COVID-19, Personal Protective Equipment and Environmental Health

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Abstract

Personal protective equipment (PPE) is extensively used to protect against aerosols from one person to another during this COVID-19 pandemic. The production of PPE has increased ten folds since January 2020 till date when compared to the last three years. Most of the PPE are polythene based and are disposed of carelessly in developing countries like India, as shown in recent reports. As of today, we do not have information on the impact of PPE per se. Also, most of the PPE is plastic-based, and their impact will be the same as other plastic-based products. In this review, we look at the impact of plastic in general on the environment and suggest the way forward in managing plastics in general and PPE in particular.

Keywords: Biodiversity, Wildlife, Aquatic Ecosystems, Freshwater, Microplastics, Management, Policy implications

1. INTRODUCTION

The ongoing pandemic SARS Covid-19 is an unprecedented global health problem. Believed to have been originated in China possibly from wildlife trade, now has become a pandemic infecting more than 7.15 million people and 408,00 mortalities globally as on today (12 June 2020) as per the World Health Organisation (https://covid19.who.int/). COVID-19 is very contagious, and it is known to transmit by the aerosols produced during the cough or sneeze of the COVID infected patients. Personal Protective Equipment (PPE) was suggested as a protection to avoid the direct and indirect spread of the infection. Generally, PPE is classified as eye and face protection, hand protection, body protection, respiratory protection and hearing protection.

In the recent health crisis, the most commonly used PPE includes goggles, face-shield, face mask, gloves, coverall/gowns (with or without aprons), head cover and shoe cover. These PPE protects humans in their day-to-day work. We should also need to understand the impact on environmental of the production, manufacture and disposal of these items[1-2]. Currently, importance is given on the control of this contagious disease; less or no attention is given on the impact of the PPE on the environment.

Due to the possible biohazard nature, the case of recycling is ruled out in the present pandemic scenario. Several countries globally banned single-use plastic, given its impact on the environment. The primary constituent of PPE is polythene. The pandemic has made the production of plastic-based single-use PPE (face masks, body cover, etc.) or synthetic rubber (gloves) increase many folds. The health of the environment and its constituent biota due to disposable single-use PPE is grave given its composition. Not only PPE has an impact on nature but also has repercussions on human health in both the short term and long term. A recent report by WWF states that "*If even only 1% of the masks were disposed of incorrectly and perhaps dispersed in nature this would result in 10 million masks per month dispersed in the environment*". The number that enters the environment is just mindboggling.

There is a tremendous increase in the production of PPE before and during COVID-19. Approximately 100 million face masks and gloves have been produced from January to May 2020 as against less than 10 million for the year 2017-2019[3]. The production of PPE in India alone increased dramatically from zero to more

than two lakhs per day in May 2020, a peak period for COVID-19. This quantum jump in the use of face masks, gloves and other PPEs will undoubtedly have an impact on environment and ecology. The information of Life Cycle Assessment on the PPE seems to be meagre, or nil as the current focus is on the control of the disease, rather than environmental protection. The production of PPE will have cost on the environment either directly or indirectly. This includes energy consumption and water use—the energy in terms of raw material extraction, manufacturing, transportation, water consumption and finally disposal. Any reduction in any of these steps would have enormous environmental benefits.

During this pandemic, we all worried about our health, which results in enhanced self-protection by PPEs. But seldom we talk or discuss the impact of the PPE on nature and wildlife, especially the aquatic ecosystems where most of the PPE will be eventually land. There are several recent reports across the globe in print, electronic and social media, that the wildlife is reclaiming back due to the lockdown down imposed due to Covid-19. There may be some element if truth in the news, but many are either false or some old news. Even if the story of reclaiming habitat is true, it will only be temporary. Sooner or later we are all back to normal- post-COVID days, resulting in our increased presence in the "so-called" reclaimed habitats, which will eventually drive away from the wildlife.

The impact on the environment, both aquatic and terrestrial will have to bear the brunt of these. Gloves, masks and wipes are all plastic polymers when these discarded into the environment; it goes into sewer systems or water bodies. These materials can pose a high threat of clogging the sewers, which might be of concern in cities located in high rainfall regions, such as Mumbai. Additionally, the plastics are known to breaks down into microplastics. Experiments show that microplastics damage aquatic life starting from the microorganisms to turtles and birds (Figure 1). Further, microplastics also is known to attract heavy metals and persistent organic pollutants, which eventually end up in aquatic life. Several questions that need to be addressed, especially in the developing country like India concerning the proper disposal of the PPE.

