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REVIEW ARTICLE

Prevalence of Covid-19 personal protective equipment in aquatic systems and impact on associated fauna

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Abstract

The use and undesignated disposal of COVID-19 related personal protective equipments (PPEs) has resulted in a spike in the global mismanagement of plastic waste. Moreover, the SARS-CoV-2 pandemic has not only affected the socio-economic state of the world but is contributing significantly to the already existing aquatic pollution dilemma. Consequently, PPE litter is an emerging pollutant in aquatic ecosystems that warrants significant attention. This review endeavoured to present a synopsis of the global mismanagement of PPE waste and highlight the devastating ramifications of the ensuing environment. The paper reveals that PPE litter is indeed negatively impacting environmental systems on varying levels around the globe. Furthermore, peak plastic loads are transported by Asian rivers and are deposited into the Pacific and Indian Oceans. Beaches and seabed are the major sinks of COVID-19 PPE litter making benthic organisms to be the most vulnerable. More studies need to be undertaken to monitor aquatic resources to get a detailed overview of COVID-19 PPE litter in the environment.

Keywords Covid-19 · Personal protective equipment · Microplastics · Aquatic systems

1 Introduction

Global microplastic (MP) litter in aquatic resources is still a persistent and reoccurring quandary exacerbated by mismanagement of plastic waste and adherence to the existing ordinance. Consequently, this has resulted in detrimental impacts on the environment and aquatic species. Plastics are generally categorized into four size classes, which are: macroplastics are greater than 25 mm (European Commission 2013); meso are 5 to 25 mm (Kershaw et al. 2019); micro are less than 5 mm (Hidalgo-Ruz et al. 2012); and nano are those that are less than 1 µm (Gigault et al. 2018). Primary MPs are explicitly produced in microscopic size; for example, microbeads and secondary MPs result from the degradation of larger plastics (Besseling et al. 2019). Subsequently, once plastics are broken down into smaller particles may be transported to other parts of the environment and be ingested by aquatic organisms. Researchers worldwide have documented the detrimental impacts of MPs in aquatic ecosystems (Browne et al. 2007; Wang et al. 2017; Sparks and Immelman 2020).

The outbreak of Covid-19 has culminated in excess procurement of personal protective equipments (PPEs) which can be defined as products that can be worn or used to curb the spread of the SARS-CoV-2 virus. These include disposable gloves such as vinyl, nitrile, folic and latex gloves (Jędruchniewicz et al. 2021), single-use (i.e. N95, surgical & KN95) and reusable facemasks (i.e. 1-ply & 2-ply cloths), face shields, wipes, aprons and hand sanitizers. The increase in the purchase of PPEs has led to high quantities of waste generation and has put pressure on existing waste management facilities and programmes. Over 200 million deposable masks were estimated to be produced daily in China amid the pandemic (Aragaw 2020). Furthermore, approximately 65 billion surgical gloves and 120 billion protective masks were used monthly worldwide (Prata et al. 2020) in the year 2020. Thus, mismanagement of such PPEs may lead to considerable waste ending up in undesignated areas such as city centres, rivers and beaches. Thus, it can be argued that the use of PPEs amid COVID-19 has indirectly augmented the global plastic waste crisis in the environment.

Services such as food deliveries and groceries have also increased the use of plastic packaging amid the SARS-CoV-2

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pandemic and thus more plastic waste has been generated (Vanapalli et al. 2020). There have been several incidences of COVID-19 PPEs in aquatic environments and it was projected to escalate exponentially as the months and years go by (De-la-Torre and Aragaw 2021). Consequently, PPE litter in aquatic environments is identified as an emerging form of plastic litter and an addition to the existing MPs crisis. PPEs like MPs are envisaged to cause hazardous ramifications in aquatic ecosystems and, even worse, may act as vectors of the COVID-19 virus contaminating humans and aquatic life. Evidence has shown that single-use masks disintegrate over time due to mechanical weathering and ageing and release microfibres into terrestrial and aquatic environments (Fadare and Okoffo 2020). Accordingly, De-la-Torre and Aragaw (2021) have asserted that COVID-19 PPEs are emerging sources of secondary MPs in aquatic environments.

