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Editorial

A New Challenge for the Management and Disposal of Personal Protective Equipment Waste during the COVID-19 Pandemic

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Abstract: To prevent the transmission of the Coronavirus (SARS-CoV-2) in the public, the demand and consumption of personal protective equipment (PPE) increased drastically. Such wide use of PPE has brough a new challenge to waste management and disposal. It is difficult to sort PPE waste before further treatment, and such waste will often end up being processed by some traditional disposal methods. During the pandemic, incineration and landfill facilities are currently under significant pressure. In addition, a certain amount of PPE waste is discarded into the environment rather than going to landfills and incinerators. It not only directly affects the ecosystem, but also indirectly threatens human health through various routes of exposure. PPE waste is also the source and carrier of pathogens and chemical contaminants, causing a secondary pollution. Therefore, it is necessary to establish appropriate strategies to deal with the PPE problems related to energy, environment and health, requiring the collaborative efforts of researchers, practitioners, policymakers, and governments.

Keywords: personal protective equipment; waste; management and disposal; COVID-19

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Coronavirus (SARS-CoV-2) has spread globally since early 2020. As of June 2021, there have been more than 176 million confirmed cases and more than 3.8 million deaths worldwide [1]. To prevent the transmission of the virus in the public, many countries have proposed various protective measures, leading to a drastic increase in the demand and disposal of personal protective equipment (PPE), especially face masks and gloves. More than 129 billion face masks and 65 billion gloves were consumed globally each month in 2020 [2]. The global PPE market size is expected to increase from USD 70,940 billion in 2020 to USD 81,790 billion by 2026 [3].

Such wide use of PPE has brough a new challenge to municipal solid waste management and disposal. First, the fast growth of PPE waste has put enormous pressure on existing waste facilities, including transfer stations, material recovery facilities, incinerators, and landfills. Globally, the production of medical waste during the COVID-19 pandemic increased from 200 tons/day in February 2020 to over 29,000 tons/day at the end of September 2020 [4]. In addition, unlike regular medical waste generated from clinics, hospitals, and nursing homes, PPE waste generated during COVID is often mixed with other municipal waste streams. It is difficult to sort and process PPE waste prior to disinfection and PPE waste will often end up in municipal waste streams. At present, the main methods of solid waste treatment are landfilling and incineration, accounting for 79% and 12% of the total treatments, respectively [5]. During the pandemic, incinerators and landfills are currently under significant pressure, despite the deployment of ancillary and additional treatment facilities in some countries.

Due to the lack of environmental awareness and regulations, a certain amount of PPE waste is discarded into the environment rather than going to landfills and incinerators (Figure 1). Since most PPE items are plastic products, these wastes can remain in the environment for a long time. Although much of PPE waste is generated in the urban area, this waste is found in the oceans through surface runoff, placing new environmental risk to oceans. Studies have shown that PPE waste can not only affect the marine ecosystem directly, but also indirectly threaten human health through various routes of exposure. On the one hand, the presence of PPE items in the marine environment will directly increase the potential risks to birds and marine fauna. For example, some marine animals can be entangled with the elastic ear loops of face masks, or trapped inside gloves, reducing their mobility, and may lead to starvation. In addition, PPE waste may be ingested by marine fauna, even endangering their lives [6]. On the other hand, PPE waste will be another source of plastic fibers and microplastics in the environment. A weathered mask can release millions of microplastics into the aquatic environment [7]. Microplastics can further accumulate and transfer through the food chain in plankton, fish, and birds, and end up within humans, thereby endangering human health.