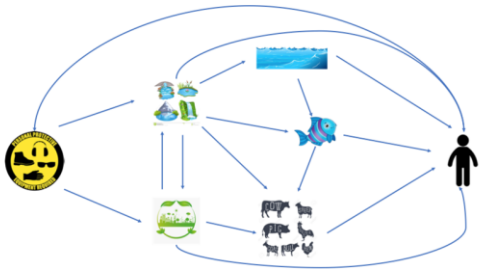

Figure 1. Pathway of impact of PPE on environment, biodiversity and humans

What happens to these after the use, especially for those which are single-use? How are they managed/disposed of? What are the methods used to dispose PPEs other than hospitals? What are the environmental and human impacts? How can PPE be managed so that the effects on the environment is reduced? In this essay, we try to highlight the environmental impact of non-safe disposal of plastics. We are not directly dealing with the impact of PPE, because the information specifically for PPE is not available. Still, the overall impact of PPE will be same as other plastic products and the recommendations for the future.

2. THE PLASTIC PROBLEM

The global plastic production increasing by approximately 8.7% annually, with a whopping $600 billion global industry. It has been estimated that annually, around eight million metric tons of plastics enter the oceans[4-5]. According to Eriksen *et al.*[6] with a conservative estimate that 5.25 trillion plastic particles currently circulate in ocean surface waters. Source for almost 80 per cent of suspected plastic pollution in the ocean is from land-based sources[5]. Waste generation and waste discharge to the environment is usually linked and directly proportional to the economic development, local infrastructure for collection, segregation and recycling, and also on legislation. Today, uncollected waste accounts for 75 per cent of these land-based discharges. In comparison, the remaining 25 per cent comes from within the waste management system in sea port area. In the environment, the plastic can undergo degradation

and disintegration due to the action of physical, chemical, and biological drivers[7-8]. The larger plastics become fragmented to form microplastics[7,9-10]. Microplastics have become an emerging contaminant of great concern due to their sheer abundance at the global level, its widespread distribution and continuous accumulation. Sewage effluent has been identified as a significant source of microplastic fibres to the marine environment because it concentrates and delivers particles derived from washing clothes and textiles[11]. Plastic pollution in the aquatic environment is one of the less-discussed subjects with endangering effects on aquatic life. The penetration of the plastic pollution in aquatic life is across the different trophic levels from microorganisms to large vertebrates[12-13]. The plastics affect aquatic life through ingestion by animals and providing new floating surface, which is transported to the new habitats. The movement of the organism to the new habitat poses a threat to the native organisms and lead to invasive species eventually[14]. As of now, there is no detailed information available on the origin of microplastics from the PPE materials.

3. IMPACT ON TERRESTRIAL AND AQUATIC ECOSYSTEMS

A significant proportion of inadequately disposed of plastic waste comes from low-to-middle-income income countries in South Asia and Sub-Saharan Africa. In these countries, approximately 80 to 90 per cent of plastic waste is poorly managed thus causing the risk of pollution of aquatic ecosystems. The studies have shown that two-thirds (67%) of the global annual river input into the oceans comes from top 20 polluting rivers and majority are located in Asia.[5] Most of the plastic litter disposed on land finally arrive in the oceans[5,15-16]. In the marine environment, it undergoes degradation and fragmentation[15]. In the terrestrial environment, the plastics interact with the biota, potentially altering geochemistry and biophysical environment and causing environmental toxicity[17]. The research spanning over five decades across ecosystems (land, freshwater and marine) have documented the impact of plastic on ecosystems and wildlife[18-22]. Rochman *et al.*[23] have reviewed the impacts of marine plastic debris on animal life. Once these plastics gets into the environment, according to Law *et al.*[13] there are three important pathways by which it can affect wildlife. These are Entanglement, Ingestion and Interaction. A brief account of each of these are given below. Entanglement and ingestion can have both lethal and sub-lethal effect on the animals[24].

Entanglement: Entanglement means "getting stuck" and it is the most ubiquitous type of impact of plastics of wildlife. The most commonly seen entanglements are by plastic ropes, fishing nets and packaging materials. Entanglement cases have been reported from the host of animal taxa in the marine environment[25]. The review shows that at least 344 species from marine turtles, seals, whales and host of seabirds[25-26]. It is also reported from marine fishes and invertebrates[25]. Entanglement also leads to the death of the animal either by chocking or by starvation. Entanglement is a severe problem in the marine environment than in terrestrial and freshwater systems[27]. Among land animals, there are several reports of head of the animal being stuck in plastic products such as bottles or bags. According to the Convention on Biological Diversity report, the entanglement has increased by 40 per cent in last decade[26]. Almost all PPE kits are equipped with elastic straps for support, and this material can pose a severe threat to aquatic animals by causing entanglement.

