Recycling of waste plastic with least effect to environment: A review

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Abstract

There is a rising problem of plastic waste which is effecting the environment. The main reason is that plastic is present in most of the daily use things. This enormous use increases the waste production and unfortunately it does not have a proper complete life cycle. The quantum of waste recycling in marginal and studies are required to put this plastic to reuse. The overall aim of the research program is to reutilize plastic in construction industry. The present study compiles the review of the techniques available for recycling plastic and the environmental concerns of recycling plastic. Recycling primarily depend upon the type of plastic. The techniques have already been bifurcated into primary, secondary, tertiary and quaternary. The energy recovery techniques are incineration and pyrolysis which effect the environment at large. The plausible reuse of waste plastic which least effect on environment is the use in construction industry. The construction industry has the capacity to use the waste plastic in bulk quantum to reduce landfill and other waste plastic problems. The research shall provide a novel material to be used in different structural members for low paid housing in construction industry.

Keywords: Recycling, Waste Plastic, Sustainability

I. INTRODUCTION

The man made inventions have polluted the natural environment in its true form. The spread of unnecessary pollution has evolved manifold and is presently out of control. It has been the essence of all sustainability researches to retrieve the natural environment. The contamination and pollution is hard to eradicate. Reutilization and recycling of wastes are being explored to cap up the issue. Among such menace plastic pollution is a much evaluated area for recycling. The large level pollution is not only the problem it has been studied that the effects are also severe at micro level. Plastic as a material is strong, lightweight, synthetic natural polymers practically non-breakable under repetitive loads and durable. The plastic recycling is uncontrollable and 79% is being accumulate as piles on the pounds and filling land. Statistically only 9% of plastic produced globally has been recycled, the second disposal option is incineration from which 12% plastic gets a life cycle [1]. A rough idea was developed for Asian countries from available sources by Liang, et al., 2021, wherein, it was recorded that MSW municipal solid waste contains 79 Mt plastic waste 42 Mt of plastic waste is available from industrial waste [2]. The policy makers of the Asian countries are seriously putting an effort to control the plastic import and the details of 2021 have shown that the use is also being limited by the countries because of the problems of plastic waste[2].

In literature the formulation of plastic goes back to 1869 when John Wesley Hyatt developed the first known artificial plastic. The word plastic comes from “plastiko" which is Greek meaning a strand of repeating molecule. At some places it has been termed as moldable and having inherent property. The plastic product formation started from a unique plastic called Bakelite. Then further development added the use of coloring agents and other additives [3]. Due to the diverse nature of the material the industrial development grew large. In 2014 it has been reported that the industrial production goes beyond 300 Mt [4]. This uncontrollable production led to develop ideas that the material needs to be reused and recycled. This notion is still not being followed with commitment. In 2017, it was assessed that whether the people have awareness to recycle the plastic or not and it was found that a substantial quantum of people have an inclination towards recycling based on their individual set knowledge. People are also being benefitted with plastic products in different spheres of life. [5]. People are outwardly willing to to participate in plastic recycling but the problem of structured process is lagging. The system understands the stakes and linkages need to be drawn with a set of finance allocation to manage this problem efficiently [6].

This idea of recycling has put together the motivation for this study and a life cycle chain is required to make use of plastic and reduce waste. The data found in literature also reveals that plastic recycling are being considered as main stream activities and over the past few decades a substantial increase is also found in this area. The structured disposal and recycling in all modes starts from sorting either from disposal points or any other sorting done at individual use source. Some countries are pressing on banning of the plastic bags This study enacts to provide that this problem of plastic waste is increasing and becoming a bloating problem. The plastic although comes from different sector of use such as automotive, household, packing, electrical sports etc. This is not being recycled at large and producing heaps of waste. The present research program is directed to use waste plastic for construction industry for an efficient reuse for plastic.