A study by Kutralam-Muniasamy et al. (2022) has endeavoured to review literature on the occurrence of PPE litter in different environmental media and the discharge of micro- and nano-plastics in aquatic environments. However, most of the studies that are available in literature are laboratory based studies which are different from the in situ release of MPs (Pizarro-Orteg et al. 2022). There is still a paucity of information on the spatial connection and deposition of PPE litter in oceans. Accordingly, the study has attempted to recapitulate information on the spatial connection and routes of deposition of PPE litter and discuss documented detrimental impacts on aquatic organisms.

2 Sources of COVID-19 related litter in aquatic environments

The disposal of COVID-19 PPEs has recently become an emerging environmental topic as such wastes are polluting numerous aquatic systems around the globe (Ardusso et al. 2021; Ammendolia et al. 2021; Okuku et al. 2021). Like conventional MPs debris found in aquatic environments, COVID-19 waste is mainly derived from terrestrial sources. Numerous studies have documented scattered COVID-19 litter in city centres, roads and parks in USA, China, Morocco and Nigeria (Mukhopadhyay 2020; Winters 2020; Ouhsine et al. 2020; Fadare and Okoffo 2020). Subsequently, such litter may then be potentially transported into aquatic environments through atmospheric deposition and torrential rainfall. Infirmaries in developed countries usually have designated areas for the disposal of COVID-19 related waste, and thus wastes from such facilities rarely enter the environment as compared to developing nations (Zhang et al. 2020). Contrary, waste produced by the broader public is usually left unaccounted for in public areas and remobilized into the environment. Mobilization of plastic related wastes may potentially be exacerbated by the lack of public awareness of the detrimental impacts such wastes have on the environment. Figure 1 illustrates the sources and transport of COVID-19 litter in the environment.

The lack of availability of disposable facilities such as trash cans in public areas (i.e. city centres & beaches) could also be contributing extensively to PPE litter concentrations (Chowdhury et al. 2021). In addition, waste disposal sites are inundated with COVID-19 related waste and thus many are already filled to capacity. Subsequently, the lack of availability of adequate waste disposal sites has facilitated for PPE litter being redistributed into the environment through atmospheric deposition. The situation may get out of hand in developing countries as there is already lack of enforcement of waste regulations. According to World Wildlife Fund (2020), mismanagement of 1 percent of single-use face masks could result in an estimated daily waste of 30,000 to 40,000 kg. Consequently, a large portion of these PPEs can potentially end up in aquatic ecosystems causing severe harm to biota (Bellasi et al. 2021).

3 Spatial connection and deposition of Covid-19 litter in oceans

The mismanagement of Covid-19 litter has resulted in augmented amounts of waste being discharged into aquatic ecosystems and a considerable portion of such wastes is widely distributed in global oceans and beaches (Ammendolia et al. 2021; Okuku et al. 2021). Peng et al. (2021) estimated that a total of 25 900 tons of COVID-19 related litter were discharged into global oceans of which 1968.4 tons were PPEs (i.e. facemasks) alone. The study attributed the elevated COVID-19 related litter in the 369 studied rivers to population dynamics near river mouths. Mismanaged plastic wastes accumulated downstream of rivers and coasts have greater probability of being washed into oceans (Meijer et al. 2021). To date, rivers situated on the Asian continent have discharged the highest amounts of COVID-19 wastes in seas and oceans as illustrated in Fig. 2. COVID-19 plastic waste discharges from South America will inevitable find their way into Southern Oceans whilst those from Europe and North America will accumulate in the Arctic Ocean (Wu et al. 2021). The North Pacific and Indian Oceans will be the hardest hit by the unabated COVID-19 litter discharges as the model by Peng et al. (2021) estimated that plastic garbage patches will be formed in the northeast Pacific and southeast Indian Oceans in the year 2100. Accordingly, the discharge of COVID-19 wastes such as facemasks could be linked to their composition as they are composed entirely of polypropylene (PP) and polyethylene (PE) which have low densities and can be transported along greater displacements.

