Recycling Plastic Waste for Infrastructure Development: Insights and Practices

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ABSTRACT

The utilisation of plastics is the major concern in the present scenario, the consumption of plastics has increased drastically; consequently, the responsible disposal of plastic wastes has created serious social and environmental arguments. Recycling and re-refining are the applicable processes for the upgrading of plastic wastes by converting them into reusable products such as aggregates and liquefied petroleum gas (LPG).Plastics pyrolysis may provide for the disposal of plastic wastes with the recovery of valuable gasoline-range hydrocarbons. These pyrolytic products can be divided into a gas fraction, a liquid fraction consisting of paraffin, olefins, naphthene and aromatics, and solid residues. Plastic wastes can be classified as industrial and municipal plastic wastes (MPWs) according to their origins; these groups have different qualities and properties and are subject to different management strategies. The municipal solid waste (MSW) products include paper, containers, tin cans, plastics, aluminium cans, and food scraps, as well as sewage. MPWs normally remain a part of MSWs as they are discarded and collected as household wastes. Plastics usually account for about 7% of the total MSW by weight and much more by volume.

Keywords: *municipal plastic wastes (MPWs), liquefied petroleum gas (LPG), municipal solid waste (MSW)*

I. INTRODUCTION

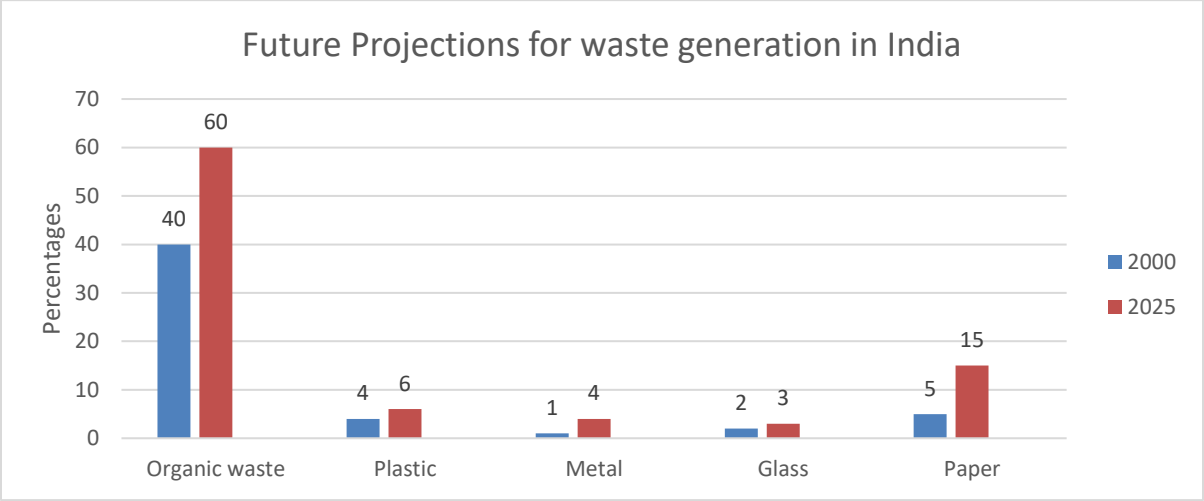
In India, statistics say that 25,940 tonnes of waste plastics are generated on a daily basis out of which approximately 80% of total plastic is discarded as waste, and 40% remains uncollected. It takes 450-1000 years for a plastic bottle to decompose. Recycling the waste plastic is the only feasible solution to reduce the adverse impact on the environment, destruction of ocean ecosystems, a threat to the lives of cattle and pollution of public spaces [2]. Recycling and re-refining are the applicable processes for the upgrading of plastic wastes by converting them into reusable products such as aggregates and liquefied petroleum gas (LPG). Possible acceptable processes are cracking and pyrolysis. The cracking process yields a highly unstable low-grade fuel oil which can be acid-corrosive, tarry, and discoloured along with a characteristically foul odour. The pyrolysis process consists of the thermal degradation of the wastes in the absence of oxygen/air.

Plastics pyrolysis may provide for the disposal of plastic wastes with the recovery of valuable gasoline-range hydrocarbons. In pyrolysis, the polymeric materials are heated to high temperatures, so their macromolecular structures are broken down into smaller molecules, and a wide range of hydrocarbons are formed. These pyrolytic products can be divided into a gas fraction, a liquid fraction consisting of paraffin, olefins, naphthene and aromatics, and solid residues.

