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The Polymer Medical Waste: A Tough Challenge for Environmental Sustainability

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Abstract: ***Medical waste is the term used for trash generated at health care units, like hospitals, medical clinics, dental practices, blood banks, or veterinary hospitals/clinics, as well as medical research facilities and laboratories. We are aware of the fact that medical waste is healthcare waste that may be contaminated by blood, body fluids or other potentially infectious materials and in the context of this related study more important the non-decomposable waste mostly plastics/ or non-degradable polymers, which could be a challenge for environmental sustainability and human health. At the same time we cannot deny the numerous positive attributes of plastics which have enabled them to achieve this particular niche. Medical facilities without the use of plastics are almost unimaginable. During the peak of the outbreak of the dreaded pandemic, a critical period for the prevention and control of the disease, the world faced the issue of COVID-19 related waste as a threat to global public environmental health. Medical waste management during this pandemic emerged as the prime issues facing public service organisations such as municipalities, in terms of logistics, environment and social***
aspects. A very high volume of medical waste like syringes, masks, safety goggles, face shields, hair covers, PPE kits, medical equipment etc comprise of polymeric material which pose a great threat to environmental sustainability. This paper discusses the various aspects of plastic medical waste and the management of the same to protect the environment. Hence it is suggested that globally the research on developing new environmentally biodegradable polymers and smart mechanisms of degradation after use in the environment should be provided the necessary impetus. It is suggested that global authorities must intervene to implement a mandate of proper practice for the maintenance of a plastic life cycle for an extremely sustainable environment.
Keywords: Polymer, plastics, environment, biodegradable, medical-waste, decomposable.

I. INTRODUCTION

Medical waste is the term used for debris generated at health care units, like hospitals, medical clinics, dental practices, blood banks, or veterinary hospitals/clinics, as well as medical research facilities and laboratories. We are aware of the fact that, medical waste is healthcare waste that may be contaminated by blood, body fluids or other potentially infectious materials and in the context of this related study more important the non-decomposable waste which could be a challenge for environmental sustainability and human health. The 1988 Medical Waste Tracking Act defined it as waste generated during medical research, testing, diagnosis, immunisation, or treatment of either human beings or animals. Some examples are syringes, masks, safety goggles, face shields, hair covers, culture dishes, glassware, bandages, gloves, discarded sharps like needles or scalpels, swabs, and tissue. Though this necessary by-product of medical services has existed since time immemorial, this environmental aspect of challenge to sustainability has been more evidently discussed at global frontiers during and post the distressing COVID pandemic outbreak which is still continuing to agonise the global population in spurts.

During the peak of the outbreak of the dreaded pandemic, a critical period for the prevention and control of the disease, the world faced the issue of COVID-19 related waste as a threat to global public environmental health. Medical waste management during this pandemic emerged as the prime issues facing public service organisations such as municipalities, in terms of logistics, environment and social aspects.

Medical waste apparently became globally conspicuous as the massive amount of medical by-products are plastics which are non-biodegradable in nature. With the outbreak of the pandemic, a large amount of plastic medical waste like PPE kit, syringes, gloves etc worsened the already grave environmental situation of plastic disposal. Medical debris which is a source of huge hazardous waste, has created enormous stir among the environmental fraternity. This is mainly due to the fact that medical waste generation and disposal is a fundamental component of concern, especially for countries with insufficient hygiene and high population. Medical facility centres like hospitals, clinics, and pathology labs for diagnostics, treatment and medical research inevitably generate wastes that are potentially hazardous for the human population as well as the environment.

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The effects are both short as well as long term . Discussions have been ongoing for framing of policies to avoid spread of infections and inappropriate dumping of non-biodegradable medical waste by providing specifications for handling waste for generation, segregation, collection, storage, transportation, and treatment. Though awareness campaigns have been carried out at all levels of society through various means of communication and education, we are still far from our future goal objectives, so that the risks of spreading the health and environmental hazards could be minimised.