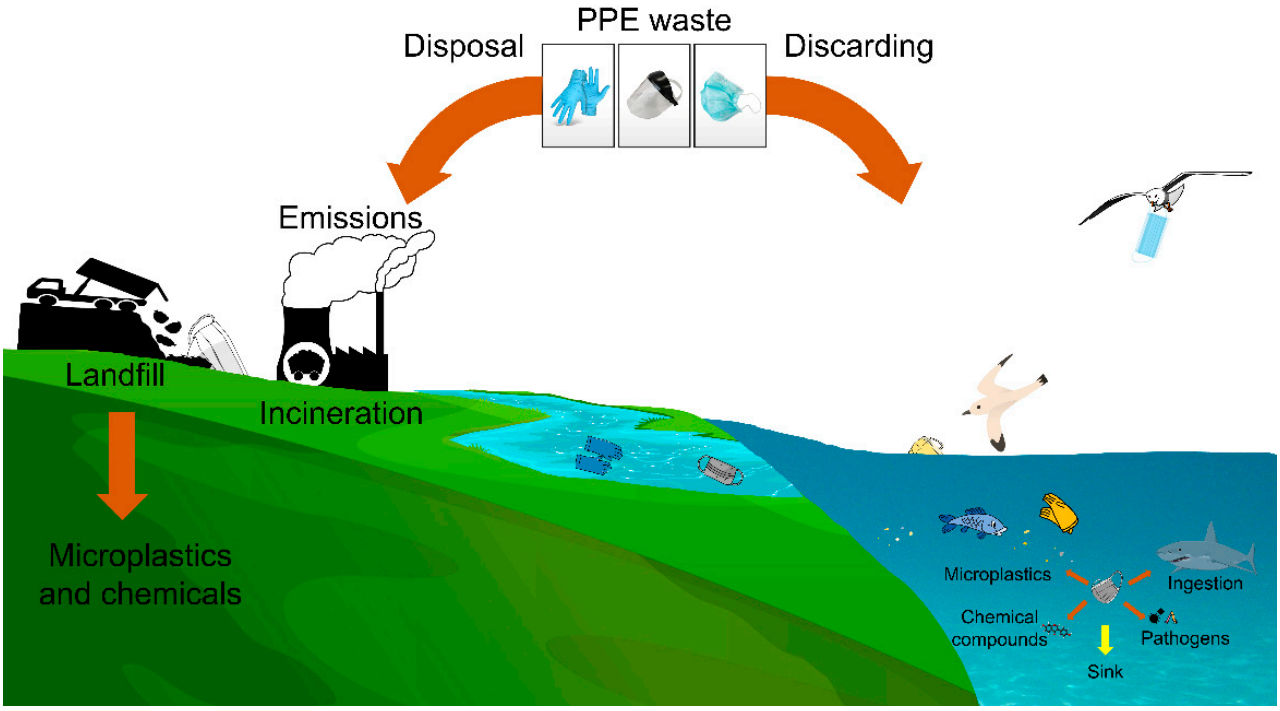

Figure 1. The environmental fate and impacts of PPE waste.

PPE waste is the source and carrier of pathogens and chemical contaminants. Current evidence suggests that the virus can persist on the media surface for 72 h or longer when the conditions are favorable [8]. The training on the handling, sorting, and processing PPE waste and preventive measures are still limited. This may put the waste management practitioners at a higher risk of infection. Along with weathering processes, discarded PPE can also release various chemical additives such as stabilizers, photosensitizers and pigments. As the physicochemical properties of these plastic PPE products change after weathering, the surface is more likely to adsorb various organic compounds and heavy metals as well, leading to the enrichment of pollutants [9]. In addition, the formation of biofilm is more conducive to microbial colonization. There may be significant differences between the microbial composition of the biofilm on masks and gloves and the microbial community in the surrounding aquatic environment, leading to some changes such as lower cell motility, higher xenobiotic degradation ability, and elevated antibiotic resistance [10]. From a systematic view, energy and environmental issues related to the production and

transportation of PPE products need to be further considered. The massive production of PPE results in a growing demand for raw plastic materials derived from fossil fuels. At the same time, the energy use associated with the transportation, distribution, and retail of PPE products contributes to the increasing emissions of greenhouse gases (GHGs), volatile organic compounds (VOCs), nitrogen oxides (NO_X), etc. It is even worse when PPE waste is burnt inappropriately, emitting more GHGs as well as toxic compounds such as dioxins, polychlorinated biphenyl (PCBs), and furans. Landfilled PPE can also release microplastics and chemical additives via leachate that may contaminate the soil and groundwater.

Although many efforts have been made to alleviate the environmental pressure caused by PPE waste, there is still a lack of effective approaches for managing the PPE production, transportation, retail, usage and treatment from a systematic view [11–13]. Distinct waste disposal characteristics and recycling behaviors were observed during the first wave of COVID-19 [14,15], and more research is needed on the subsequent waves with respect to PPE waste disposal and recycling. In order to achieve a safe and sustainable management and disposal of PPE waste, it is recommended to (i) establish a universally applicable PPE assessment system to monitor the trend of PPE waste in terms of its type, quantity, and spatiotemporal distribution; (ii) develop green and degradable materials for PPE, as well as new production technologies to reduce their environmental impact; (iii) employ efficient and viable disinfection methods such as ultraviolet light, ozone gas, and microwave for improving PPE waste recycling; (iv) increase the public awareness for the collection and segregation of PPE waste at source; (v) explore the alternative uses of PPE waste (e.g., mixing in concrete for construction, recovery of plastic particles from decomposed PPE, other waste-to-energy technologies); and (vi) adopt new regulations and determine the best management practices for PPE waste to avoid waste persisting in the natural environment. In general, it is undeniable that PPE plays an important role in preventing the spread of the Coronavirus. It can also be a part of our daily lives both during and after the pandemic. Therefore, it is necessary to establish appropriate strategies to deal with the PPE waste problems related to energy, the environment, and health. This requires a multidisciplinary approach and the collaborative efforts of researchers, practitioners, policymakers, focus groups, and governments.

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