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Reusable masks for COVID-19: A missing piece of the microplastic problem during the global health crisis

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Dear Editor,

Coronavirus Disease 2019 (COVID-19) has spread rapidly to 188 countries and regions since the first cases in Wuhan, China, at the end of 2019. As of October 7, 2020, more than 35.5 million people have been diagnosed with novel coronavirus and the total number of COVID-19 death cases has exceeded one million globally (WHO, 2020a). Given that pandemic is spreading fast, countries worldwide have mandated face masks in public places to reduce transmission of respiratory droplets by infected individuals and protect healthy individuals from inhaling droplets. Eight months into the COVID-19 pandemic, there remains an unprecedented demand for personal protective equipment (PPE) products including, face masks, gloves, coveralls, gowns, goggles, and face shields. Previously, World Health Organization warned of a potential PPE shortage with an estimated requirement of 89 million medical masks each month and requested to increase manufacturing by 40% (WHO, 2020b). Since March 1, 2020, according to customs statistics, China has exported 26.7 million N-95/KN-95 masks, 504.8 million surgical masks, 195.9 million gloves, 17.3 million surgical gowns and 873,000 goggles. Responding to evolving global needs, both national and international companies augmented their manufacturing and output of PPE products. For example, 3 M (USA) has multiplied its output of N95 masks to 95 million per month by May and the annual rate was projected from 1.1 billion to 2 billion masks by the end of 2020 (Gereffi, 2020). Meanwhile, the far lower prices for PPE have been increased dramatically in the last months. The Berkeley public health center reported an increase for N95 masks from $1.27 to $5.90, for surgical masks from $0.05 to $0.55, for isolation gowns from $0.5 to $5, for face shields from $0.50 to $4.50 and for exam glove pairs from $0.04 to $0.12 during pandemic period (Laurel Lucia, 2020). This is mainly due to several factors such as, supply shortages, a limited number of PPE manufacturing companies worldwide and increasing awareness among people to use high quality products (Ranney et al., 2020). In addition, the March 2020 collapse in oil production under the weight of COVID-19 pandemic has become one of the major drivers for the exceptional growth of plastics (King, 2020; Wood Mackenzie, 2020). Notwithstanding the impact of plummeted oil price and production, companies are forced to turn crude oils into virgin plastics, that may possibly result in the massive plastic production for PPE and elevating their prices to overcome increasing oil losses.

During the outbreak, many countries experienced challenges in acquiring sufficient quantities of quality masks largely because they are underfunded. In developing countries such as Thailand, Japan, Mexico, Vietnam, and South Africa, where surgical and N95 masks have been reserved for health care providers or are scarce, the main alternative for the general public seems to be the use of nonmedical reusable masks made up of fabric or cloth. Reusable masks are washable and cost-effective and thus do not constitute an additional burden on already diminished economic activity. Countries like South Africa and Thailand have made it mandatory for the public to wear cloth face masks alone and diminished the use of N95 and surgical masks (RSA, 2020; WHO Thailand, 2020). According to Ministry of Public health of Thailand, from April 3, 2020, over 43 million cloth masks have been distributed to public (WHO Thailand, 2020). In just a matter of months, the use of reusable face masks is quite widespread among public and have quickly evolved as an essential public health item in the combat against the pandemic. Indeed, the rapid expansion of sales on millions of cloth masks has been reported in online sources such as Amazon and Etsy (Kavilanz, 2020). The Chicago-based global market research estimated the cloth face mask market would reach $800 million in the US, and $3 billion globally, by the end of 2020 (Kavilanz, 2020).

According to the WHO, the ideal reusable masks can be rewashed multiple times and have a combination of three distinctive layers, providing 2–5 times increased filtration efficiency compared to a single layer of the same cloth: 1) an inner layer of a hydrophilic material (e.g. cotton or cotton blends) that absorbs; 2) an outermost layer made of a non-absorbent hydrophobic material (e.g., a fabric that is a combination of cotton and polyester; nylon or rayon; polypropylene; polyester; or their blends) to limit external contamination; 3) a middle hydrophobic layer of synthetic non-woven material (e.g. polypropylene) or a cotton layer that filters or retain droplets, with elastic ties (rubber bands, string, cloth strips, or hair ties) for wearing (WHO, 2020c). These reusable

