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Review Article

Abating Plastic Footprints of Covid-19: Strategies and Solutions

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ABSTRACT

In the course of the COVID-19 pandemic, increased utilization of single-use plastics along with their inadequate and inefficient waste management has translated into an environmental crisis of plastic accumulation. An online survey conducted on 253 people, to ascertain usage pattern of personal protective equipments (PPE), plastic food take away containers and plastic packaging materials before and during the COVID-19 pandemic shows daily usage of surgical masks by medical and non-medical professionals increased by 63.16% and 49.64%, respectively. Monthly frequency of online shopping also increased from 48.22% to 52.96%. Although frequency of ordering in food reported a drop from 42.6% to 23.71 %. Large volumes of non-infected PPE continue to be dumped with municipal waste littering roadsides or being sent for incineration with biomedical waste. The existing incineration facilities have become overburdened leading to the accumulation of medical waste. Single-use plastics have a long degradation time of over 500 years and overtime degrade to yield microplastics. Increased use of PPEs could thus trigger the accumulation of microplastic in the environment within a short time. There is an urgent need to develop a circular model which includes segregation, sterilization, recycling, and repurposing of major portion of used PPE. Some innovative recycling efforts being made world over on pilot scale in the last 1 year have been reviewed. These baby steps need to be replicated on a large scale. Reduction in plastic pollution can also be achieved by the replacement of plastics obtained from petrochemicals with environmentally sustainable and biodegradable bioplastics.

Key words: Bio plastic, COVID-19, Incineration recycling, Online survey, Plastic pollution, Single-use plastic.

1. INTRODUCTION

Pandemics do not merely have health concerns, rather these have social, economic and environmental impacts. The World Health Organization (WHO) declared COVID-19, an infectious disease caused by SARS-CoV-2 virus, as a pandemic on March 11, 2020. As per the latest update of WHO on October 01, 2021, global COVID cases surpassed 233 million and approximately 4.7 million deaths. SARS-CoV-2 virus can spread rapidly from human to human through droplets and close contact with an infected person when exposed to coughing, sneezing, respiratory droplets, or aerosols [1,2].

The increasing number of infected cases aggravated the generation of infected medical waste [3]. The fear of transmission of virus triggered the use of single-use plastic (plastic produced and designed to be thrown away after being used only once) in the form of surgical masks, gloves, PPE gears, disposable containers, and plastic bags for groceries. The nationwide lockdown suppressed the recovery and recycling process of plastic [4]. Moreover, a sudden drop in the oil prices reduced the production cost of virgin plastic from petrochemicals and made the recycling process economically unviable. As the world slowly limps back to normalcy there is a need for strategies to blur these plastic footprints of COVID-19.

A survey-based study covering 253 people has been conducted to ascertain the usage of personal protective equipment (PPE), plastic food takes away containers & plastic packaging materials before and during the COVID-19 pandemic. The study clearly shows a marked increase in the single-use plastics and the fear of transmission might result in permanent changes in plastic usage patterns. Various innovative recycling techniques taken world over to erase the plastic footprints of COVID-19 pandemic have also been discussed.

The low cost and versatile chemical and mechanical properties of plastic which include resistance to weathering, non-biodegradability, photostability, durability, lightweight, easy mouldability, and hydrophobicity have contributed to their utility in all aspects of life. In a nutshell, from agriculture to transport and from aerospace to food packaging and biomedical field, the use of plastic has become an integral part of life.

Single-use plastics are the items that are intended to be used once and then disposed off. These are made from polymers of HDPE, LDPE, PET, PS, PP, PS (Figure 1).

