COMMENT

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Volunteer cleaners negotiate a Bulgarian reservoir jammed with plastics.

Classify plastic waste as hazardous

Policies for managing plastic debris are outdated and threaten the health of people and wildlife, say **Chelsea M. Rochman**, **Mark Anthony Browne** and colleagues.

Last year, 280 million tonnes of plastic was produced globally. Less than half of it was consigned to landfill or recycled. Of the remaining 150 million tonnes, some may still be in use; the rest litters continents and oceans (see 'Plastic world').

Plastic debris can physically harm wildlife[1,2]. Moreover, many plastics may be chemically harmful in some contexts — either because they are themselves potentially toxic[3] or because they absorb other pollutants[4,5]. Yet in the United States, Europe, Australia and Japan, plastics are classified as solid waste — so are treated in the same way as food scraps or grass clippings.

We believe that if countries classified the most harmful plastics as hazardous, their environmental agencies would have the power to restore affected habitats and prevent more dangerous debris from accumulating. Ultimately, such a move could boost research on new polymers and replace the most problematic materials with safer ones.

It is now almost impossible to walk in the countryside or on a beach without encountering bits of plastic. Larger pieces, from bottles and bags to floating pontoons, can transport species to new habitats where they might do damage. Such debris can kill or injure ecologically and commercially important species, including mussels, salt-marsh grasses and corals[1,2]. Mammals, reptiles and birds can also be harmed through eating plastic or becoming entangled in it. Last year, the secretariat of the Convention on Biological Diversity in Montreal, Canada, reported ▸

that all sea turtle species, 45% of marine mammal species and 21% of seabird species can be harmed in this way.

HEALTH RISK

As plastic breaks into smaller pieces, it is more likely to infiltrate food webs[2]. In laboratory and field studies, fish, invertebrates and microorganisms ingest micrometer-sized particles[2], which also come from synthetic (polyester or acrylic) clothing[6] and cleaning products containing plastics. More research is needed to investigate the effects of organisms ingesting debris in the wild. Nevertheless, studies in humans[7] and mussels[2] have found that ingested and inhaled microplastic gets into cells and tissues where it can cause harm. (In patients who have had their knee or hip joints replaced with plastic implants, such particles can disrupt cellular processes and degrade tissues.)

"The biggest producers of plastic waste must act now."

Plastics are made up of repeating units called monomers that bind together to form long chains, or polymers. These chains are generally thought to be chemically inert, yet unreacted monomers and other harmful ingredients can be found in plastics[3,4]. According to a hazard-ranking model based on the United Nations' Globally Harmonized System of Classification and Labelling of Chemicals, the chemical ingredients of more than 50% of plastics are hazardous[3]. Studies investigating, for instance, the transfer of additives in polyvinylchloride (PVC) from medical supplies to humans indicate that these chemicals can accumulate in the blood[8]. In laboratory tests, monomers and other ingredients of PVC, polystyrene, polyurethane and polycarbonate can be carcinogenic and can affect organisms in a similar way to the hormone oestrogen[3,4,9].

The monomers making up some plastics, such as polyethylene (used to make carrier bags), are thought to be more benign. Yet these materials can still become toxic by picking up other pollutants[4,5]. Pesticides and organic pollutants such as polychlorinated biphenyls are consistently found on plastic waste at harmful concentrations 100 times those found in sediments and 1 million times those occurring in sea water[4]. Many of these are 'priority pollutants': chemicals that are regulated by government agencies, including the US Environmental Protection Agency (EPA), because of their toxicity or persistence in organisms and food webs. These chemicals can disrupt key physiological processes, such as cell division and immunity, causing disease or reducing organisms' ability to escape from predators or reproduce.

In an analysis (unpublished results), we found that at least 78% of priority pollutants listed by the EPA and 61% listed by the European Union are associated with plastic debris. Some are ingredients of plastic, and others are absorbed from the environment. Preliminary evidence indicates that priority pollutants can enter the tissues of species after they eat debris[4,10]. Seabirds that have consumed plastic waste have polychlorinated biphenyls in their tissues at 300% greater concentrations than in those that have not eaten plastic[4].

NAME GAME

Governments have struggled for decades to reduce plastic debris. The International Convention for the Prevention of Pollution From Ships (MARPOL) was signed in 1973, although a complete ban on the disposal of plastics at sea was not enacted until the end of 1988. Yet despite 134 nations agreeing to eliminate plastics disposal at sea, oceanic sampling suggests that the problem has persisted or worsened since MARPOL was signed. In the North Pacific, the concentration of microplastic debris has increased by two orders of magnitude. As far as we know, no attempts have been made to regulate the disposal of plastics on land at an international level.