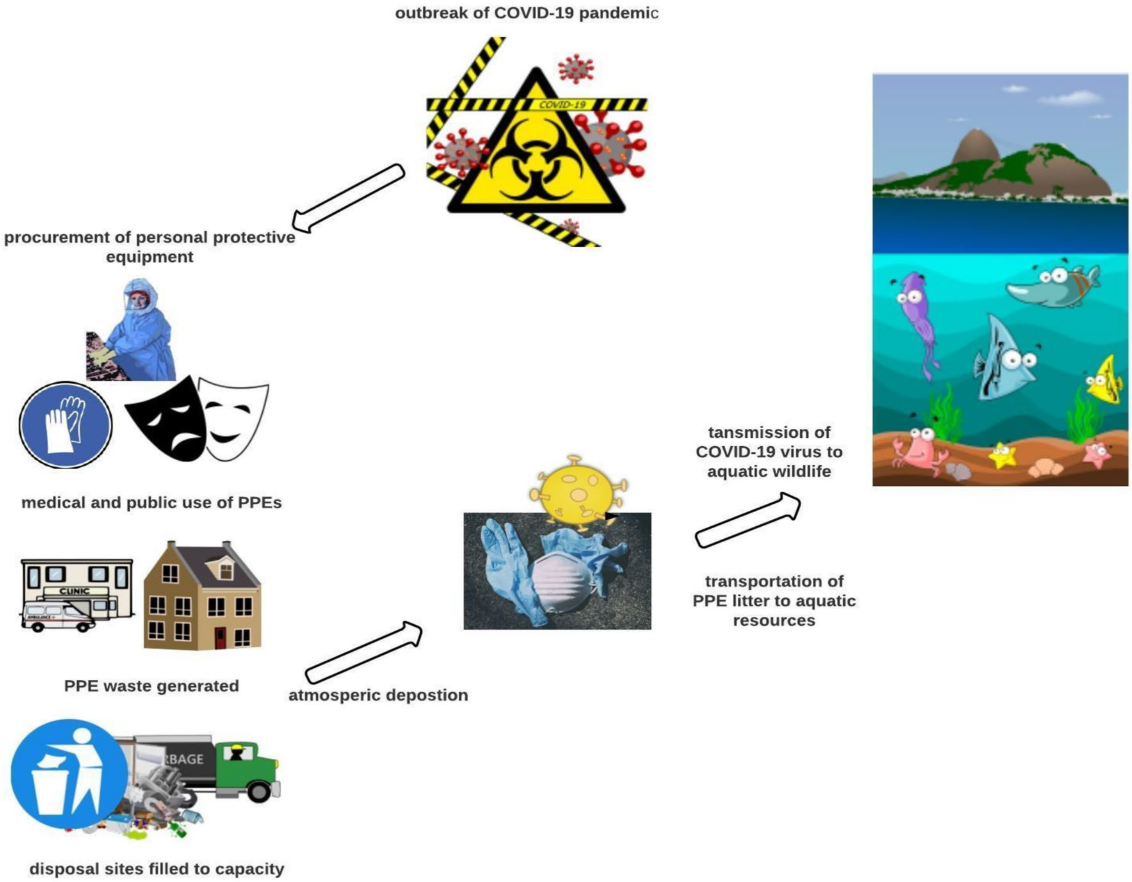

Fig. 1 Sources and transport of COVID-19 litter in the environment

Chowdhury et al. (2021) revealed that nations with elevated populations near coastal areas with high levels of mismanaged wastes released more wastes into oceans as shown in Table 1. PPE litter discharge into oceans decreased in the sequence of Asia > Europe > North America > South America which was attributed to the high acceptance of facemasks by the general public in the different continents (Peng et al. 2021; Benson et al. 2021). The easing of lockdown restrictions by numerous countries allowed more people to use recreational spaces such as rivers and beaches provided they used facemasks and other PPEs (Canning-Clode et al. 2020). Consequently, this could have possibly aggravated COVID-19 PPE litter accumulations on beaches and oceans around the world. For example, the incidence of illegal wild camps has been reported to increase plastic waste accumulations on beaches (Oceanographic n.d). Latin American and Caribbean coasts are renowned tourist destinations and already facemasks as well as other COVID-19 litter have been documented on beaches in Chile, Argentina and Peru (Thiel et al. 2021; Ardusso et al. 2021; De-la-Torre et al. 2021). Subsequently, COVID-19 PPEs on these beaches and other LAC coastal environments will inevitably escalate exponentially as the years go by (Alfonso et al. 2021). Similarly, Hassan et al. (2022) recorded higher amounts of COVID-19 litter in Egyptian and Saudi Arabian coastlines during weekends and attributed it to the tourism industry and fisheries.