Unique properties of single-use plastic which include biological inertness, hydrophobicity, and non-biodegradability render them suitable to check the transmission of microbes. During the COVID-19 pandemic, worldwide health regulatory bodies have laid down strict protocols to reduce the transmission of virus which include the use of PPE kits by healthcare workers and mandatory use of face masks for

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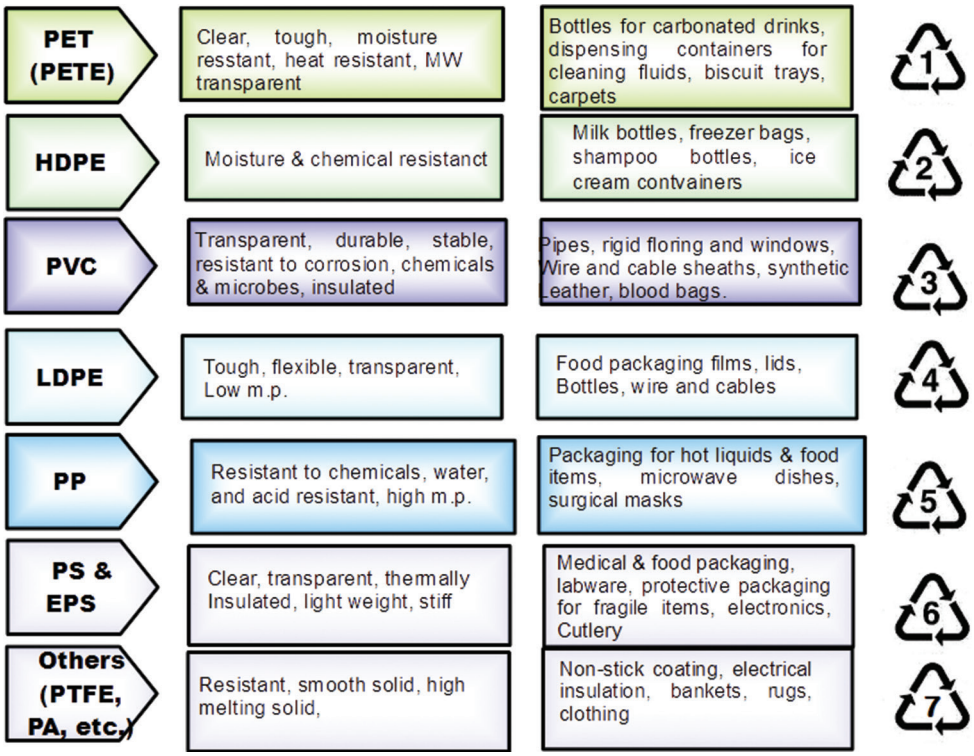

Figure 1: Different types of polymers with their resin identification codes.

the public. Also, the membranes used for the process of plasmapheresis are composed of polyethersulfone, polymethylmethacrylate,and polypropylene (PP) [5], the nasopharyngeal swabs used for the collection of biological samples are made of nylon [6]. Moreover, online delivery of essential commodities, groceries, and packed takeaway food during the lockdown period has further raised the usage of plastic in the form of shopping bags and packaging materials to prevent cross-contamination. In this way, with the advent of the COVID-19 pandemic, the increased use of plastic item led to sharp growth in plastic waste. Medical waste has grown up to 370% and packaging plastic demand up to 40% [7].

2. MATERIALS AND METHODS

An online survey was conducted on 253 people which included academicians, students, medical professionals, and homemakers of various parts of the North India region for a period of 4 days (28 September 2021 to 11 October 2021). The aim of the survey was to ascertain the usage frequency of PPE, plastic food takes away containers and plastic packaging materials before and during the COVID-19 pandemic and their disposal patterns. The questionnaire was based on the usage of surgical masks, gloves, face shield, frequency of ordering food and online shopping before and during COVID-19 pandemic, normal practice of disposal of the safety essentials, segregation of garbage, fate of plastic containers, and packaging/bubble wrap, awareness about the non-biodegradable nature of plastic items. Obtained data were evaluated and is presented in Figure 2a-h.