Ingestion: Animals ingest or eat plastics either intentionally, unintentionally, or indirectly through the consumption of prey species containing plastic by the predator. Studies have documented over 233 species of marine animals known to ingest plastic in some of the other forms[25-26]. The extreme case was reported from sperm whale (*Physeter microcephalus*) which ingested a large quantity of plastics and other materials which included rope, hose, flowerpots, plastic sheets and so on[28]. Ingestion of plastics by animals can have multiple impacts on animals' health and thus survival. Large quantities of plastic can lead to chocking of the stomach, poor appetite and consequently, the mortality[29]. Plastics might pose a severe threat to filter-feeding organisms such as clams (bivalve molluscs or clams), as it can affect the feeding

behaviour and eventually death by starvation. A decline in the filter feeder population might drastically affect the water quality (as most of the filter feeders are water purifiers) and aquatic food web by increasing the phytoplankton density, which leads the algal blooms. Plastic can also disrupt the normal functioning of the gut and alimentary canal of the vertebrates. This ultimately leads to death. In the laboratory, the experiments have shown that the response of plastic in animals can lead to oxidative stress, disruption in the metabolic activity, reduced enzyme activity, and cellular necrosis among many others[30-34]. Ingestion also a pathway of transport of toxic chemicals into organisms body[35].

Interaction: Interaction with the materials of plastic origin includes collisions, obstructions, abrasions or use as a substrate. Interaction can impact on organisms in multiple ways[36]. For example, fishing nets has been shown to cause damage to coral reef ecosystems, which are highly sensitive habitats and harbour unique flora and fauna. Plastics can also impact ecosystem structure and functioning such as reduced light penetration, availability organic matter, oxygen exchange and chocking, thus hindering primary productivity, which leads to either eutrophication or anoxic condition. A recent study from the Indian Ocean showed that the presence of plastic debris in various forms (macroplastic, mesoplastic and large microplastic particles) even in the remote coral island of Maldives[37]. This study highlights that remote locations are also affected by the longevity and long-range global ocean transport of marine plastic debris.

Microplastics (plastics <5 mm, including nanoplastics which are <0.1 um) originate from the fragmentation of the larger plastics in the environment due to climatic and other factors[17]. The potential effects of microplastics can be seen at different biological levels, ranging from sub-cellular level to species to ecosystem level. But most of the research focused on impacts on individual adult organisms. Impacts of microplastics have been extensively studied in the marine environment, but far less or negligible in the terrestrial and freshwater environment. Microplastics are considered as one of the emergent threat in the terrestrial ecosystems[17]. Ingestion of microplastics was shown in different organisms. This can happen through filter-feeding (e.g., mussels or clams), swallowing from surrounding contaminated water (e.g., fishes and crustaceans), or consumption or predation of organisms that have previously ingested microplastics (e.g., higher trophic level organisms such as birds, carnivores fishes, etc.)[38].

There is mounting evidence that plastics and its derivatives such as microplastics have an impact on organisms' growth, physiology, fertility, reproduction and consequently survival across multiple taxa studied[39-44]. When microplastics gets in to the digestive system of an organism it will affects the feeding signals and eventually leads to death due to the starvation[45]. Thus, causing feeling of fullness which reduces the intake of food, consequently decreasing the fitness and survival of the individuals. However, there is evidence that many organisms do not exhibit any changes in feeding patterns in response to microplastic ingestion. Several organisms with different functional groups such as suspension-feeders and detritivores invertebrates showed no impact of microplastics[46]. However, some organisms might likely suffer from the presence of microplastic particles in the gut, which can have physiological impacts. Apart from marine life, there is also a potential consequence of the presence of microplastics in the marine environment for human food security, food safety and health[47].

4. WAY FORWARD

The threat of an SARS Covid-19 global pandemic is likely to be with us for some time, as new strains will continue to emerge and travel quickly through the new global economy. But for virus infected clinical waste, the best option currently we have is incineration. During the course of pandemic and thereafter, the challenge for disposal of waste PPE will only increase. Hence, it is important for the government to make sure that existing facilities can handle such large quantities.