Plastic wastes can be classified as industrial and municipal plastic wastes (MPWs) according to their origins; these groups have different qualities and properties and are subject to different management strategies. The municipal solid waste (MSW) products include paper, containers, tin cans, plastics, aluminium cans, and food scraps, as well as sewage. MPWs normally remain a part of MSWs as they are discarded and collected as household wastes. Plastics usually account for about 7% of the total MSW by weight and much more by volume. To recycle MPWs, separation of plastics from other household wastes is required. The waste products of industry and commerce include plastic, paper, wood, and metal scraps, as well as agricultural waste products [4].

The utilisation of plastics is the major concern in the present scenario, the consumption of plastics has increased drastically; consequently, the responsible disposal of plastic wastes has created serious social and environmental arguments Table 1 shows the contents of solid waste generated in India. Though the generation of organic waste and paper is more this type of waste is bio-degradable and won't cause any harm to the environment. But the plastics are a source which slowly degrades the underground soil leading to the groundwater and ultimately to human beings and environment.

Table 1. Prediction of the increase in waste generation in India



(http://blogs.nelson.wisc.edu/es112-311-3/2014/03/11/waste/)

Necessity of project

Increased utilization of plastics has been posing problems for the environment regarding the volume of the waste generated. Civic bodies have been facing problems in the collection, transportation and disposal of municipal solid waste due to rapid changes in the waste composition, urbanization and increasing per capita waste generation rates. The waste plastics due to their non-biodegradable nature have a negative impact on environment in the long run. The commonly practised methods for management of solid waste in India are open dumping and land filling. On disposing of the plastics in a combination of municipal solid waste, plastics pollute the soil, and in certain cases, they percolate through the soil reaching the groundwater table.

II. LITERATURE STUDY

With bitumen, showed improved binding property and poor wetting property. Roads constructed Increased utilization of plastics has been posing problems for the environment regarding the volume of the waste generated. Civic bodies have been facing problems in the collection, transportation and disposal of municipal solid waste due to rapid changes in the waste composition, urbanization and increasing per capita waste generation rates. The waste plastics due to their non-biodegradable nature have a negative impact on environment in the long run. The commonly practised methods for management of solid waste in India are open dumping and land filling. On disposing of the plastics in a combination of municipal solid waste, plastics pollute the soil, and in certain cases, they percolate through the soil reaching the groundwater table.

The fresh density of concrete containing plastic as fine aggregate and their results indicated that the fresh density of concrete containing 10%, 15%, and 20% plastic aggregate as a replacement of fine aggregate tends to decrease by 5%, 7%, and 8.7% respectively, below the reference concrete Ismail and Al-Hashmi et al. (2008).
Ahmadia et al. (2011) have examined the effect of waste plastic bottles (Polyethylene Terephthalate (PET)) on the engineering properties of stone mastic asphalt (SMA) mixture. Studies were carried out at various percentages of PET (0%, 2%, 4%, 6%, 8% and 10%). The results show that the addition of PET has a significant positive effect on the properties of SMA.

Köfteci et al. (2014) investigated the performance of bitumen modified by three groups of polyvinyl chloride (PVC) based waste plastics (window, blinds and cable wastes).

Experimental investigations were carried out at 1%, 3%, 5% replacement with a modifier. The results proved that the performance of the mixtures varied with temperature, PVC (from the window and blinds wastes) have shown

improved performance at high temperatures; whereas PVC (from cable wastes) have shown better performance at low temperatures.

Vasudevan et al. (2012) proved that softened waste plastics form a film like structure over the aggregate when it is sprayed over the hot aggregate at 160oC. In the construction of asphalt pavement, hot bitumen is coated over hot stone aggregate and rolled. Bitumen acts as a binder. When water is stagnated, over the road it penetrates and results in potholes, a defective spot on the pavement. Uses of anti-stripping agents have limited use only, and the process also increases the cost of road laying. Use of plastic as virgin as well as waste to modify the bitumen and also the use of PCA is being studied to find better results for the better performance of the pavement. The formed plastic-coated aggregate, when mixed using this method in various parts of Tamil Nadu (India) have proved to offer better performance as compared to conventional pavements. The studies have proved that the addition of shredded wastes to hot bitumen have improved the temperature susceptibility of bitumen by forming an oily coat over the aggregate.
Behl et al. (2014) have studied the properties of bitumen with addition of chemically modified waste PVC up to a level of 3% and 5% of bitumen. The results indicate that the strength and stability of the mix increased with the incorporation of PVC pipe waste.