Previous studies have revealed that land based sources are dominant factors contributing to plastic pollution in oceans (Benson et al. 2021) and that rivers are the chief transporters (Mvovo 2021). Moreover, it is estimated that 80% of plastic wastes in oceans around the world are the result of land based inputs whilst 20% are linked to maritime activities (Li et al. 2016). Peng et al.'s (2021) river discharge model has recently showed that considerable amount of COVID-19 wastes is transported by rivers to oceans and is redistributed in lower latitudes of rivers within a period of three years. Currently, Asian rivers have the highest COVID-19 litter transport loads (Peng et al. 2021) and the transportation of COVID-19 waste in these rivers is influenced by their high water runoffs and velocities (Schmidt et al. 2017). A model on the deposition of COVID-19 related litter revealed that beaches are the major sinks of such wastes followed by seabed-and-water, respectively. Peng et al. (2021) further states that sedimentation and beaching of COVID-19 litter is mostly confined to river mouths and is evidence that the distribution of such wastes is limited to coastal locations.

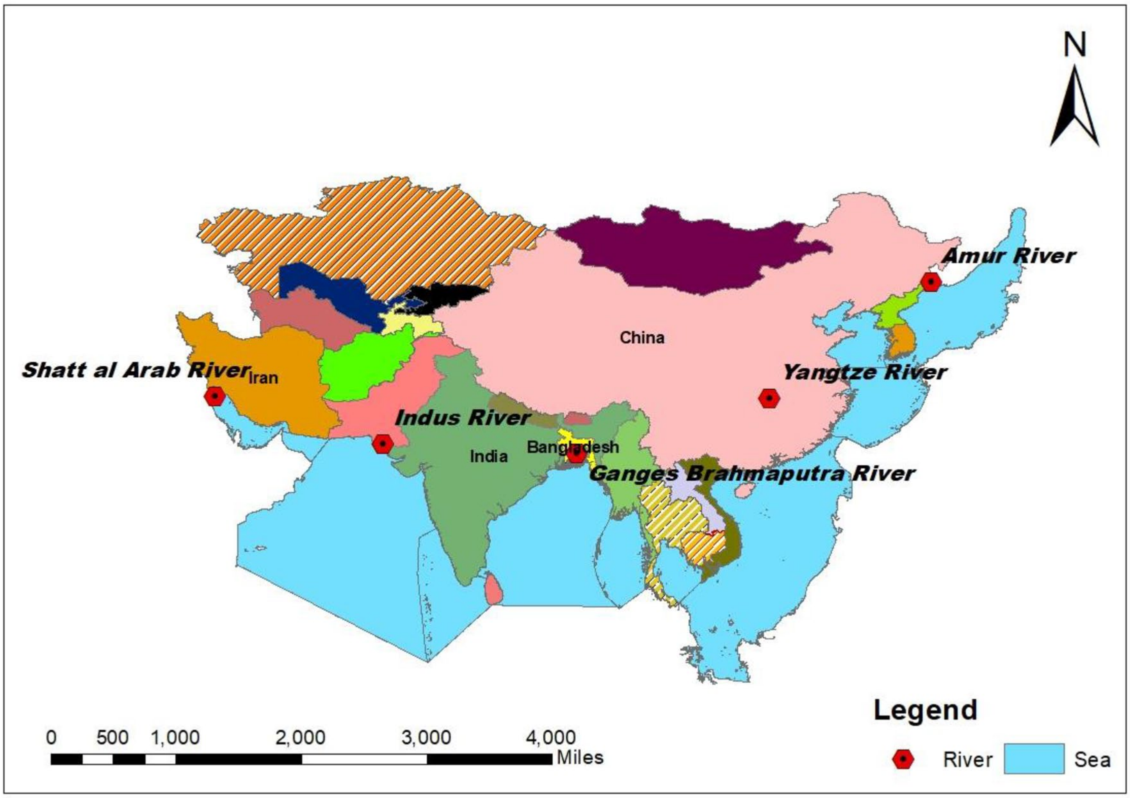

Fig. 2 Rivers that have discharged the highest COVID-19 wastes on beaches and the sea (source: Peng et al. 2021)