II. PLASTICS IN AND OUT

The numerous positive attributes of plastics have enabled them to achieve this particular niche. Plastics are polymers [1] which is something made up of multiple units as chains of molecules. Each link of the chain is usually made of carbon, hydrogen, oxygen, and/or silicon. Polymers originate from petroleum and other products heated under controlled conditions and broken down into smaller molecules called monomers. These monomers are the building blocks for polymers. Different combinations of monomers produce plastic resins with different characteristics, such as strength or moulding capability. Gradually due to their rich array of attributes they have been extensively used in multiple industries. The field of medicine found this material magical due to its biocompatibility, cost effectiveness, patient friendly, light weight and attributes much beyond these. Plastics have continued to play a pivotal role as materials in domestic life, public health, and medicine. Due to their ability for chemical, physical, and biological degradation, human society has continued to rely on plastics. This is true for the health care sector too. As with many other modern-day uses of plastics, a key virtue in medicine and public health is the versatility of plastics aided with an extremely low cost, which has enabled the mass production of disposable single-use health care products that are functional and at the same time extremely hygienic. However, not all current uses of plastics are prudent and sustainable, reports a study [2] as illustrated by the widespread, unwanted human exposure to endocrine-disrupting bisphenol A (BPA) and di-(2-ethylhexyl) phthalate (DEHP), problem have been reported, arising from the large quantities of plastic being disposed of, and depletion of non-renewable petroleum resources as a result of the ever-increasing mass production of plastic consumer articles. Of late this has been perceived as the greatest challenge to environmental sustainability.

III. THE SUDDEN UPSURGE IN MEDICAL WASTE

Plastics made our lives so easy that the very thought of discarding them would be uncomfortable. In context to this paper when we say medical plastic waste we definitely know the concern during the pandemic, as plastic waste continued to grow in volumes during this time. We know why plastics have been preferably used to create medical tools and devices like surgical gloves, syringes, insulin pens, IV tubes, catheters, inflatable splits, moreover in the pandemic times, PPE Kits, masks, gloves etc. These are created for one-time use, they are aseptic and biocompatible. Though Medical waste does not comprise only plastics, but post and during the pandemic a huge quantity of medical waste in the form of plastics has been generated which has compelled the environmentalists and the medical world to give more than a thought to it. The mismanagement of medical plastic waste has been posing a serious challenge for environmental sustainability Globally the environmental intelligentsia has demanded to reduce plastic consumption. How huge this challenge is, has been known to experts as the use of plastics have made our life easier. From household goods to medical equipment, plastics have now become an integral part of our life. Plastics have enabled industries with the ease of processing, transparency, cost effectiveness and much more.

When it comes to the medical industry, elimination, replacement or even reducing the use of plastic is still a tough task to achieve. Single use plastics offer immense health benefits in terms of maintaining a sterile environment, thus have become part of our daily life especially during this pandemic. The unprecedented outbreak of COVID -19 culminated in tons of medical plastic wastes. As reported by WHO fact sheet 2018 every year an estimated 16 billion injections are administered worldwide, of those needles and syringes all are not properly disposed of. Open burning and incineration of health care wastes can result in the emission of dioxins, furans, and particulate matter. Now this waste generation drastically increased in volumes during the COVID-19 outbreak and is continuing to produce large volumes of such waste, putting the environment at further risk. A 1 February 2022**,** news release of WHO states that tens of thousands of tonnes of extra medical waste generated as a result of COVID-19 pandemic has put tremendous strain on health care waste management systems around the world, threatening human and environmental health and exposing a dire need to improve waste management practices. Hospitals are reported to produce more than 5 million tons of waste each year – that is 29 pounds of waste per bed per day. Around 25% of the waste generated by a hospital is plastic [3]. This study analysed the recycling potential of plastic wastes generated by health care facilities.

Another study discusses the recycling of plastics and states that, as the solution for medical plastic waste [4]. This study discussed in detail the techniques of medical plastic recycling which seems to be limited mainly due to difficulties involved in sorting or cleaning. They went on to infer that recycling medical plastic wastes is possible only through proper coordination between the healthcare sector and recycling industries. Further it was stated that new recycling technologies are to be adopted in a sustainable manner. Moreover, the plastics used in medical applications must be designed to facilitate recycling. Another research examined the gaps in the field, and tried to formulate the sustainable medical waste management problem for the pandemic, by designing several practical examples with different scales, for example using CPLEX solver and comparing different conditions of the practical implications using the sensitivity analysis of demand parameter [5]. A study published early this year [6] discussed the adverse effect of medical waste on the environment and suggested certain policies to control the same. In their four scenario assumptions, one if the medical waste resulting from COVID-19 is incinerated, would largely impact the air quality. If disposed by distillation sterilisation, it would produce a large amount of wastewater and waste residue. Hence they proposed three policy recommendations: strict control of medical waste water discharge, reduction and transformation of the emitted wastes.