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masks should be washed using a complete wash cycle at 60 °C with detergent and can only be used after being well-dried (WHO, 2020c). Guidelines provided by various organizations including the U.S. Centers for Disease Control and Prevention, the Infection Control Expert Group (Australia), and the Pan-Canadian Public Health Network have also made similar recommendations for reusable masks made from high-quality material, such as high-grade cotton, and having multiple layers and particularly hybrid constructions. Commercially available homemade reusable face masks include different types of fabrics with significant portion of synthetic textiles, such as cotton quilt, flannel (65% cotton and 35% polyester), synthetic silk (100% polyester), natural silk, spandex (52% nylon, 39% polyester, and 9% polyether-polyurea copolymer), satin (97% polyester and 3% spandex), chiffon (90% polyester and 10% spandex), cotton/polyester, and polyester/polyamide mix (Konda et al., 2020). In addition, the online shopping and retail stores offer a wide variety of reusable face masks with in-built or disposable filters that are made up of plastic materials similar to disposable masks. Studies have confirmed the effectiveness of homemade cloth face masks, which likely have two or three layers, in reducing droplets from coughing and sneezing (Aydin et al., 2020; Konda et al., 2020). A recent study surveyed the state of mask-wearing and found that a majority of persons leaving their home reported using cloth face masks (61.9% to 76.4%) than other types (Fisher et al., 2020). With the continuous spread of the COVID-19 pandemic, the reusable face mask market is witnessing high demand across the globe. Developed countries have certification for reusable masks that ensures their composition and reusability (number of washes possible), and only masks that are certified are allowed in the market. For countries like Portugal, Spain, Belgium, Germany, and France, the certification is from the Technological Centre for the Textile and Clothing Industry of Portugal (ww.citeve.pt). However, the situation in several countries across continents is not the same, and evidence for certifications is sparse, leading to uncertified and substandard masks being reported as sold in the market and shops (Lam et al., 2020) (Fig. 1).

Considering that plastic pollution in the marine environment is a global issue, in light of the COVID-19 pandemic-induced changes, an increasing number of research papers have raised concerns about plastic waste management and the improper disposal of PPE (Sharma et al., 2020; Silva et al., 2020). Two recent studies have investigated whether surgical face masks and N95 masks could be a source of microplastic (plastic fragments with dimension of <5 mm) pollutants in the environment. The results strongly suggest that these masks act as a potential source of microfibers when they are released into the environment, adding additional burden to current microplastic pollution (Fadare and Okoffo, 2020; Aragaw, 2020). Reusable masks are presently excluded from microplastic surveys; as of now, the environmental impact of reusable masks is unknown and not scientifically documented. One can imagine why should we consider reusable masks as a potential source of microplastics. Under these circumstances, it is imperative to step back and examine the basic scientific evidence regarding the machine- and hand-laundering of synthetic textiles and clothing for microplastic pollution.

Generally, the release of microplastics from clothing is mainly caused by mechanical action and chemical (e.g. detergent) stresses, leading to the detachment of microfibers from fabrics (made up of polyester, polyester-cotton blend, cotton, rayon, and acrylic fabrics, among others) during the washing process in laundry machines (Napper and Thompson, 2016). Further, the short staple fibers are easily broken and released from the fabric, contributing majorly to microfiber contamination. A quick review of the academic literature reveals a number of studies that indicate that laundering clothing is a significant point source for emissions of microplastics (Napper and Thompson, 2016; Almroth et al., 2018; Belzagui et al., 2019; De Falco et al., 2019; Zambrano et al., 2019; O'Brien et al., 2020). The emission values of microfibers are influenced by mode of laundering (i.e. machine or hand), type of detergent and conditioner used, temperature conditions, and type of clothing being laundered (Hartline et al., 2016; Napper and Thompson, 2016; Zambrano et al., 2019). The size of majority of microfibers released from laundering ranged from <6 μm to >2 mm. Boucher and Friot (2017) estimated that synthetic clothes, the main source of primary

Fig. 1. Reusable face masks sold in street markets and shops. a) Kim Yong market in Hadyai district in Thailand's southern of Songkhla province; Photo credit: The Straits Times, b) Johor Baru, Malaysia; Photo credit: Venesa Devi, Metro News, c) Gurney Plaza, Penang; Photo credit: N. Trisha, Nation, and d) Salt Lake City, Utah; Photo credit: Kristin Murphy, Desert News.

microplastics, contribute about 35% of the global release of primary microplastics to the earth's oceans. As textiles have become an important source of microplastics, arguably, it is important to consider including reusable masks in microplastic research to address questions concerning its contribution to microfiber generation during machine- and hand-laundering.