Table 1 Estimated facemasks entering oceans annually amid the COVID-19 pandemic

Country	Facemask acceptance (%)[a]	Facemasks discarded (daily)[b]	Mismanaged wastes (ton)[c]	Wastes entering Oceans (ton)[c]
Indonesia	80	122 538 579	250 371.39	100 148.553
India	80	386 401 228	128 007.22	51 202.88
Vietnam	90	–	83 140.58	33 256.23
Philippines	80	–	153 824.65	1529.86
Chile	85	–	3551.32	1420.52
Brazil	75	140 289 215	13 589.92	5435.96
Argentina	75	31 524 052	4044.14	1617.66
Mexico	75	81 227 634	4448.51	1779.41
Iran	80	51 067 713	4827.27	1930.91
United Arab Emirates	85	–	8442.30	3377.69
Saudi Arabia	80	23 394 921	110.52	44.21
Russia	80	86 393 201	25 651.47	10 260.58
Italy	80	33 374 928	9585.86	3834.34
Turkey	80	51 278 153	22 812.72	9125.08
Nigeria	70	75 034 810	21 519.67	8607.86

[a]Available at: https://www.worldometers.info/population/

[b]Benson et al. (2021)

[c]Chowdhury et al. (2021)

Likewise, Wu et al.'s (2021) plastic model also showed that plastics entering the ocean are predominately deposited in beaches and benthic sediments which in turn pose detrimental impacts on benthic organism that thrive in the sediments. The different densities of PPE plastic wastes results in transportation by water currents, whereas some may be deposited onto beaches or seabed (De-la-Torre and Aragaw 2021). For instance, PVC and HDPE have higher densities than water, and thus PPEs such as gloves and inner layers of single-use facemasks can be buried in aquatic sediments.

4 Weathering of Covid-19 PPEs and contribution to microplastics

A myriad of PPE items used by healthcare workers and the general public are indiscriminately disposed off daily. Similar to a majority of plastic waste, PPEs are composed of diverse artificial persistent polymer types (Fadare and Okoffo 2020). For example, single-use masks are made of synthetic material consisting mainly of PP and PE (Fadare et al. 2020; Silva et al. 2021) and gloves are comprised mainly of nitrile rubber, low density polyethylene (LDPE), PVC and latex (Nowakowski et al. 2020). All these polymers found in PPEs are highly persistent, and take a long time to breakdown and thus have potential to cause severe environmental complications. Aragaw (2020) showed that the outer layers of single-use facemasks retrieved from a lake in Ethiopia were made of PP and the inner layers were composed of HDPE. In addition, 4.5 and 9 g of PP are contained in surgical and single-use N95 masks, respectively (Akber Abbasi et al. 2020). The majority of surgical masks consist of three layers (i.e. inner, middle & outer) and are made of soft fibres, melt gusted filter and non-woven fibres (Fadare and Okoffo 2020). The transportation and deposition of PPEs in aquatic ecosystems is not yet well documented but like MPs may be subjected to various environmental weathering processes and sediments may as well be sinks of such wastes. Accordingly, these Covid-19 related wastes can be potentially broken down into particles smaller than 5 mm and thus become MPs (Zambrano-Monserrate et al. 2020).