IEECP 21, July 29-30, 2021, Silicon Valley, San Francisco, CA – USA

DAI : *https://sci-index.com/DAI/2021.99101/IEECP/14811831*

II. CONVENTIONAL RECYCLING OF WASTE PLASTIC

The recycling process is not just a figurative word it encompasses of different conversion methods. These conversion methods start from primary methods and ends to incineration or energy recovery. In such bifurcation the mechanical recycling is the most difficult and final product is often questioned in terms of contents. The properties are also deviated and a set of rules apply to control the system [7]. Gu, et al. 2017, studied extrusion process and presented that mechanical recycling is the most efficient and has least environmental impact [8]. The recycling methods segregated in research steps up from land fill or disposal at marine, then to reuse, then secondary recycling involving additive additions and mechanical recycling, then comes energy recovery and then monomerization [9]. In studies carried out at Qatar by Al-Maadeed et al., 2012, the mechanical recycling was appreciated and found most appropriate when other products are being drawn [10]. The first step for all methods are sorting, back in 1984, Lohani stated that the scavenging is the best method for sorting and collection. The solid waste management still have issues at collection point even after almost 40 years. The reason is presumably the lack of coordinated scale wise structure for plastic recycling. This has a societal impact as it can draw cleanliness and incentives for plastic recollection [11].

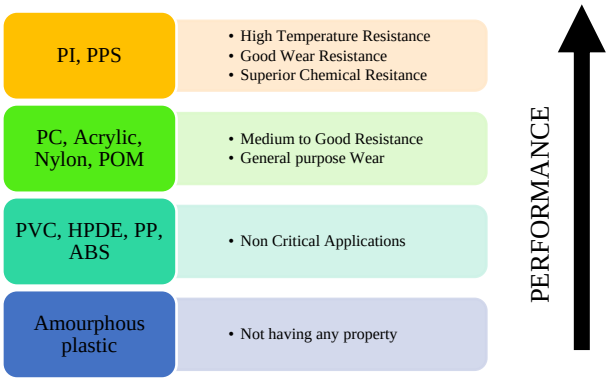

Figure 1: Performance of different Thermoplastic [12]

The recycling of the different type of thermoplastic gives a different performance level. Figure 1 shows the hierarchal depiction of some high performance plastics and also the low amorphous plastic. The second aspect which has remained under discussion is the cost adhered to recycle. Drain, et al., 1981, in their research highlighted that the cost is an important part of the recycling process. This process should be centralized to form a part of the circular economy and not only individual gains should play lead role. The study is equally applicable for all waste management system [13].

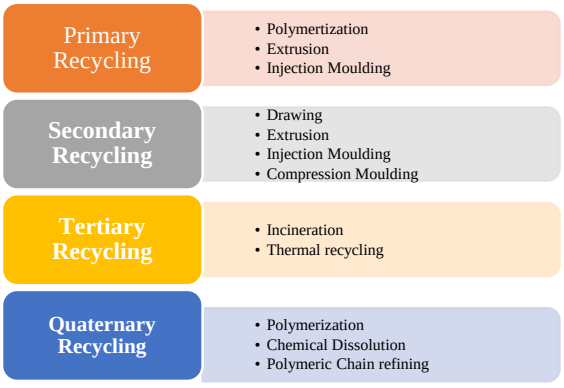

Figure 2: Thermoplastic Recycling Methods [17]

Kiran et al., 2000, studied degradation which is a sort of low temperature pyrolysis. This employs thermos gravimetric analysis [14]. The frequent set of plastic that comes to mind is the PET bottles. These bottles can be used twice and multiple reuse makes the bottles worth far more reliable than any other material. The economy of reuse definitely vary from person to person and involves hygiene issues [15]. The secondary methods are more stringent. This after collection synthesizes the waste for recycling [16]. The synthesis method effects the cost of the recycling.

The resin size after the first sort also require determination from the treatment after collection. These methods are the inert steps available to recycle the plastic. The sort is washed sometime was water and sometimes with chemical treatment. The pellets further require removal of contaminants and degraded material [18]. The stream branches off to other variants of recycling and recycling method for energy recovery are tertiary. The recycled products in all such methods are fuels [19]. Other methods include depolymerization, solvolysis, thermolysis each involving braking the molecular chain of the plastic polymer [7]. Figure 2 shows the available thermoplastic plastic recycling methods.