Assuming that reusable masks do undergo similar effects as other clothing during washing, emissions of a variety of natural (e.g. cellulose) and synthetic (e.g. polyester, nylon, rayon) fibers are expected, depending on the cloth characteristics (Fig. 2). After laundering, they are discharged into wastewater and enter the environment through wastewater effluent, atmospheric deposition, or through contaminated sludge, finally making their way into oceans and human food chain (Yang et al., 2019; Henry et al., 2019; O'Brien et al., 2020). Natural and synthetic fibers appear to be ubiquitous in the world's oceans, with variation in abundance and composition among ocean basins (Suaria et al., 2020). Among these fibers, cotton microfibers are considered biodegradable, but little is known about their degradation in marine environments (Henry et al., 2019). It is important to highlight that cellulose fibers are mostly man-made and are extruded and processed industrially. Importantly, cellulose-based fabrics have shown to shed more microfibers than laundering polyester; however, differences may occur based on fabric constructions and washing conditions (Zambrano et al., 2019). Moreover, microfibers comprised of rubber, polypropylene, and nylon are not easily biodegradable. Over time, these non-biodegradable microfibers break down to generate smaller tiny plastic particles in the environment (GESAMP, 2015; Koelmans and Pahl, 2019). The negative impacts of microfibers on aquatic organisms have been well-studied and well-documented in recent reviews (Avio et al., 2020; Kutralam-Muniasamy et al., 2020). Further, textile microfibers have a number of chemicals, added at the manufacturing stage, including, resins, softeners, dyes, and flame retardants, and it is possible that they can become coated in organic micropollutants and heavy metals during their persistence in the environment. Once released in the body, they will be hazardous for marine life (Carbery et al., 2018; Fred-Ahmadu et al., 2020).

Another important research question is regarding the number of microfibers released from reusable masks. For example, De Falco et al. (2019) reported that the quantity of microfibers released during washing differs with the type of garment being washed, ranging from 124 to 308 mg for each kilogram of fabric washed, which corresponds to microfibers ranging between 640,000 and 1,500,000 units. Owing to the lack of evidence, there is an immense knowledge gap regarding the emissions of microfibers from reusable masks during each wash, and it is now essential to start investigations addressing these issues. The estimation is particularly important since millions of reusable masks are being/already sold, washed every day by public around the globe. From an experimental design, machine- and hand-laundering of 1 kg of reusable masks (each mask weighs ~20–50 g) is a good starting point to quantify the mass of microfibers generated and to understand their characteristics (i.e. size and polymer).

Beyond this, even the reusable masks have a limited time of use. Some can be used efficiently until 25 washes and others until 50 (ww.citeve.pt). Therefore, what happens with these masks after use is a concern that is overlooked in recent literature. Alarmingly, from what has been observed in the COVID-19 pandemic, it is not inevitable that these masks will end up either in nature or in domestic waste. In case of non-certified reusable masks, there are currently no recommendations agreed upon regarding the lifetime/number of cycles of using a reusable mask, misleading the public to consume more and often. Thereby, the increased usage and regular washing will ultimately weaken the fabric and consequently result in the disposal of reusable masks and their