3. RESULTS AND DISCUSSION

The use of PPE kits checks the viral transmission and provide the safety which was confirmed by 42.1% and 3.8% increase in daily usage of PPE kits by medical and non-medical professionals, respectively. Daily usage of surgical masks by medical and non-medical professionals increased by 63.16% and 49.64%, respectively (Figure 2a and b). Daily usage of face shields by medical and nonmedical professionals increased by 36.84% and 8.97%, respectively. People have ordered food from outside during pandemic less frequently as compared to before the pandemic, a drop of 18.86 % in monthly ordering was seen (Figure 2c). Whereas the rate of monthly online shopping was increased 4.74% (Figure 2d). Probably the increased risk of infection, health concern, and strict restrictions to go out of home resulted in decreased rate of ordering food from outside and increased rate of online shopping. Despite of the fact that more than 90.9% of population has awareness about the non-biodegradable nature of PPE kit and plastic containers/wraps which come with ordered food and online shopping (Figure 2g), 31.6% of people reuse and 47.82% people throw the containers/wraps in garbage (Figure 2h).

The precautionary measures to check the spread of virus have not only affected the public health and the world economy but also threatened the environment by measurable increase in plastic debris [8]. One of the major concerns is that the fear of infections and increased apprehension for health and hygiene might permanently tilt individual preferences for single-use plastics.

The degradation time of single-use plastic obtained from petrochemicals is up to 500 years. During the course of degradation, most of the plastic slowly breaks down into smaller fragments of size less than 5 nm, called microplastics [9]. Microplastic particles, which account for 13% of the plastic waste, have been found to be present in food, drinking water, table salt, soil, air, deep sea, and ice [10-12]. These macroscopic fragments of plastics have been found blocking the respiratory and digestive passage of terrestrial and aquatic animals [13]. Fourier-transform infrared spectroscopy analysis of the degrading face mask exhibited the characteristic peaks for the PP and high-density polyethylene in the outer and inner layers respectively [14]. This study confirms that the increased use of PPEs could trigger the accumulation of microplastic in the environment within a short time.

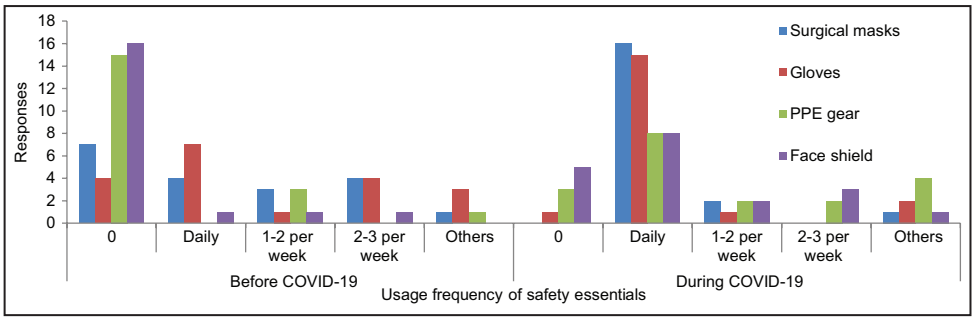

Figure 2a: Usage frequency of safety essentials by medical professionals.

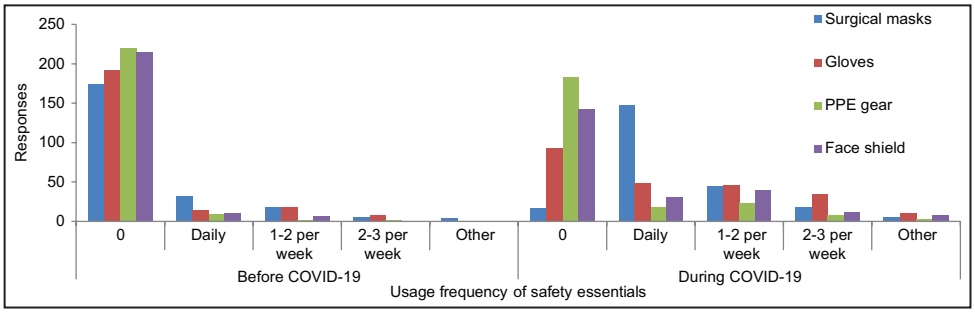

Figure 2b: Usage frequency of safety essentials by non-medical professionals.