Dohare et al. (2014) have studied waste plastic Pyrolysis oil represents a good alternative fuel and therefore must be taken into consideration in the future for transport purpose. This plastic oil has compositions similar to the existing primary hydrocarbons (i.e.-petrol, diesel and gasoline). Possible these oil products can be used directly for energy generation or in a refinery for reprocessing. The study of this paper concludes that prospects for using small or medium scale pyrolysis processes to handle the waste plastics appear reasonable, but more investigations are needed. Presences of P.E.T. and P.V.C. in mixed plastic waste are also a matter of concern. Contaminants and additives present in municipal plastic waste have adverse effects on environment, and they should be removed before the process.
Kofteci et al. (2014) studied, the effects of three PVC based waste materials on bitumen with an original penetration value 160/220 were examined regarding penetration, softening point, rotational viscosity (RV), dynamic shear rheometer (DSR), and bending beam rheometer (BBR) tests. As a result of the modifications for all three type modifiers, it was seen that with increasing amounts of additives, the penetration values decreased, and softening point values increased. This implies that the bitumen tends to get harder with additives.

Bajracharya et al. (2015) investigated the mechanical behaviour of mixed plastic solid waste under different loading conditions for utilisation as construction material using the coupon and full-scale specimens. From coupon test, the strength values were found to be 14.8, 19.8, 20, 5.6 MPa in tension, compression, flexure and shear respectively, while the modulus of elasticity is 0.91, 1.03, 0.72 GPa in tension, compression and flexure respectively. The results indicated that strength properties of mixed plastic solid waste were comparable to softwood structural timber indicating the feasibility for reuse. Indian road congress has suggested that the addition of modifiers such as plastics & rubber improves the properties of bitumen. Plastics in the form of carry-bags, disposable cups and PET bottles collected from garbage dumps have proved to be a feasible construction material.

Azhdarpour et al. (2016) have investigated the effect of plastic waste addition as a fine sand replacement on the engineering properties of concrete. The results of laboratory tests showed that the compressive, tensile, and flexural strength of samples increased when 5–10% of the fine concrete aggregates were replaced by the same percentage of PET fragments. Corinaldesi et al. (2015) have investigated the properties of plasters, where fine sand was replaced up to 100% by waste PET particles, wood particles and pulverized glass fibre reinforced plastic (GFRP) waste, respectively. The results proved that the plasters possessed low conductivity values reducing the energy consumption in construction.

Sahoo et al. (2018) studied that options for the recycling are conversion into raw material for the industry, fuel production and utilization as construction material. Utilization of recycled plastics in the construction sector provides ecological and economical benefits, due to the increasing demand for building materials. The present work investigates the feasible applications for the utilization of processed recyclable waste plastic materials in construction sector. Materials such as plastic coarse aggregate (PCA) and plastic fine aggregate (PFA) were processed from the plastic bottles generated in the university campus. The application of these materials in areas such as concrete production, block manufacturing, pavement construction and soil stabilization has been studied. The results were compared with natural fine aggregate (NFA) and natural coarse aggregate (NCA).

III. OBJECTIVES OF STUDY

- To investigate the properties of processed plastic coarse aggregate (PCA) and plastic fine aggregate (PFA) for their utilization as aggregate in concrete preparation and pavement construction.
- To study the mechanical properties of blocks prepared with PFA as substitute for fine sand.
- To develop a working laboratory model for capturing the released gases obtained from burning waste plastic.
- To analyse the fuel obtained from heating waste plastic.

IV. PROPOSED METHODOLOGY

- To prepare aggregates from waste(HDPE) plastic in a controlled environment.
- To perform all the lab tests like specific gravity, crushing value, abrasion tests etc.for the utilization of plastic as an aggregate in concrete preparation and pavement construction.
- To perform the mechanical property tests on prepared plastic aggregates of blocks prepared and compare with the blocks prepared from Normal Coarse aggregate..
- To perform compressive strength test of blocks prepared from PCA on Compression Testing Machine and compare with the standard blocks.
- For subgrade analysis, performing California Bearing Ratio test (CBR test) is best suitable and comparing it with standard aggregate model.
- For optimum binder content determination of Marshall's stability can be performed.
- To develop a working laboratory model for capturing the released gases and residue obtained from burning waste plastic.
- To analyse the fuel obtained from heating waste plastic.

V. CONCLUSION

- Most of the plastic energy exhausted by plastic deformation is converted into heat which when exposed to environment leads to harmfulness. Firstly, we have a reliable and efficient apparatus for performing and converting the waste plastic into the source of usefulness.
- Secondly, the output given by the setup in the form of flammable gases can be used as a source of heat generation.
- Further study can be done in determining type (LPG, LNG, etc.) and composition (Nitrogen, sulphur etc.) of heat energy generated and the work can be performed in the determining the type (organic/inorganic) of adsorbent. Also, a method could be suggested for storing the generated energy.

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