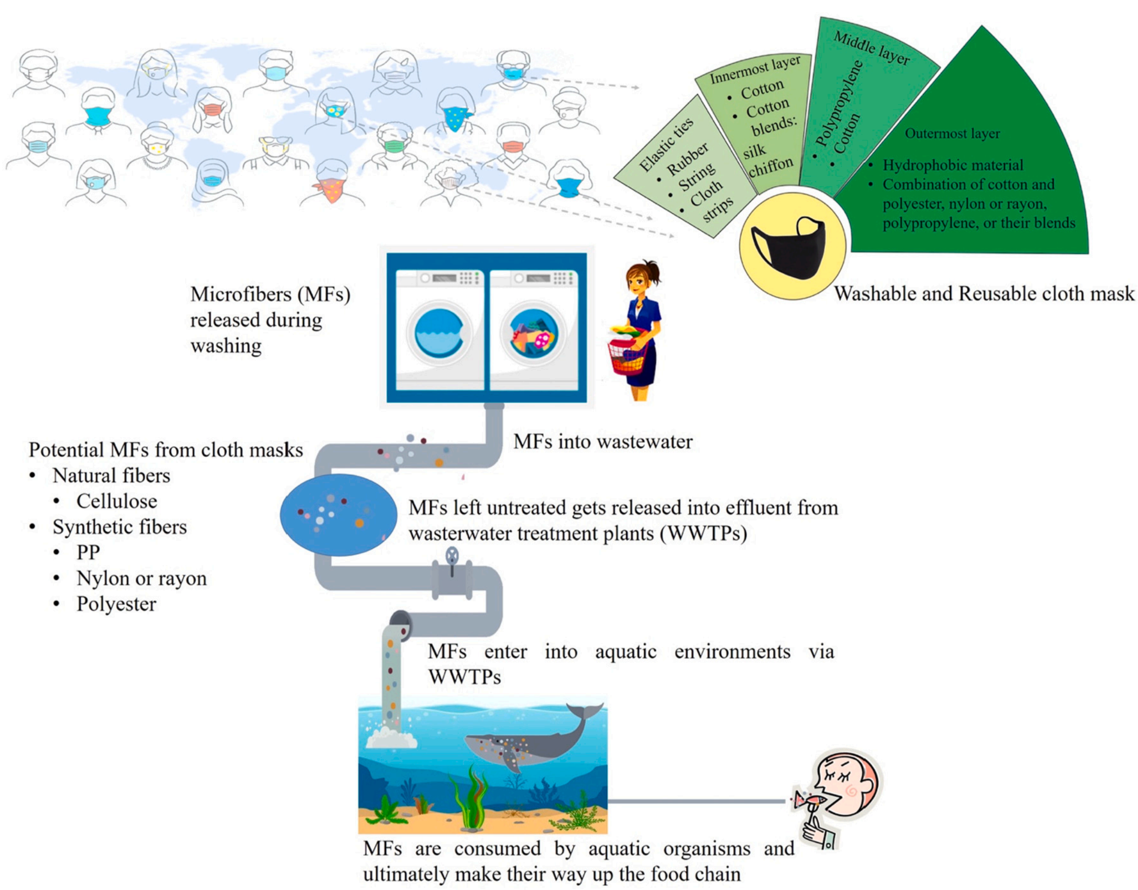

Fig. 2. Potential release, transfer, and fate of microfibers from reusable face masks.

accumulation in the environment. This further emphasizes the necessity of conducting investigations on reusable masks to understand their contribution of microfibers during machine- and hand-laundering throughout their life cycle. On the other hand, it is expected that the related authorities might take action and advise the public on the best usage conditions of uncertified reusable masks with respect to these terms in the near future.

It should also be taken into account that marine plastic litter also originates from fishing, recreational activities like tourism, aquaculture and/or directly discharged from ships (Galgani et al., 2019). This pandemic has caused the shipping and maritime industry to shut down for the safety and prevention of the escalation of COVID-19. During April 2020, nearly 44.3% of the global ocean and 77.5% of 22 national jurisdictions showed a decrease in marine traffic density (March et al., 2020). Furthermore, activities related to tourism, fishing and aquaculture came to a standstill during this pandemic (FAO, 2020). From the environmental point of view, the impact of reduction in these activities is broad and even with the following gradual recovery of maritime activities, we may expect a large decrease in litter generation. Yet, it is not possible to estimate the extent of the impact of COVID-19 as there is no robust data on hand for the analysis of trends in marine litter contamination because of the temporary closure of field campaigns in many countries. While there is a lot we do not yet know, we do know that, a large increase in mask production and usage is equally worrisome as they are already showing up in water bodies along various beaches and coastlines around the world. While we wait for the data, however, we presume that the poor PPE disposal may continue to rise and end up contributing to marine litter.

In conclusion, we emphasize the immediate need for understanding the degree of risk and potential significance of the environmental impact of reusable face masks to fill the knowledge gap during the global health crisis. Moreover, we believe that this open discussion would trigger some productive conversations among researchers and will hopefully accelerate multidisciplinary research to promote scientific development and management of this source of microplastic pollution. With face masks becoming a normalized requirement due to the COVID-19 pandemic, there is a chance of increasing environmental microplastic concentrations and thus a higher chance of interaction, ingestion, and hazardous effects across food webs. Therefore, the calls for further research and rapid development in this area are of urgent importance as the use of reusable masks continues to increase among the general public and will continue to do so for an extended period of time in the future.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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V.C. Shruti[a], Fermín Pérez-Guevara[b,c], I. Elizalde-Martínez[a], Gurusamy Kutralam-Muniasamy[b,*]

[a] *Centro Mexicano para la Producción más Limpia (CMP+L), Instituto Politécnico Nacional (IPN), Av. Acueducto s/n, Col. Barrio la Laguna Ticomán, Del Gustavo A. Madero, C.P. 07340, México City, Mexico*

[b] *Department of Biotechnology and Bioengineering, Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional, Ciudad de México, Mexico*

[c] *Nanoscience & Nanotechnology Program, Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional, Ciudad de México, Mexico*

[*] Corresponding author.
E-mail address: mgurusamy@cinvestav.mx (G. Kutralam-Muniasamy).