Due to the precipitous upsurge of plastic waste globally it has been acknowledged that although the consumption of these plastics protects our life but at the same time it is pivotal to move toward plastic recycling processes and environmentally friendly and sustainable alternatives, like biodegradable plastics having an economic perspective. One recent study discusses the aspects of this issue of concern [7]. This review article presented information to provide a future perspective on how worldwide COVID-19 disruption worked as a catalyst to improve plastic and medical waste management. They suggested most effective disinfection technologies for COVID-19 wastes, such as high/low heat technologies and chemical disinfection, and PPE reusing processes, including dry heat, vaporise hydrogen peroxide, ozone, and UV light during the outbreak. Further it was stated that medical waste treatment facilities must be more automatic, with a minimum of personnel involved. Further some recent valid guidelines from different international organisations and countries, future outlook, and practical recommendations that could be effective during this epidemic or even in the post-pandemic world for plastic and medical waste management were provided. Ultimately, we unanimously agree that governments should administer certain guidelines to improve their waste management because of the potential of pathogen transmission and plastic medical waste generation which could enhance the environmental awareness of the society. Citizens at the same time should alter their viewpoints on plastic consumption by elevating sustainable behaviours, abandoning old habits, and adjusting to novel ones so much needed for a positive transformation of the global environment.

IV. THE MASSIVE ENVIRONMENTAL CONCERN

A group raised a serious concern about the rising medical plastics during and after the pandemic [8]. They expressed concern about the rising plastic medical waste which will exacerbate the global plastic pollution as the use of personal protective equipment (PPE, gloves, masks) became mandatory to prevent the spread of the virus. Plastics eventually break down in micro & nanoscopic bits due to physical or chemical or biological actions in the environment, which ultimately can enter animal and human food webs. Hence, plastic management programs need to be sturdier focusing more on preventing the entry of the micro and nano plastics into the environment and food web. In the present pandemic situation, it is eventually imperative to know about how much plastic waste is being generated and how different countries across the globe are coping up with their plastic waste management. A study carried out more than a decade back expressed serious concerns about this issue [9]. The theme concept of the study was about plastics, the Environment and Human Health. They discussed the current understanding of the benefits and concerns surrounding the use of plastics and looked to future priorities, challenges and opportunities. Inevitably plastics bring many benefits due to their versatility and hence offer future technological and medical advances. However, it is indeed a cause of concern as, about the usage and disposal which are diverse, they accumulate as waste in landfills and in natural habitats, causing physical problems for wildlife due to ingestion or entanglement in plastic, the leaching of chemicals from the basic plastic products and moreover the possibilities of plastics to transfer chemicals to wildlife and humans. Over and above it can be concluded that the usage of plastics and their disposal systems under current use are not sustainable. Another grave area of concern is the raw materials for plastic production. Around 4 percent of world oil production is used as a feedstock to make plastics and a similar amount is used as energy in the process [9]. Yet over a third of current production is used to make items of packaging, which are then rapidly discarded. Hence looking at our declining reserves of fossil fuels, capacity for disposal of waste to landfill, this linear use of hydrocarbons, via packaging and other short-lived applications of plastic, is simply not sustainable, till we find suitable alternatives of synthesis, recycling of plastics and sustainable methods of disposal.

