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Environmental and Human Health Impact of Single-Use Plastic-Made Personal Protective Equipment Used to Limit the Spread of SARS-CoV-2

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Abstract. The novel Coronavirus (SARS-CoV-2) has wreaked havoc throughout the world, affecting nearly every country. Several countries are currently battling the virus's second or third wave, which is wreaking havoc far worse than the first. A variety of plastic-based personal protective equipment (PPE) was instrumental in protecting people during the COVID-19 pandemic. Every day, a significant amount of single-use PPE including masks, gloves, protective aprons, face shields, safety glasses, sanitiser containers, plastic shoes, and medical gowns (made primarily of polypropylene) is discarded by health care workers and the general public. While this personal protective equipment is lowering the spread of SARS-CoV2, the lacking of sustainable management possesses a serious threat to public health and the environment. As the SARS-CoV-2 virus can survive in discarded medical waste for up to 168 hours, likely, the medical waste originating from hospitals, clinics, medical centres, home isolation, and quarantine facilities where the infected individual is getting treatment could spread and increase the infectivity of the virus. Therefore, this paper discusses the environmental and human health consequences of single-use personal protective equipment used to reduce the spread of SARS-CoV-2.

INTRODUCTION

The COVID-19 pandemic has revealed alarming statistics in terms of confirmed cases and deaths. It has been reported that plastic items such as personal protective equipment, confirmatory COVID-19 tests, and vaccination vials, as well as the syringe, had a role in the COVID-19 pandemic by saving lives [1]. Medical waste generation by healthcare facilities has increased dramatically in recent years, and cities with high COVID-19 incidence rates are struggling to keep up with the demand [2]. The varieties of plastic waste generated during the COVID-19 pandemic are depicted in Figure 1. Plastics are required for usage in the vast majority of nations and are critical in preventing disease contamination and transmission [3]. However, when such plastic waste is improperly disposed of, it can act as a pollutant, resulting in environmental harm. For example, disposing of used face masks in improper locations can create a socio-environmental concern [4]. However, it is becoming increasingly difficult for any country or municipality to handle and treat medical waste promptly as a result of the huge growth in medical waste production. But the rise in residue generation indicates the vulnerability of residue management systems globally, which is exacerbated by a lack of public policies and a lack of awareness among a broad segment of the population [5].

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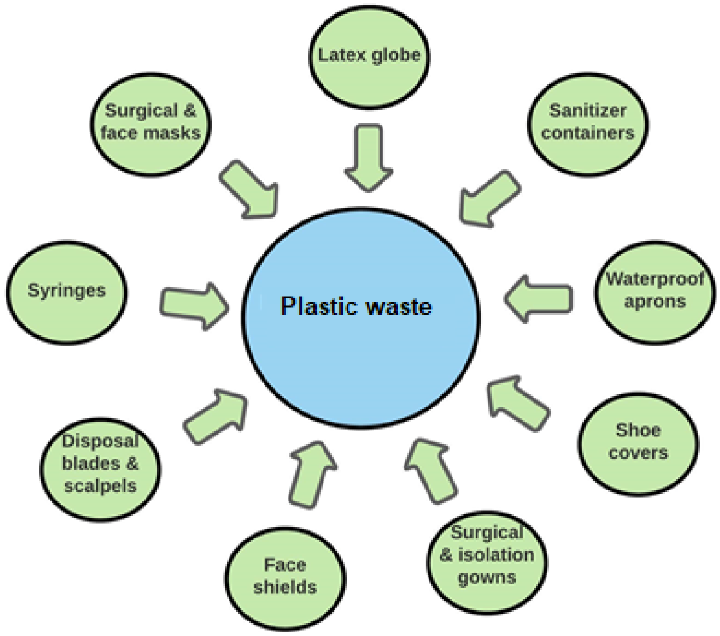

FIGURE 1. Plastic based waste generated during the COVID-19 pandemic [3]

Although some countries or localities may be able to effectively manage medical waste alternatives, others may be compelled to use unsuitable methods. Approximately 11 million people in Wuhan, China, generated 200 tonnes of medical waste in a single day (February 24, 2020), which is four times more than the city's capacity to burn, forcing the government to run a mobile waste management facility [6]. On the other hand, several Indian towns are pursuing a defective system of medical waste disposal and management, which mostly relies on landfilling and local burning tactics [1, 7]. Because of the persistence and high contagiousness of the SARS-CoV-2 virus, many nations have classified all hospital waste as hazardous, requiring it to be burnt at high temperatures to ensure sterilisation before being disposed of in landfills. Incineration of medical waste, which is mostly plastic, is not recommended since it produces greenhouse gases as well as other potentially harmful compounds such as heavy metals, dioxins, polychlorinated biphenyls (PCBs), and furans [8]. A major impact on the environment and human health is caused by the improper management of plastic waste. When plastic medical waste is disposed of in improper locations, the residues are advected into water [9], where the macro-, micro-, and nanoplastics in the water cause significant problems to aquatic animal [10].

