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The COVID-19 pandemic necessitates a shift to a plastic circular economy

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The COVID-19 pandemic is exacerbating plastic pollution. A shift in waste management practices is thus urgently needed to close the plastic loop, requiring governments, researchers and industries working towards intelligent design and sustainable upcycling.

Plastic pollution is ubiquitous. As of 2015, approximately 6,300 million metric tons (Mt) of plastic waste had been generated globally[1], motivating myriad initiatives to reduce plastic consumption. However, the focus on plastic waste reduction has since been overshadowed by the COVID-19 pandemic. Traditionally minor sources of plastic pollution — including personal protective equipment (PPE) — have become far more prominent, exacerbating consumption. Moreover, some regulatory measures meant to reduce plastic have been delayed and/or rolled back during the pandemic, stalling or even reversing the longstanding global battle to mitigate plastic pollution.

Approximately 400 Mt of plastic waste was produced globally in 2019 (REF.[1]). However, the estimated waste volume reached over 530 Mt in the first 7 months of the COVID-19 outbreak (December 2019–June 2020) (REF.[2]), suggesting plastic waste totals for 2020 would be at least double those of 2019. Part of this increase results from the public demand for disposable face masks and gloves; globally, an estimated ~3.4 billion protective face masks were discarded daily from December 2019 to June 2020 (REF.[2]). Moreover, the consumption of plastic packaging by takeaway services, e-commerce outlets and express delivery industries increased extensively with social distancing requirements. Takeaway and home delivery services generated additional 1.21 Mt of plastic waste from April to May 2020 during the lockdown in Singapore alone.

A notable portion of this waste does not make it to municipal waste streams. Masks, gloves and other plastics (including hand sanitizer bottles) are found indiscriminately littered and disposed of without precautionary measures. Such inadequate plastic waste management results in an alarming accumulation of plastic in soil and aquatic ecosystems. For example, it is estimated that approximately 1.56 billion face masks (~5.66 Mt of plastic) ended up in the oceans in 2020. Large pieces of plastic waste, (including masks,) can break into microplastics (>100 nm and <5 mm) and nanoplastics (<100 nm)[3]. The accidental ingestion of these micro-/nano-plastics by marine and freshwater organisms, alongside unexpected accumulation in terrestrial plants and animals, and transport in the atmosphere as “plastic-rain” or “plastic-smog,” raise concerns for the safety of human food, drinking water and breathable air[4]. Moreover, micro-/nano-plastics can serve as potential vectors for pathogens and toxic contaminants, leading to injury and death, with direct negative effects on biodiversity.

The marked increase in PPE waste has overwhelmed waste management programs globally, as used plastic PPE must be disposed of suitably to prevent cross-contamination. Indeed, potentially contaminated plastics are restricted at recycling centres, meaning incineration and landfilling are being widely prioritized. Such disposal methods are a clear deviation from the goals of plastic circular economy and sustainable development[5], and incineration can also lead to serious deteriorations in air quality via long-term emission of volatile toxins (including dioxins and furans) and greenhouse gases[6].

Thus, governments must ensure that the plastic waste generated during the COVID-19 pandemic is collected, segregated and disposed of in a coordinated manner. Waste treatment facilities should have real-time information of incoming PPE waste volume, types and hotspots of generation, and potentially contaminated waste should be collected in specifically labelled reusable containers for easy separation and treatment. An integrated mechanical and chemical recycling process is therefore needed for the disposal of plastic PPE in the immediate future[7]. Hydrocracking, for instance, is a potentially sustainable process[8] because of its low carbon emissions and energy consumption, and the ease of controlling related pollutants. More effective use of current waste management technologies should be leveraged with government incentives to efficiently reach the goal of generating zero plastic pollution. Going forward, end-of-life plastic PPE should be designed to be completely degraded or properly upcycled for value-added applications rather than being mismanaged.