Hao et al. (2022) used N95, surgical and normal masks to estimate the release rate of MPs and found them to decrease in the order of 2667 < 2547 < 2343 particles. Moreover, they found that the release kinetics of masks did not differ with type of mask and that MPs of sizes between 0.1 and 0.5 mm were released in larger quantities. Rathinamoorthy and Balasaraswathi et al. (2022) revealed that dry (i.e. handling, wearing & disposal) and wet (i.e. immersion in seawater & freshwater) states influenced the release of fibres by facemask and that seawater (27,348.9 fibres $mask^{-1}$) resulted in a greater release of microfibres than freshwater (17,702.86 fibres $mask^{-1}$). Moreover, the difference release rate of fibres was attributed to the higher salinity and density of seawater compared to freshwater. Numerous PPE contain polypropylene which is a plastic polymer that releases numerous amounts of microfibres when it has undergone environmental degradation. Morgana et al. (2021) exposed virgin surgical facemasks to a kitchen chopper in aqueous solution for 2 min and found them to release 28,000 MP per mask. The alteration of mechanical properties of plastics results in their fragmentation in natural environments and is determined by their chemical composition (Pizarro-Ortega et al., 2022).

The degradation of plastics is known to be aggravated by UV radiation mechanical weathering through suspension of water (Lambert et al. 2014; Liu et al. 2016). Free radical chain reactions results in photo-oxidation which is the main phenomenon responsible for the weathering of masks in aquatic systems (Cai et al. 2018). UV radiation causes C–C and C-H bonds that make up polyolefin (i.e. polyethylene & polypropylene) to break up and thus form new functional groups. Like regular plastics, facemasks exposed to UV radiation will result in the formation of hydroxyl and carbonyl groups (Pizarro-Orteg et al. 2022) and the chain scission of polyolefin will result in the formation of oxygen containing and ketone functional groups (Resmeriță et al. 2018). Moreover, Gewert et al. (2018) revealed that dicarboxylic acids (i.e. $C_xH_{2x-2}O$) are formed when PE and PP are exposed to UV radiation. The middle layers of masks are more susceptible to UV weathering in comparison to the inner and outer layers (Wang et al. 2021). Furthermore, Wang et al. (2021) revealed that the longer the exposure to UV radiation the greater the number of microfibres released. The degrading of gloves is thought to be consistent with other plastic types whilst evidence has shown single-use masks have the potential to breakdown more rapidly when exposed to mechanical forces (Aragaw et al. 2020). Accordingly, this could be attributed to the fibrous composition of the makeup of most surgical masks. Shen et al. (2021) showed that 116,600 microfibres were generated after a single-use facemask is washed on three consecutive occasions in water. The study further revealed that masks are likely to release more microfibres when broken down into smaller pieces and ageing plays a decisive role in releasing microfibres by the masks.

5 Occurrence of COVID-19 PPEs in aquatic environments

Recent reports estimated 1.56 billion facemasks may have potentially entered oceans in the year 2020 (Oceans Asia 2020). Numerous studies around the globe have documented the presence of PPEs in aquatic environments and some of the studies are presented in Table 2. Sarkodie et al. (2020) is one of the first reports on the occurrence of PPEs in water

Table 2 COVID-19 related litter in aquatic environments around the world

Region	Environment	PPE type	Abundance/Density	References
Bushehr, Persian Gulf	Beach	Facemasks, gloves	2382 PPE items	Akhbarizadeh et al. (2021)
Santa Martha, Colombia	Beach	Facemask	NR	Ardusso et al. (2021)
Buenos Aires, Argentina	Beach	Facemasks, gloves, face shields	NR	Ardusso et al. (2021)
Cox's Bazar, Bangladesh	Beach	Facemasks, gloves	29,254 PPE items	Rakib et al. (2021)
Santiago de Chile, Chile	Beach	Facemasks, wet wipes	NR	Ardusso et al. (2021)
Mediterranean Sea, Egypt	Beach	Gloves, facemasks	2.93 PPE items m^{-2}, 0.29 PPE items m^{-2}	Hassan et al. (2022)
Kenya	Beach	NR	0 to 5.6×10^{-2} items m^{-2}	Okuku et al. (2021)
Mediterranean	Seafloor	NR	NR	Genries (2020)
Quindío, Colombia	River	Facemasks	NR	Ardusso et al. (2021)
Lima, Peru	Beach	Facemasks, face shields, gloves	0 to 7.44×10^{-4} PPE m^{-2}	De-la-Torre et al. (2021)
Morocco	Beach	Facemasks	1.13×10^{-5} PPE m^{-2}	Haddad et al. (2021)
Jakarta Bay, Indonesia	River	PPE	NR	Cordova et al. (2021)
Chile	Beach	NR	6.00×10^{-3} items m^{-2}	Thiel et al. (2021)
Red Sea, Saudi Arabia	Beach	Gloves, facemasks	0.86 PPE items m^{-2}	Hasan et al. (2022)
Peru and Argentina	Coasts	Peru: facemasks, face shields, gloves; Argentina: facemasks, face shields	Peru:462 PPE items; 6.60×10^{-4} PPE m^{-2}, Argentina: 43 PPE items; 7.21×10^{-4} PPE m^{-2}	De-la-Torre et al. (2022)
Ethiopia	Lake	Facemasks	221 PPEs with density of 1.22×10^{-5} PPE m^{-2} to 2.88×10^{-4} PPE m^{-2}	Aragaw et al. (2022)
Moroccan Mediterranean	Beach	Facemasks	321 facemasks with density of 0.0012 m^{-2}	Mghili et al. (2022)
Caspian Sea	Sea	Facemasks (95.3%)	1.02×10^{-4} PPE m^{-2}	Hatami et al. (2022)