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V. THE LOOMING DANGER AND THE POSSIBLE WAY OUT

The sudden boom in plastic usage globally in all spheres and to be specific pertaining to this paper in the medical field certainly disrupted the global environmental balance of the medical plastic waste, putting a question mark as to how this can be positively channelized and reduced. An expert insight attempted to raise this concern [10]. They estimated that around 3.4 billion single-use facemasks, face shields were discarded daily during the pandemic globally. Their comprehensive data analysis indicated that COVID-19 would reverse the momentum of global battle to bring down plastic waste pollution. As governments globally are looking to reinforce the economy by supporting businesses during the pandemic, there are possibilities to discover new industries that can innovate new reusable or non-plastic PPEs. This unanticipated global tragedy of this scale has resulted in unmanageable levels of biomedical plastic wastes. This expert insight creates awareness for the adoption of dynamic waste management strategies targeted at reducing environmental contamination by plastics generated during the COVID-19 pandemic. An interesting book [11] has appropriately laid down certain facts about recycling of plastics. It is a general tendency to consider plastics for one-time use and discarded as trash which amounts to the concerns of sustainability. In this book the authors created the positive aspects of the economic benefits of plastics as not being highlighted by our current system. Our mindset regarding plastic as "trash" has to be altered and they must be considered as a renewable resource that must be properly disposed of as per known procedures. They went on to suggest that a circular economy is healing and regeneration which means that instead of being used once and then wasted, materials should circulate continuously around a closed-loop system. In the case of plastics, this would mean retaining the economic worth of the material while preventing pollution of the environment.

Recycling of the polymeric material can be a valuable option to optimise the usage of resources at the same time preventing environmental damage of trash deposits. Thermoplastics are though recycled with ease but with extensive use of innovation even thermosets can now be recycled [12]. Recycling of polymers has been referred to in a recent study [13]. Another study clearly discussed the harmful effects of plastic trash as a challenge to environmental sustainability. The study discusses that plastics disposal contaminated waterways and extensively limited the landfill areas and thus generating unhealthy odours, noxious gases and other hydrocarbons during incinerations [14]. Plastics disintegrate into smaller particles to <0.1 µm. Depending on the size, disintegrated plastics are classified as macro plastics (>5 cm); microplastics (5 mm to 5 cm); microplastics (100 nm to 5 mm); and nano plastics (<100 nm). Microplastics convey pollutants_via food to the users affecting the ecosystems[15]. The nano- and microplastics are ingested by most marine and terrestrial organisms. It was thus suggested that whenever possible recycling was a better option to incineration or landfill. This study was a valuable resource for the countless benefits of plastics as feedstock recycling in material processing, especially in iron and steel industries. Plastics known to replace fossilised resources as reductant, alloying materials and binders in iron ore pelletization, cause reduction in process temperature, energy resources conservation, contribute to energy generation and hydrogen economy and reduce harmful emissions. They further stated that both the thermoplastics and the thermosets were extremely useful in the iron ore industry. Plastics have higher H2 content, high calorific value with high carbon reactivity than coal. The feedstock recycling offers a competent waste management strategy for waste plastics. A valuable option which has been discussed globally is the development of biodegradable polymers to lessen the challenge to environmental sustainability. We all know that polymers are highly stable against the existing environmental factors, microorganisms, chemicals, degradation which has been the greatest threat to the society from the environmental aspect of accumulation of plastic waste and its management globally. Plastic waste is known to accumulate in the environment and disintegrate into microplastics as small as 5 mm in size, further stays in the environment and can enter food webs and harm the human and animal system. One such study [16] discusses the present viewpoint and scenario of the environmental acceptability of biodegradable polymers and the opportunities and challenges regarding the solution of the problem of microplastics and their impact on the environment.

VI. CONCLUSION

The very fact that plastics now have become an integral part of the medical system and as of now no alternative as such has been successfully invented to even reduce the usage of plastic in our day-to-day life. It is one such material which guarantees multiple benefits and magical virtues which has eased our lives in many ways. Especially for medical usage the commodity is irreplaceable. At the same time the fact that improper disposal of plastics can pose a serious problem to environmental sustainability also cannot be ruled out which has been discussed earlier. Hence it is suggested that a major introspection is imperative to shift the society away from the paradigm of "making, using, disposing" and focus on increasing recycling, encouraging reuse, promoting and developing a market for recycled products, and redesigning goods with end-of-life considerations in mind. Whenever recycling is impossible, proper disposal techniques practised for minimal environmental damage.