CONSEQUENCES OF SINGLE-USE PLASTIC-MADE PERSONAL PROTECTIVE EQUIPMENT

The increased waste generation associated with personal protective equipment (PPE) was accompanied by a rise in the usage and disposal of single-use plastics, which have a negative impact on both the environment and human health. The N95 face masks that are recommended for use are manufactured of plastics such as polypropylene (PP) and polythene terephthalate. Similarly, surgical gloves are manufactured of nonwoven materials (e.g., spun-bond meltblown spunbond) that frequently combine additional polymers such as polythene (PE), polypropylene (PP), and polythene terephthalate (PET) [11]. Such masks are prone to disintegrate into smaller microplastic fragments (Figure 2) [12].

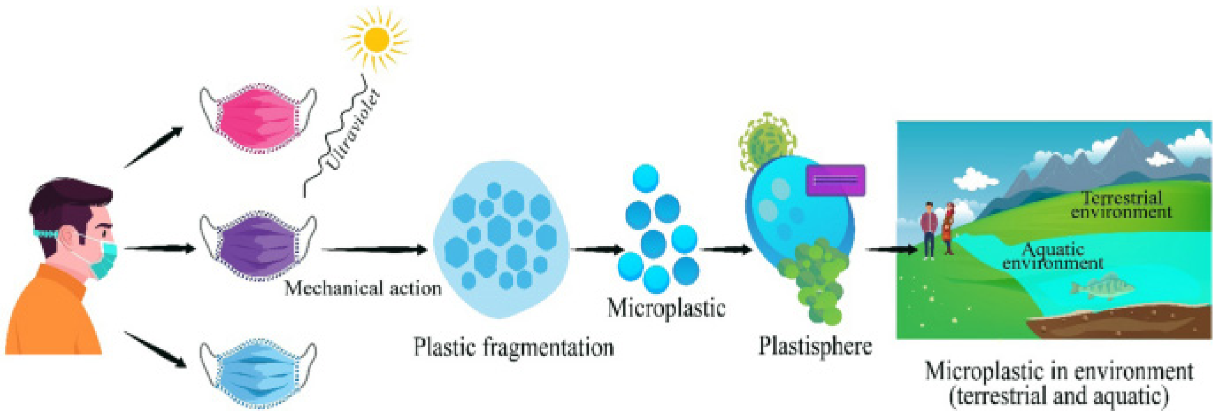

FIGURE 2. Environmental fate of microplastics that originate from single-use plastic e.g. face masks [12]

Environmental Impact

Before the COVID-19 outbreak, plastic pollution had been scaling in the terrestrial, aquatic and atmospheric environments [13]. Though on release in the environment not only PPE but also plastic litter will result in blockage of the sewerage lines in the city areas. Besides they can hamper the water infiltration and poor oxygenation of the agricultural lands, resulting in a reduction of agricultural production [14]. Also, numerous micro- and nano-size plastic materials are produced and shattered in the environment from plastic pollution. The presence of this plastic debris along with their polymer variety, poses a serious health risk to humans due to their ease of absorption in the gastrointestinal tract as a result of either intestinal obstructions or intestinal abrasions [10]. However, plastic pollution is thought to be harmless biochemically, the main concern is regarding the various additives with plastic materials that were used during the production of these plastics for enhancing their characteristics [15]. Moreover, plastic can act as a vector for various contaminations, exotic species or even pathogens like SARS-CoV2 [5]. Plastic additives and pollutants can strain out and accumulate in various environmental areas, reducing land and water quality and posing major dangers to biodiversity [16]. Besides, a very suitable breeding place for the mosquito Aedes spe. is created by disposing of plastic in the open environment especially aquatic places such as lakes, ponds or puddles.