We feel that the physical dangers of plastic debris are well enough established, and the suggestions of the chemical dangers sufficiently worrying, that the biggest producers of plastic waste — the United States, Europe and China — must act now. These countries should agree to classify as hazardous the most harmful plastics, including those that cannot be reused or recycled because they lack durability or contain mixtures of materials that cannot be separated.

Focusing on the most problematic materials is a realistic first step. Currently, just four plastics — PVC, polystyrene, polyurethane and polycarbonate[3,4] — make up roughly 30% of production. These are particularly difficult to recycle and are made of potentially toxic materials. PVC is used in construction, such as in pipes that carry drinking water; polystyrene is used for food packaging; polyurethane in furniture; and polycarbonate in electronics. Healthcare and technology industries are already replacing PVC components in intravenous-drip bags and in computers with materials that are safer, more durable and recyclable, such as polypropylene and aluminium.

With a change in plastics categorization, numerous affected habitats could immediately be cleaned up under national legislation using government funds. In the United States, for instance, the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 would enable the EPA to clear the vast accumulations of plastic that litter the terrestrial, freshwater and marine habitats under US jurisdiction.

CHAIN REACTION

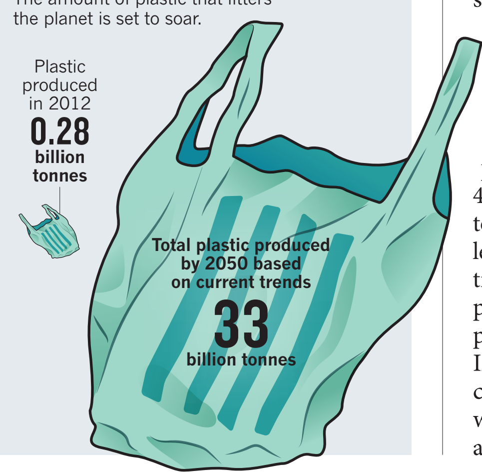
History shows that this approach works. Chlorofluorocarbons (CFCs) and persistent organic pollutants were reclassified as hazardous under the Montreal Protocol in 1989 and the Stockholm Convention in 2004, respectively. This led, in each case, to nearly 200 countries stopping the production of some 30 dangerous chemical groups and replacing them with safer ones. For CFCs, all production stopped within seven years.

Our critics counter that without evidence of catastrophic harm to health or the environment, it is a stretch to equate plastics to CFCs and other substances classed as toxic. We disagree. We believe that manufacturers of plastic, along with the food and textile industries that rely heavily on it, should have to prove that their products and packaging are safe. Such demands are routinely made on the food and pharmaceutical industries by directives from numerous agencies, including the US Food and Drug Administration and the European Medicines Agency.

Ultimately, changes in regulation need to drive the development of a closed-loop system in which all plastics are reused and recycled. Today, most plastic waste goes to landfills where chemicals leach from the plastic into surrounding habitats[4]. Worldwide, the recycling of plastics is increasing. From 2005 to 2010, for example, US and UK plastics recycling rose by 4% and 9%, respectively. Still, current efforts to 'reduce, reuse, recycle' cause other problems. Recycling often involves burning plastics and using the energy released for other purposes, but incineration can generate priority pollutants and greenhouse gases. In a closed-loop system, plastics would be continually reused and replenished only when materials become too degraded — analogous to the reuse of glass bottles by the

PLASTIC WORLD

The amount of plastic that litters the planet is set to soar.



JOHN CANCALOSI/NATUREPL.COM

Wildlife such as this white stork (*Ciconia ciconia*) can become entangled in discarded plastic bags.

UK dairy industry from the late 1800s to the mid-1990s.

Many people think that replacing materials such as wood and glass with plastic to make goods lighter can help to address climate change. However, the benefits must be balanced against the negative impacts of plastics so that they are used only when they have smaller carbon and ecological footprints than alternatives. Others may argue that in the current global economic crisis, nations can ill afford to regulate an industry that, in the United States alone, is worth US$1 trillion and employs 1.1 million people. Yet dealing with plastic waste is hugely costly; removing litter, most of which is plastic, from the west coast of the United States costs taxpayers $520 million each year. Also, the production of safer materials would spur innovation and boost employment in research and development. In fact, in the past three years or so, some plastics manufacturers themselves, under pressure from lobbyists and perhaps perceiving that current practices are unsustainable, have called for closed-loop systems.

If current consumption rates continue, the planet will hold another 33 billion tonnes of plastic by 2050. This would fill 2.75 billion refuse-collection trucks, which would wrap around the planet roughly 800 times if placed end to end. We estimate that this could be reduced to just 4 billion tonnes if the most problematic plastics are classified as hazardous immediately and replaced with safer, reusable materials in the next decade. ■

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