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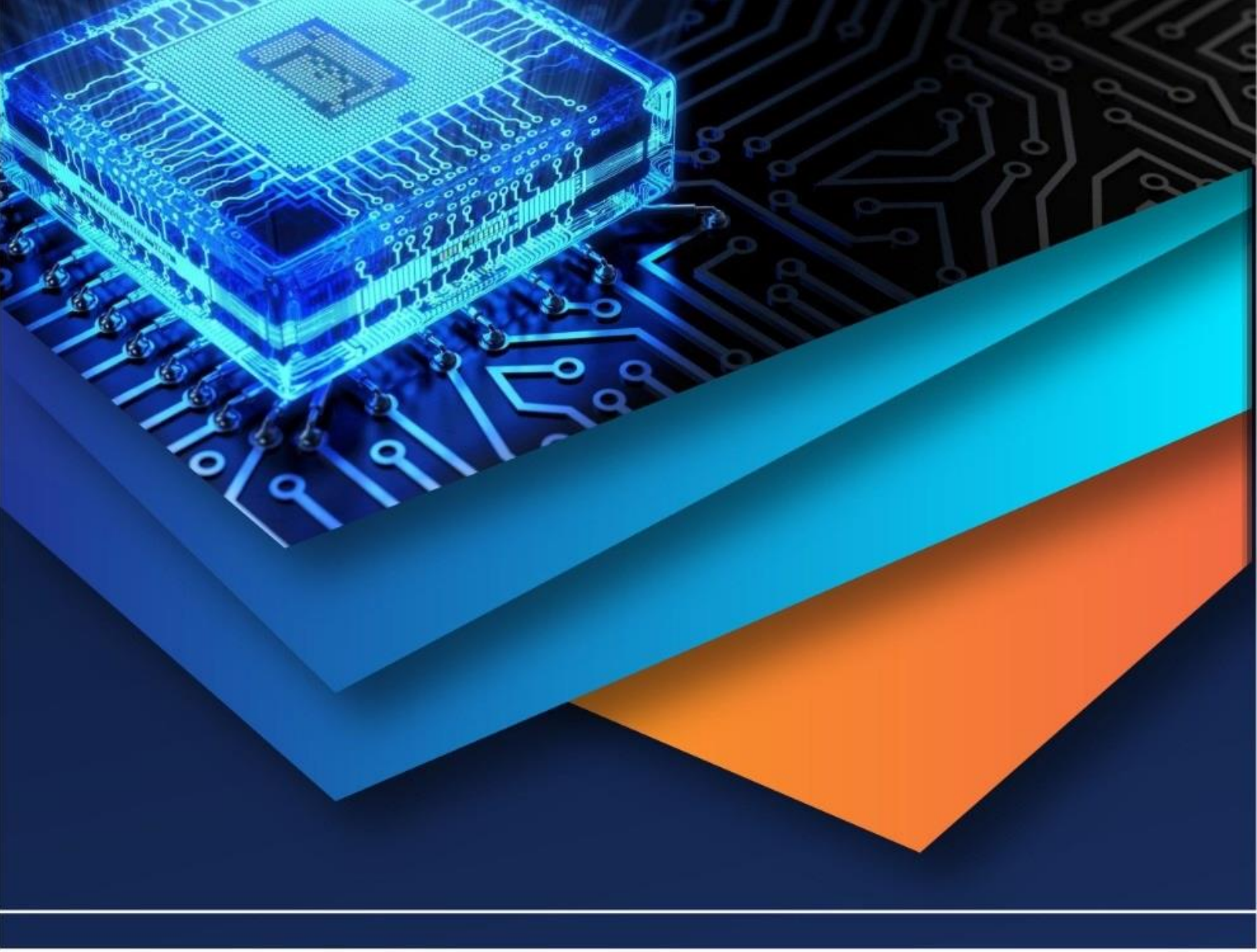
The use of biodegradable polymers has been a promising alternative, but based on studies, there are multiple aspects that need to be considered further regarding environmental sustainability, acceptability, and degradability in the existing complex natural environment. Hence it is suggested that globally the research on developing new environmentally biodegradable polymers and smart mechanisms of degradation after use in the environment should be provided the necessary impetus. It is suggested that global authorities must intervene to implement a mandate of proper practice for the maintenance of a plastic life cycle for an extremely sustainable environment.

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