undergoing a reevaluation, in light of the potential environmental toll. In some cases, reusable plastic products are gaining ground, and estimates suggest the potential for a 50 percent reduction in medical equipment costs. Almost a quarter of all U.S. hospitals are now using reprocessing to decrease disposable waste.

Nevertheless, the largest source of plastics-related environmental damage stems from the overuse of items whose long-term harm outweighs their short-term benefit. Typically, these are consumer convenience items, often quickly discarded after a short use-life, including plastic water bottles, grocery bags, packaging, Styrofoam cups, Teflon-coated dental floss and other products. Halden recommends a thorough life-cycle assessment of plastics-based products, to identify safer, more sustainable replacement materials that reduce adverse effects to the environment and human health from plastic consumption.

"Many current types and consumption patterns of plastics are unsusustainable, as indicated by harmful plastic components circulating in our blood streams and multiple giant garbage patches of plastic debris swirling in the world's oceans. Continued use of plastics into the future will require us to redesign these indispensable materials of daily life to

make them compatible with human health and the ecosystems we rely on," says Halden.

Rolf Halden has been appointed to lead a new effort to protect human health and critical ecosystems, called the Center for Environmental Security (CES) at Arizona State University. The goal of the Center is to protect human populations and the planet by detecting, minimizing and ultimately eliminating harmful chemical and biological agents through engineering interventions.

Provided by Arizona State University

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