Of course, a balance needs to be struck between protecting public health and mitigating environmental

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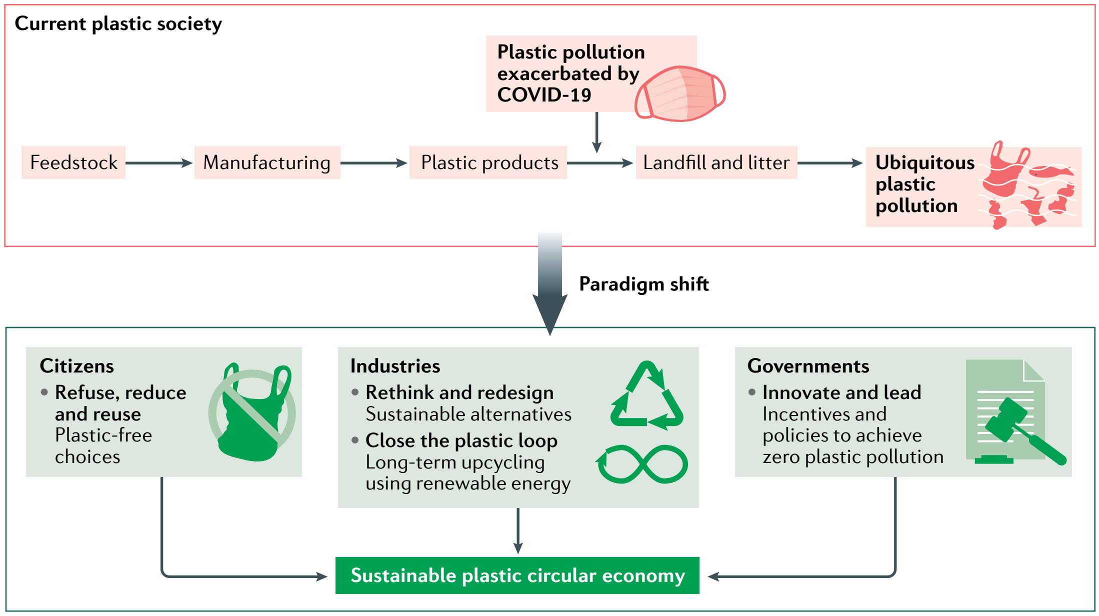

Fig. 1 | **A proposed shift towards a circular plastic economy.** Global plastic pollution has been exacerbated by the COVID-19 pandemic. Sustainable plastic use should be prioritized, with the aim to create a circular plastic economy.

damage during the COVID-19 pandemic. In the long-term, though, current plastic waste management schemes alone cannot keep pace with the estimated growth in plastic waste generation, even if capacity is increased. This problem has been magnified by COVID-19, but the pandemic is not the root cause of it – single-use plastics were already pervasive and disposed of improperly. There is a pressing need for an immediate shift towards the plastic circular economy, both during the pandemic, but even more importantly, afterwards. Achieving this goal requires cooperation between consumers, researchers, governments and industries (FIG. 1).

Technological breakthroughs are needed to create a closed-loop plastic society, starting at the design stage and up through disposal and environmental recovery. Biodegradable plastics are a promising future technology; however, full techno-economic and environmental footprint assessments for industrial-scale applications are needed before they are broadly implemented. Industries should provide exhaustive information of the biodegradable plastic stream flow to related researchers and policymakers so that appropriate techno-socio-economic analyses can be conducted to formulate policies. Beyond biodegradable plastics, advanced and efficient catalytic conversion routes for plastic waste upcycling offer opportunities to enhance the profitability from both environmental and resource-recovery viewpoints. These upcycling technologies should be encouraged and implemented by governments in their waste management programs. Renewable energy, such as low- or medium-grade solar thermal power, should be used to upcycle plastic waste to obtain hydrogen fuel and produce clean carbon[9]. With concerted efforts from industries, and financial and policy support from governments, these novel technologies could be upscaled for commercial applications alongside the push to achieve net-zero emissions in the coming decades.

Closing the loop on plastic might not be a reality just yet. However, heightened consumer awareness, increased industry innovation, expanded government investment and continued research can mitigate plastic burdens on the environment and develop a society guided by a circular economy.

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Competing interests

The authors declare no competing interests.