NR not reported

systems. Polyamide (PA) and PP were the dominant polymer types of PPEs collected along a coast in Qatar by Veerasingam et al. (2020). Surprisingly, 70 disposal facemasks were retrieved on beaches of desolate islands of Soko in China (Kassam 2020). Accordingly, it can be argued that the composition of COVID-19 waste in beaches is the result of transport loads from terrestrial sources such as streets, parks, inland rivers and tributaries. Cordova et al. (2021) in Indonesia recorded PPE litter in Marinda and Cilincing Rivers, with facemasks being the most abundant type. Though facemasks and gloves are the most abundant types of COVID-19 related litter found in aquatic environments, Konyn (2020) encountered hand sanitizer bottles in a Mediterranean Ocean. Consequently, these types of litter found in aquatic resources can disrupt ecosystem food chains and thus have negative impacts on aquatic wildlife.

The outbreak of COVID-19 has resulted in exorbitant pressure on waste management facilities. This culminates from excessive procurement of PPEs for medical and household use. Consequently, this is has led to many of these waste products being mismanaged and illegally disposed of in undesignated sites. Moreover, COVID-19 related wastes will inevitably find their way into aquatic environments and thus augment the existing plastic pollution in such environments. Mismanagement of plastic waste was already prevalent in many developing countries preceding the outbreak of the COVID-19 pandemic and is exacerbated by PPE wastes. There are very few available PPE disposal facilities for people who live in slums and thus most of their wastes end up in illegal dumping sites. Furthermore, many informal settlements are situated along flood plains and consequently, PPE wastes may be directly dumped in water bodies. The regulation of medical waste differs in many countries as some may opt to incinerate whereas others dispose in designated landfill sites. Subsequently, wastes that are deposited in landfills may be displaced to other areas such aquatic ecosystems through atmospheric deposition and by illegal waste collectors. The management of COVID-19 related waste is dictated by the economic status of the country as proficient management of such wastes requires certain technologies that are not readily available in developing countries (Zhang et al. 2020; Chowdhury et al. 2021).

Developed nations like the USA have treated COVID-19 related waste the same as regular medical waste and followed the same disposal methods already in place as recommended by the World Health Organization. Contrary, developing countries like the Philippines have specially designated areas for COVID-19 related waste such as Luzon Island (Das et al. 2021). Oyedotun et al. (2020) revealed that households in Nigeria and Guyana admitted that they disposed their PPE wastes in streets and rivers. Therefore, it can be argued that some PPE related litter found in aquatic environments can be linked to household PPE generated wastes that are mismanaged. Consequently, these wastes can be transported to other aquatic resources and thus end up in estuaries and oceans. Prior to the COVID-19 global pandemic, many citizens engaged in plastic waste beach and river cleanup programmes. Subsequently, many people who engaged in such initiatives are becoming more reluctant to pick up litter, more especially PPEs for the fear of contamination with SARS-CoV-2 virus, which has increased. More initiatives should be made by officials to enforce separation of PPE related wastes from conventional household wastes by residents. Furthermore, PPE collection vehicles should be dispensed to collect these wastes from households every other day to ensure correct disposal of such wastes. This may play a significant part in curbing the spread of the SARS-CoV-2 virus and alleviating of plastic pollution in the environment.