Reusable PPE has been suggested in the western countries to reduce environmental impact. The selection of a reusable or disposable textile

system for use in hospitals is a decision that depends on factors such as barrier effectiveness, cost, comfort, and sustainability[48]. These are much more sustainable than those which are disposable. The studies have shown that the reusable textile systems provided substantially better environmental profiles than disposable systems[49]. Thus, the environmental benefit of reusable isolation PPEs are significant. The research has shown that the reusable gown system showed a 28 per cent reduction in energy consumption, a 30 per cent reduction in greenhouse gas emissions, a 41 per cent reduction in freshwater water consumption, and a 93 per cent reduction in solid waste generation[48]. Also, a recent case study showed that reusable isolation gown systems resulted in a 30 per cent reduction in costs compared to disposable gown systems[50]. Incineration not only destroys viruses but also reduces the amount or volume of the waste leftover in general. In UK it is shown that the heat generated from the burning of waste in incinerators was used as a source of energy to heat local buildings or to generate electricity. Another study in the UK in 2018, showed that waste incinerated in municipal plants contributed almost two per cent of the UK energy. Multiple studies suggested after sterilization of used PPE with ethylene oxide, alcohol, ozone UV or gamma irradiation can then be reused.

Especially country like India with high population density and lack of awareness regarding health and environment, federal policy and strict implementation is needed. India is one of the top polluters of plastics in the world and also ranked high in terms of mismanaged disposal and others. The lack of or limited public awareness on the environmental impact hinders the successful implementation of laws. Hence the public needs to be made aware. India has Bio-Medical Waste Management Rules, (2016), and the Central Pollution Control Board (CPCB) guidelines to ensure that all waste generated specifically during testing and treatment of patients including Covid-19 is disposed of in a proper scientific manner. India, for example, has a poor track record of medical waste disposal with many violations despite the fact that strict government rules have been reported from various parts of the country. This includes mixing of medical and general waste and illegal dumping. As reported in various media, ever since the start of the COVID pandemic, large quantities of used PPE have been found dumped indiscriminately in many parts of the country[51]. Also, there are reports that a significant quantity of these used PPE stored and sold in the informal sector for potential resale.

The PPE is intended to help us fight a public health challenge, not create a plastic pollution problem which is already a significant environmental challenge. Working closely with all parties in the supply chain starting from the raw materials supplier to consumer, we can better manage PPE requirements, and, in turn, help protect the environment. The studies have warned that we should be cautious and aware of detrimental impact on environmental from discarded plastics. The plastic production and usage continue to increase during this pandemic, particularly in developing countries like India. The environmental impact of disposal of the PPE should be considered to avoid the impacts of these contaminants across life forms and finally to humans. Thus, there are a number of opportunities both for policy-based and consumer-driven changes for managing the waste in developing countries.

Role of Citizens: Citizens can play a critical role in crowdsourcing data of PPE disposal. Initial data and such initiative undertaken in Chicago suggests that gloves are the most common PPE waste in USA. Whereas in China, masks are discarded the most. We don't have any data for India. Such initiative is need of the hour not only for managing the waste but also to understand the health hazard in the near future if there is any in post-Covid scenario. Thus, citizens can play an active role in the environmental movement. In India, the government promotes the use of home-made masks using cotton cloth material. The impact of these materials on the environment is minimal when compared to the masks made by the plastic and associated materials. Additionally, the home-made cloth masks can be reused multiple times after the cleaning as recommended.

Role of Government: Government has to invest in science (research), management of waste

(technology), awareness and implementation (law and education). The economic and technological development will not come to rescue in large scale disasters such as pandemic which ravaged the whole world. We never know what kind of pandemic will emerge from unsafe and unscientific handling of the plastic waste. Ignoring science in research, management and awareness can be fatal to human society.

Strict implementation of laws that restrict the rampant and illegal disposal needs to be in place. Each local governing institutions, especially municipal corporations, should come out with a strategy to collect or segregate the PPE from the municipal solid waste and appropriate disposal mechanism.

Role of Scientists: Despite the large-scale presence of plastics and microplastics across India's terrestrial and aquatic systems, hardly any long-term or large-scale monitoring data have been collected. Hence long-term monitoring of the impact on these systems and the biodiversity it harbours needs to be studied. Laboratory and field based studies in India to assess the impact of plastics/PPE on wildlife and environment is required. Developing of new recyclable polymers for the production of the PPE should be taken up as a priority area of research.

Role of Civil Society Organization: India has thousands of civil society organizations working with the various stakeholders across social and economic strata. These organization should take this pandemic as an opportunity to create awareness among different stakeholders. India, with its huge population and younger demographic profile, has the advantage to change the world view. We suggest there is a need to think creatively about how plastics research, conservation action, and policy could be better linked to achieve positive conservation outcomes for wildlife directly affected by plastic pollution[54].

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Conflicts of Interest

There are no conflicts of interest.

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