



How to Cope with Plastics Pollution of Oceans?



Daniel A Lowy*

Director of Science and Innovation, Hungary

***Corresponding author:** Daniel A Lowy, Hungary

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Opinion

Plastic pollution of oceans has become an increasingly widespread and alarming phenomenon, which represents a threat to the future of mankind. Statistical data are disturbing; at least 8 million tons of plastics leak in the ocean every year, a quantity equivalent to dumping in the water one garbage truck of plastic every minute. Consequences on the ecosystem are dramatic. For example, 18 sperm whales beached themselves at a young age (typically, their life span is of 70 years); they were all found to contain pieces of plastic in their stomach. In present, 90% of seabirds have ingested plastics (as compared to 5% in 1960.) Extrapolating available data, the Ellen MacArthur Foundation and World Economic Forum anticipate that by 2050, in the San Francisco Bay there would be more plastic in the ocean than fish. In 2016, the total quantity of plastic trash in the Pacific Ocean was estimated to 0.82 trillion kg. Trash accumulates in 5 ocean garbage patches, the largest being the Great Pacific Garbage Patch, located between Hawaii and California; it extends over a surface area twice the size of Texas, which equivalates with the overall size of three countries: France, Spain, and Italy. Over 5 trillion pieces of plastic currently litter the ocean. Should it be allowed to circulate, the plastic will impact our ecosystem, health, and economies. Solving this problem requires a combination of closing the source and cleaning up the plastic waste already accumulated in the ocean [1].

While plastic debris do not biodegrade for hundreds of years, they undergo photodegrading, when exposed to the Sun's UV radiations. As shown in the Figure, assisted by waves and currents, plastic remains break down into ever-smaller pieces (from initial diameters of <5mm to nanobeads of <500nm), which enter the water as microbeads, and can be absorbed by organisms from plankton to mussels, crabs, and up. Plastics pose another significant risk, as persistent organic pollutants, present in the ocean, can adsorb onto the surface of plastic debris. Hence, plastic beads can collect hydrophobic chemicals, such as DDT and polycyclic aromatic hydrocarbons (PAHs), both carcinogenic and endocrine disruptors, potentially resulting in cancerous tumors, birth defects, or other developmental disorders. Therefore, there are justified concerns related to such materials, which can be ingested by creatures throughout the food web, getting absorbed in animal tissue, and bioaccumulating as they move up the food chain [1].

Fortunately, young generations' environmental awareness is encouraging. In 2014, Boyan Slat, a 24-years-old Dutch innovator initiated The Ocean Cleanup Project, which constitutes the largest cleanup in history. He invented a massive plastic-cleaning device, which collects the waste from the surface of the ocean. The system consists of a 600-meter-long floater, which sits on the water and a tapered 3-meter-deep skirt attached below. Natural forces, the current, wind, and waves propel both the plastic and system. As the system moves faster than the plastic, the plastic waste can be captured. A full-scale deployment of this systems may clean up 50 % of the Great Pacific Garbage Patch every 5 years [2]. Nevertheless, an open-ended question lasts: what should the fate of collected plastic waste be?

Given that approximately 129 million tons of plastic are produced yearly, almost entirely from petroleum, it causes the depletion of oil and gas reserves [3,4]. This large-scale production of plastics diminishes the availability of petroleum resources as non-renewable fossil fuel, since plastics are petroleum-based materials. The expedited accumulation of plastic debris calls urgently for sustainable waste management, a major goal to all societies. Currently, close to 80% of global plastic wastes are placed in landfill, where they become a carbon sink, or are dumped in the sea, as non-biodegradable litters. Both practices represent a defiance of the environmental impact of human activities.

Incineration, blast furnace, or gasification of plastics do not represent a feasible solution to the problem, as toxic gases are produced, and production costs are high [5]. Consequently, there is a great demand for recycling of plastics into reusable products is a conventional strategy for addressing this issue. Several obstacles of recycling technique, such as the need of labor-intensive sorting, cleaning, and segregation procedures along with water pollution impede the process sustainability. Today's fast-growing need for energy and materials has imposed a new perspective on waste streams and their use for energy and materials recovery, particularly in developed regions of the world, such as Europe, the United States, and Japan [6]. As a result, the plastic waste conversion into energy was developed through innovation advancement and extensive research. Oil produced through the pyrolysis of plastics have high calorific value and can be used as an alternative fuel [7] (Figure 1).

Over the past decades various technologies have been developed to overcome the drawback of non-biodegradability of plastic wastes. Pyrolysis of plastic wastes into fuel allows to conserve valuable petroleum resources and to protect the environment, creating a plastic waste free world. Thermal decomposition-based technologies for plastic waste treatment enable their conversion to fuel or syngas (synthesis gas), or produce oil and gasoline, combustible gas mixtures, and coke [9]. These processes involve catalytic decomposition of plastics into hydrocarbons that can be used as fuels, such as diesel and kerosene. Catalytic cracking processes of waste plastics can be conducted on zeolites or mesoporous materials, taking advantage of their porous structure and acid properties [10]; also, amorphous alumina-silica have been used as catalysts. Thermal decomposition proceeds at low pressure (usually around 20 torr) and moderate temperatures (typically, at 450-550 °C) [11,12]. When the gas mixture released from plastics is treated with high-temperature water vapor (reformation), the long carbon chains break up and yield syngas (the mixture of carbon monoxide and hydrogen); alternatively, short chains hydrocarbons can be obtained, which serve as fuel (yields of the condenser ranging from 77 to 88%) [9], along with gaseous combustible hydrocarbons with 2-4 carbon atoms (C₂-C₄), and coke that can be used in the steel industry.

Overall advantages of pyrolysis include:

1. The removal of mountains of waste, while creating useful products,
2. Production of Diesel oil and combustible gas mixtures that can be used as fuels,
3. Making of high-purity coke, which is in high demand in steel industry,
4. Manufacturing of syngas can be used as a fuel or for synthesis.

On January 16, 2018, the European Commission adopted the first-ever Europe-wide strategy on plastics, as a part of the transition toward a more circular economy. It is aimed to protect the environment from plastic pollution, while fostering growth and innovation, turning a challenge into a positive agenda for the Future of Europe. Under the new plans, all plastic packaging on the EU market will be recyclable by 2030; also, the consumption of single-use plastics will be reduced and the intentional use of microplastics will be restricted. As imposed by the statutory recycling targets of the European Union's Circular Economy Package (CEP), EU member states will be required to reach a recycling rate of 55% by 2025, 60% by 2030, and 65% by 2035. Recently, the government of the United Kingdom announced plans to establish a £20-million fund intended

for developing a more sustainable end-of-life process for plastics. The Plastics Research and Innovation Fund will focus on reducing the environmental impact of plastics manufacturing processes by finding new innovations to put in place instead, moving the UK toward a circular economy [13,14].

On October 5 2018, an international conference entitled The Universal Sea was held in Budapest, where artists and scientists proposed to strengthen environmental awareness on the plastic pollution of oceans. While artists have the responsibility to warn of the problem, the mission of scientists is to solve the problem.

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