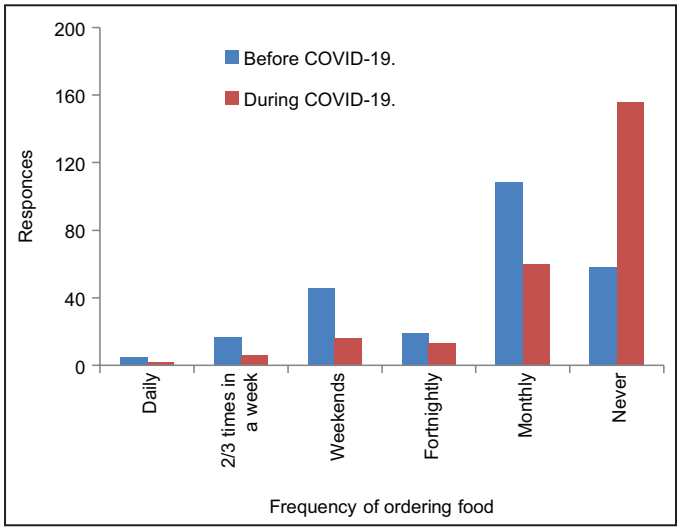

Figure 2c: Frequency of ordering food before and during COVID-19.

4. FUTURISTIC APPROACH AND APPLICATIONS

Before the pandemic, many countries had placed a complete ban on the use of non-biodegradable bags, but it has been temporarily lifted to reduce the transmission of virus. On the global level, plastic waste management techniques include mechanical recycling, incineration (pyrolysis at a high temperature in absence of oxygen), and landfilling. Due to the lack of adequate and efficient waste management policies, only 16% of global plastic waste is mechanically recycled. Major portion of the plastic waste is either incinerated (25%), landfilled (40%), or leaked into the environment [15].

Biochemical waste cannot be sent for recycling with other municipal waste. In fact WHO & Central Pollution Control Board (CPCB) [16] guidelines have mandated incineration of PPE and other infectious waste. Thus, all bio-wastes and used PPE collected from hospitals, airports, malls are sent for incineration. The existing incineration facilities have become overburdened leading to the accumulation of medical waste. Incineration should be practiced as the last resort for highly infective waste as it may release harmful gases such as dioxins, furans, mercury, and polychlorinated biphenyl into the atmosphere [17].

Out of the total biomedical waste generated only 15% can be classified as hazardous should be sent for incineration. The rest of the waste can be sent for recycling after proper disinfection. Studies have shown that the COVID virus can remain virulent on plastic surfaces for more than 72 h [18]. Thus, there is a need to quarantine the used plastic waste before it is recycled or the biomedical wastes can be heated to elevated temperatures with superheated steam to decontaminate it before sending for recycling.

Many innovative solutions are coming up to address the problem of accumulated medical waste. Recently Saberian *et al*. [19] used a 2% blend of shredded face masks added to recycled concrete aggregate to build pavements and roads the blend exhibited increased strength and stiffness. The face masks were decontaminated by simply spraying an antiseptic solution and then microwave exposure for 1 min. Since PP is known to possess good acoustic properties, Maderuelo-Sanz *el al*. [20] recycled surgical masks to make sound porous absorbers and found their performance comparable to the commercial ones. Dash *et al*. [21] performed thermal pyrolysis of plastic syringes in a semi-batch reactor at 450°C to produce pyrolytic oil whose physical properties matched that of commercial transportation fuels. A French startup "Plaxtil" [22] and a USA-based company "Terra Cycle" [23] have been collecting used surgical masks, and placing them in quarantine for 4 days and then grinding it into small pieces and subjected to U.V radiations for decontamination. It is then mixed with a binding material to mold into plastic items. Meanwhile, in Spain, a consortium of pharmacists collected marks from 261 pharmacies, sent them to recycling unit to recover useful material. A student from Keywong [24] University Korea, removed metal & elastic from the masks and directly melted them in molds to form stools. Biodegradable masks manufactured from Biomass are being synthesized by the University of Lausanne [25] and Queensland University of Technology [26].