III. RECYCLING IMPACT ON ENVIRONMENT

The climate change, global warming and odor in the environment are prime drivers which shows the impact of plastic on the environment. The virgin plastic developed from polymerization has a different set of formulation. The plastic recycling has a different environmental impact than the virgin plastic. The comparison of two may result that recycling plastic pellets reuse are less harmful than virgin plastic. The process of recycling also signifies the environmental hazard for marine, land and air. [20][21]. Presently the pharma industries are also considering upon the demand of the plastic and due to the pandemic situation may questions are being asked to control the outburst of medical and municipal waste [22]. Plastics are widely used as essentials in health care. Blood bags, waste syringes and other items are also formed from plastic. Due to prevalent situation masks gloves, sanitizer bottles, face shields are required which are made up of plastic. This is a growing concern that plastic consumption has increased manifold it requires media publicity and social awareness [23]. The footprint should be reduced to achieve sustainability. The viable option is construction industry that might have the solution for its circular reuse by producing blocks, rebars, sheets etc.

Table 1: Waste Plastic Generation in Asian Countries[2]

Sr. No.	Country	Total Plastic Waste (2018)
1	China	49.71
2	Pakistan	5.51
3	Koera,Rep.	4.38
4	Vietnam	3.3
5	Israel	1.03
6	Yemen Rep	0.93
7	Srilanka	0.56
8	Mongolia	0.46
9	Tajikistan	0.36
10	Watar	0.25
11	Turkmenistan	0.16
12	Brunei Darussalum	0.05
13	India	17.66
14	Japan	11.19
15	Turkey	6.28
16	Thailand	5.96
17	Iran, Islamic rep	3.24
18	Saudi Arabia	3.11
19	Indonesia	3.101
20	Philipine	2.61
21	Malaysia	2.65
22	Singapore	1.24

In the literature a compilation for the year 2018 was found and has been redrawn at Table 1 which shows the plastic which goes to landfill in Asian countries [2]. Since the research Lohani, 1984 who provided a review which was cursory that Asian countries are opting for Solid Waste Management [11]. These when compared with the statistics of Liang et al., 2021, shows that 40 years are not even sufficient to cater the issue of plastic waste [2]. The reason is probable population growth, increase in demand, easy availability of the material and so forth. Plastic produced from fishing gears and other also in parallel describes that marine areas are also being polluted at large. Deshpande, et al., have also depicted the increase of the adverse effect of social, economic, and environmental in Norway due to this plastic waste [24]. The people of China have also brought their thoughts for quantification of the waste produced from PET materials. This quantification shall enable proper recycling and waste management control to this menace. This idea has also been implemented in different areas of the world. As quantification reduces uncertainty and provides a relationship of demand and supple. In a small island of Grenada this idea was implemented by Elgie, et al., 2021, an economic model was devised and the advantage of the area was that everything is imported [25]. About 7421 tons of plastic was imported. The control highlighted that it is feasible to control the plastic once the original figures are in place.

The polyethylene amongst the other plastic is becoming an issue and in very near future it will become a problem [26]. Some uses derived for plastic also covers soil improvement. The properties of soil improve by optimizing Plastic-Eucalyptus wood char in soil [27]. This was recorded to increase the soil fertility making a sustainable use of the plastic. Environmental, social and economic aspect of this present day plastic problem requires a solid waste network discussed by Mamashli & Javadian, 2021, [28]. This study states that in order to manage the solid waste facilities which includes vehicles, equipment etc. are required to setup the system for recycling. The well-established factors determine the planning and implementation of recycling techniques The underutilization of the potential of waste is also waste [29]. The trend of construction waste and other waste are catered during execution of each project. However, the life cycle of plastic is still under debate and entails the attitude and assessment of the life cycle to be developed for plastic [30][31].