6 Impact of COVID-19 waste on aquatic organisms

The occurrence of MPs in aquatic ecosystems is known to cause serious harm to organisms as well as humans, as they have the potential to move up the trophic levels. Their non-biodegradable nature exacerbates the potential contamination of the food chain. PPEs like plastics can potentially harm aquatic organisms in their unaltered state, and even in their degraded state. Though the phenomenon of COVID-19 waste in aquatic environments is fairly novel, there have been several reports on negative impacts of this kind of litter on aquatic organism where some have been fatal. Neto et al. (2021) in Juquehy Beach, Brazil revealed that a Magellanic Penguin was found dead and upon a necropsy analysis, it was evident that the penguin had consumed a full protective face-mask. This study was the first to report on the fatality of an aquatic organism with a direct link to ingestion of COVID-19 PPE litter (Neto et al. 2021). PPE litter such as gloves and masks could entangle, trap or be ingested by organisms and thus hindering their performance in their natural environment (Kuhn and van Franeker 2020; De-la-Torre et al. 2021).

Subsequently, PPEs can potentially have short and long-term impacts on aquatic organisms. Organisms may be entangled by straps of masks thus drown in water (Hiemstra et al. 2021). When PPEs are exposed to environmental mechanical forces, they become smaller and thus can be easily ingested by aquatic organisms. Moreover, ingestion of PPE litter by organisms may result in sickness and disruption of metabolic activities. Hiemstra et al. (2021) reported on a freshwater fish species (*Perca fluviatilis*) that was trapped in a latex glove in Leiden, Netherlands. Subsequently, they reported that it was the first fatality to be recorded on a fresh water species resulting from the occurrence of COVID-19 related litter. This is alarming as they may be numerous similar incidences that have occurred but have not been accounted for yet. Accordingly, this generates evidence that PPE litter in aquatic environments is indeed having detrimental impacts on biodiversity.

Furthermore, two crabs (*Carcinus maenas*) were found in a lake deadly entangled in latex gloves by Opération Mer Propre (2020) in France. The entanglement of organisms by PPE litter may result in limited propagation and thus deny access to other food resources which may result in the starvation and improper functioning of the organism. PPE litter is made of different colours making them easily consumable once they have become MPs. The different colours of sanitizer bottle lids could also result in the ingestion of such wastes by aquatic wildlife since colour is a dominant factor that determines the ingestion of MPs by organisms (Santos et al. 2016). COVID-19 related wastes could serve as vectors of hazardous chemicals into aquatic resources as they can potentially interact with heavy metals and organic compounds. Subsequently, this could be deleterious to aquatic species through the disruption of metabolic activities. Furthermore, PPEs could result in the spreading of diseases through bio-film accumulation. The mismanagement of COVID-19 PPE litter may also lead to the transmission of SARS-CoV-2 to aquatic organisms as the virus is said to remain active for 3 days on plastic materials (De-la-Torre et al. 2021).

7 Conclusion and recommendations

The SARS-CoV-2 pandemic has not only affected socio-economic state of the world, but is contributing significantly to the already existing aquatic pollution dilemma. Conversely, there is still a paucity of information on the impacts of these emerging pollutants in aquatic ecosystems. However, the available evidence has revealed that COVID-19 PPE litter is escalating MP pollution in water bodies and that the situation is aggravated by the mismanagement of these wastes. Moreover, the presence of plastic waste in natural environments is catastrophic to aquatic dwelling organisms. Thus, it is paramount that environmental authorities take account of the insurgence of these litters in the environment and implement stringent regulations to mitigate the PPE litter quandary. Elaborate awareness programmes through the use of established media to make the public aware of the current crisis. Relevant medical and environmental bodies should consider using more eco-friendly material when producing PPEs. It is further suggested that more studies be undertaken to monitor the impact of PPE contamination of aquatic resources to generate adequate information on COVID-19 PPE litter in the environment.

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Declarations

Conflict of interest The authors have no conflict to declare or disclose.

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