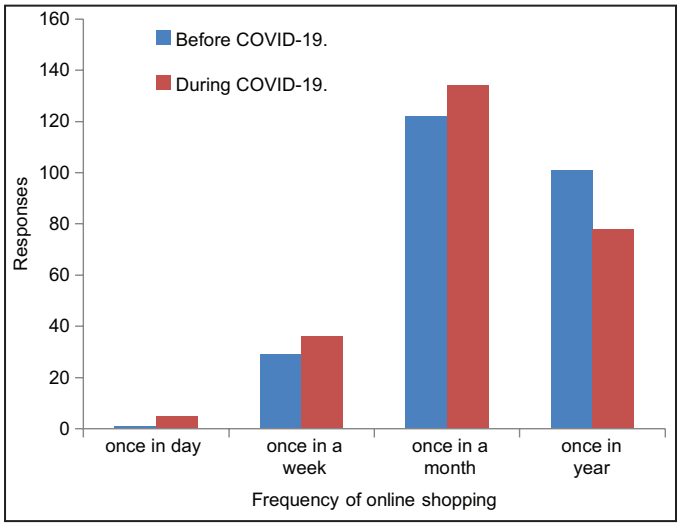

Figure 2d: Frequency of online shopping before and during COVID-19.

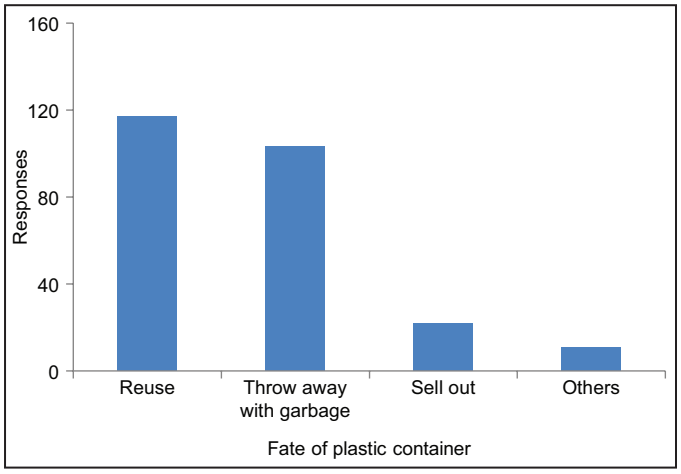

Figure 2e: Fate of plastic containers coming with ordered food.

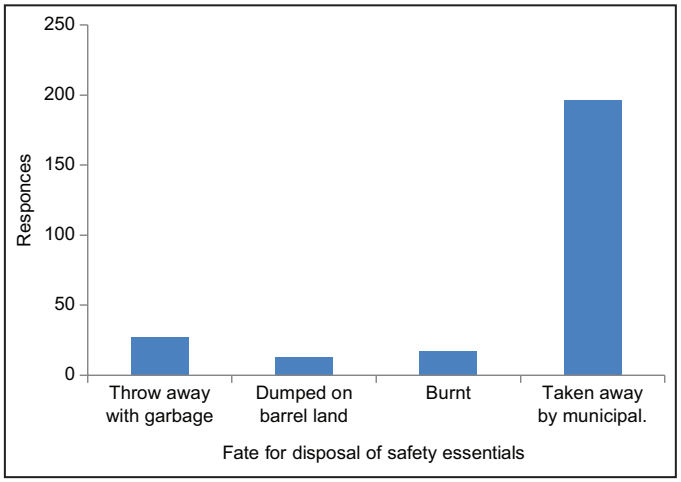

Figure 2f: Normal practice for the disposal of safety essentials.

Plastic roads in India were first developed by Vasudevan in 2001 [27]. He was awarded the Padam Shree in 2018. In India, one lakh roads have been built using plastic waste. Every 1 Km road uses nine tons of bitumen and 1 ton of plastic waste [28]. Laboratory and