IV. MINIMIZING ENVIRONMENT CONCERNS DURING RECYCLING

The main source of waste comes from the Municipal Plastic Waste (MPW). A depiction of different portions of plastic in MSW is shown in Figure 3. In order to target the plastic waste and reduce environmental concerns the detail bifurcation analysis is required from source MSW. This identification helps reduce the effort of recycling and provides a target plastic for recycling. The bifurcation shows that MSW contains 8% of (PET) polyethylene terephthalate, about 10% (PVC) Polyvinyl Chloride and (uPVC) un-plasticized, about 30% of (HDPE) High Density Polyethylene & (LDPE) low density polyethylene, about 19% proportion of (PP) Polypropylene, (PS) Polystyrene in proportion of about 6% and other plastic of about 19% [32][33][34]. These plastics have a recyclable value. Polyethylene group is the largest to be available in the MSW and becomes an important nominee for use in recycling. The recycling of PE would reduce by 35-30% of the plastic waste. All plastics are not recyclable and many become amorphous prior to any treatment. In fact, due to presence of impurities the plastics after repetitive recycling degrade and are not stable. This is added with a touch of additive to improve the process. The additives not only give the required property but also provides a solution to reduce environmental concerns.

The plastic recycling is not easy and a proper set of skill development is required. The plastic recycling provides a large scale of employment and money minting solutions. The use of plastic extends to making toys and stationary items which also has a societal impact [20]. The leading sector for plastic reuse is undoubtedly packaging. [35]. Other than industry household also bears a quantum for recycling. Jiang, et al., 2021, have also highlighted that in present era social media can play a vital role to enlighten the societal drive for waste plastic management [36].

Recently in Bangladesh plastic PET bottles have been suggested as eco-friendly solution to replace bricks [37]. Plastic recycling advocacy is making its place in the construction industry in building, roads and other uses. Sharma and Bansal, 2016, used different type of waste plastic and used it in the concrete being used as additive usually provide crack arrest and decrease the strength component in concrete. This method utilizes the waste in the concrete such variants are not preferred for significant structural work. Sharma & Bansal, 2016, reviewed the compilations of different studies where plastic was used in concrete[38]. Plastic waste reutilization in construction industry is being studied for roads, soil improvement concrete filler and production of other building products. This industry shall provide a platform for a huge quantum of waste recycling.

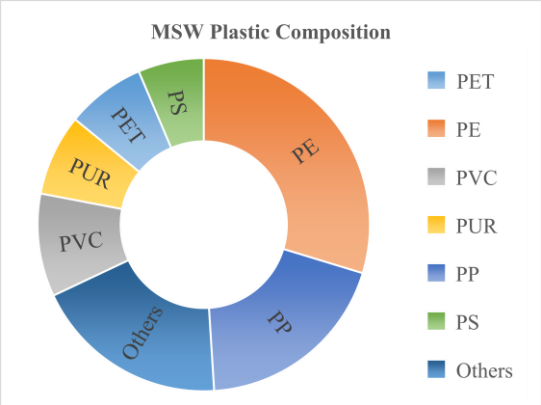

Figure 3: General Composition of plastic in MSW[32][33][34]

V. CONCLUSION

The plastic waste disposed produces landfill and pollutes the Environment. The Asian countries are generating waste plastic at large and if the issue is not addressed to complete the life cycle of plastic then this menace shall further create problems. The literature is evident that recycling methods does not completely eliminate all type of plastic waste. The present recycling methods also employ incineration which produces environmental hazards. The construction industry however can provide a sustainable solution for waste plastic reutilization. The societal aspect considering the present pandemic situation has gained much attention in providing awareness for plastic reuse. The involvement at individual level is required for plastic disposal. The present study shall form a basis to explore plastic reuse in construction industry to develop rebars, sheets, blocks and other construction variant.

VI. ACKNOWLEDGMENTS

Our thanks to thank CE department, Capital University of Science and Technology and members of SMaRG for providing assistance in the research.

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