The disposed face masks are not only a source of microplastics but also transports pollutants [17]. Anastopoulos and Pashalidis [18] tested three different dyes (methylene blue, crystal violet, and malachite green), and reported that single-use surgical face masks play the role of dye carriers in the aquatic environment. Microplastics, due to their lipid-loving or lipophilic behaviour, can easily arrest and contain pollutants such as pesticides, medicines, and oil [19]. Because of their high surface area, they can easily carry dangerous contaminants like polycystic aromatic hydrocarbons, polychlorinated biphenyls and per/poly-fluoroalkyl substances [20]. Microplastic pollution with contaminants can be a great health hazard since it can act as a vector for transmission of various antibiotic-resistant bacteria as well as coronavirus like deadly viruses [21]. As a result of the prevalence of MPs in nature, pollution with disposed face masks can be even more dangerous with their ability to act as a medium for disease outbreaks. A breach of balance between the environmental species can occur by the low-density polymers of PPEs, playing the role of an artificial substrate for colonizing the invasive species [22].

The ingestion of plastic particles can result in the death of aquatic plants, animals, and seabirds. Being attracted by the movement and fancy colours of the disposed of plastic, they easily ingest them considering any type of food particles. Ingestion of microplastics by aquatic animals like molluscs, mussels and oysters lead to the entrance of plastics into the food chain of the ecosystem. Human beings, as the final consumer in the food chain, are also at danger of different physical and toxicological health concerns associated with the consumption of aquatic organisms [10].

Human Health Impact

Various additives are used in the processing and manufacturing of plastic products to increase their yield, improve their aesthetic qualities, and increase their durability [23]. However, these ingredients are associated with negative human health consequences such as (a) direct toxicity (b) Carcinogens and (c) endocrine disruption that causes cancer, birth defects, immune system suppression, and developmental problems in children [24].

People are exposed to these chemicals not only during the manufacturing process but also as a result of their use, as some chemicals migrate from the plastic packaging. However, microplastics from medical waste may be subjected to biphenol A, polyvinyl chloride, polythene terephthalate, polythene high-density polythene, biphenol A sources, tetrabromobisphenol A sources, and bisphenol A, among other things. Microplastics have been discovered in human faeces, and more recently their presence has been discovered inside the human placenta, demonstrating that humans are consuming microplastics [25].

Microplastics have the potential to impair immunological function as well as neurotoxicity. It is also possible that it will harm human skin. In a survey of eight adults from Japan and Europe, microplastics were discovered on their faces [25]. All subjects tested positive for at least one type of microplastic after consuming food that had been wrapped in plastic, drinking water from plastic bottles, and six of them swallowing fish. However, the investigation was preliminary, the sample size was tiny, and the results were unable to determine the true source of the plastic particles. Yang [26] analysed and observed the presence of microplastics in all three distinct kinds of salt samples obtained from supermarkets. In contrast to rock/well salt and lake salt, the results of the test revealed that sea salt contains the highest quantities of microplastic. Additionally, microplastics have been discovered in sea salts and rock salts, both of which are commonly utilised in the production of table salts in Spain. Polythene terephthalate was found to be the most frequent microplastic in these two studies [27].

People can become contaminated with microplastics through eating contaminated food, drinking contaminated water or breathing polluted air, which can result in cytotoxicity, an acute response such as hemolysis or hypersensitivity, and unintentional immunological responses. Microplastics, which are eaten by people through marine species, are increasingly widely recognised [10]. Human protein is derived from fish, which contributed to 6.1% of total protein consumed globally in 2007. Humans can swallow the microplastics that crustaceans and fish eat [28]. An examination of muscle tissue samples to determine approximate microplastic concentration was proposed as a bioaccumulation example of the food chain that could lead to human exposure to microplastics [29]. A recent study discovered that individuals in the United Kingdom may be exposed to an average of 123 microplastic particles every year from mould ingestion on a year-to-year basis. Because diets can vary greatly, microplastic exposure in nations with a higher intake of shellfish has been estimated to grow to 4620 particles per capita per year in these countries [29]. The absorption produces cell toxicity in human liver cells as a result of their metabolism. Lumen MPs can interact with fluids through adsorbent processes, which are enhanced by the wide surface area and loading of the particle. The surface of the plastic particle can be adsorbed by big proteins, which can alter the intestinal immune system and the inflammation that surrounds the particle. MPs could also be absorbed through the intestines as a result of this process [30].

CONCLUSION

Plastic plays a crucial function in our society, particularly during pandemics, but it can also cause several issues. Considering all of the issues faced by the plastic waste produced in the health sector during the COVID-19 pandemic, waste must be disposed of safely. Designing new reusable personal protective equipment models with lower energy consumption is one option for reducing contaminated trash generated by previously used personal protective equipment. However, to assure its efficiency, a good design standard, material selection, and user guideline must be followed. In addition to addressing urgent concerns about disposable face masks, there is an opportunity to create innovative technology for sustainable plastic waste management, which is currently a difficulty for the waste management industry.

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