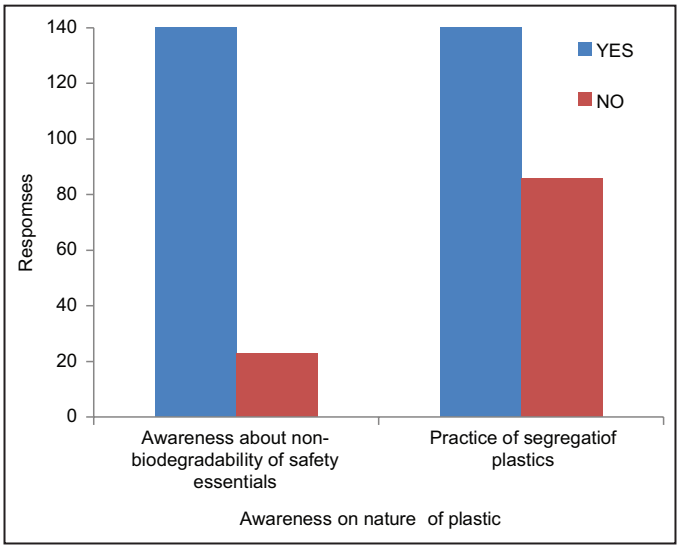

Figure 2g: Awareness about degradation behaviour of plastic and practise of segregation of plastic.

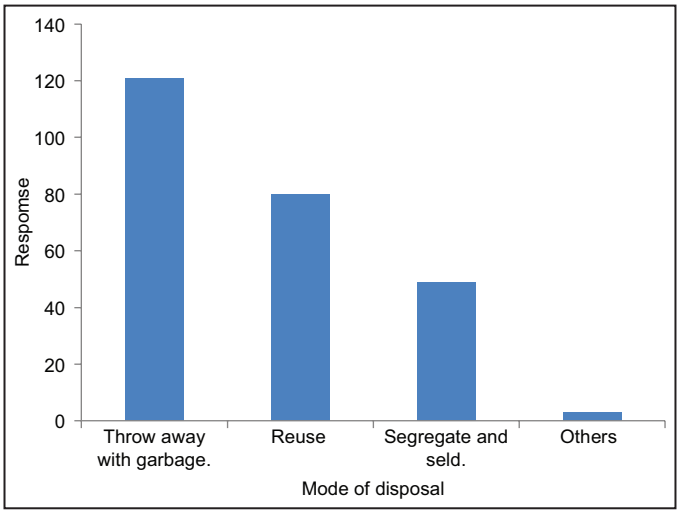

Figure 2h: Mode of disposal of packaging/bubble wrap which come with online shopping.

field performance studies have shown that plastic in bitumen mixes increases durability of these roads [29].

An Indian startup Rudra Environmental solutions has developed a thermo catalytic process that successfully depolymerizes mixed plastics to yield usable fuel oil. Each ton of mixed plastic is reported to yield 600–650 L of fuel oil [30].

With PPE and other single use plastics being produced at a rapid rate, we need to find a way to either give it another life or to break it down to harmless products. The innovative solutions of making roads and fuels can be extended to take care of the huge amounts of used safety essentials & plastic waste being generated.

5. CONCLUSION

The COVID crisis has proven that plastic saves lives, all safety essentials, disposable syringes, IV tubing's blood bags & urine bags are made of plastics. However, excessive usage along with inadequate and inefficient waste management strategies is the core cause of plastic pollution. Our Survey clearly shows that daily usage of PPE kits

and face masks have increased by 17.4% and 70.84% in the general population. It also indicates that the safety essentials like face masks and PPE kits are being dumped with municipal waste. Although there is increased awareness about advantages of waste segregation, still, waste segregation is not practiced. Hopefully, the environmental emphasis on plastic pollution and ban on single-use plastics will return to limelight once the COVID crisis is over. In the meantime, we can all contribute using reusable cloth masks, limiting ordering in food, reusing plastic containers, segregating all plastic wastes to be given to rag pickers. Online shopping platforms can minimize plastic packaging.

Contaminated medical waste should be disposed off after proper sterilization so that the possibility of infection can be brought down. While used PPE collected from places other than hospitals such as airports can be quarantined for a few days and then sent for recycling rather than incineration with highly infective biomedical waste. Innovative solutions must be utilized to recycle the accumulated bio medical waste into materials for civil construction and roads. Moreover, conventional plastics should be replaced by bioplastics which are biodegradable and environmentally sustainable.

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