Recycling of Waste Plastics for Sustainable Environment

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***Abstract*:- The need for better use of waste plastics and rubber materials became paramount in the quest to facilitate sustainable water and sanitation management, owing to their large mass in pollution of water bodies, drainage, and other environmental arenas since there disposal is a serious issue.**

In this research, plastic waste collected from river channels and water bodies will be analyzed for better use. The focus will be on how high plastic production rate became a threat to the environment, detrimental effect of plastic wastes to natural environment, awareness by the public on how to discard their plastic wastes, reuse of plastic waste materials for sustainable building, and how its use affects general mechanical and durability properties of concrete. The feasibility of using waste plastics for lightweight concrete will be examined and various properties of resulting concrete addressed with a focus on durability and compressive strength of resulting concrete. Although concrete made from plastic waste is less strong than regular concrete, it can still be used for applications that require lightweight materials. When other recycling options are impractical or prohibitively expensive, it serves as an alternative to reduce waste production.

Keywords: Concrete, Waste, Plastic, Rubber, Environment, Biodegradable

INTRODUCTION

The rate of pollution of water body has generated a threat to existence to mankind. The recent flooding that occurred at KwaZulu Natal in South Africa in midyear 2022 has shown that uncontrolled waste disposal of plastic materials is a major threat to both aquatic animals and the humans around the environ. Macro plastic can be harmful by entangling or clogging the digestive tract of large animals, as well as by increasing the number of sea mammals and birds that are harmed or killed (Kögel et al., 2020). The primary negative effect of vertical transport of microplastics is the risk of reaching aquifer systems, which could have a significant negative impact on the local population and the natural environment (Campanale et al., 2022). Cleaner environments require effective water resource management and purification using liquid-based membrane processes for particles and macromolecules separation (al-Shaeli et al., 2022). Collected plastic wastes can be utilized into concrete for sustainable buildings.

GENEALOGY OF PLASTIC WASTE

Plastic materials came into high demand due to its acceptability in all face of life. The high rate of demand as shown in figure 1 shows there is need to control its production for a safer environment.

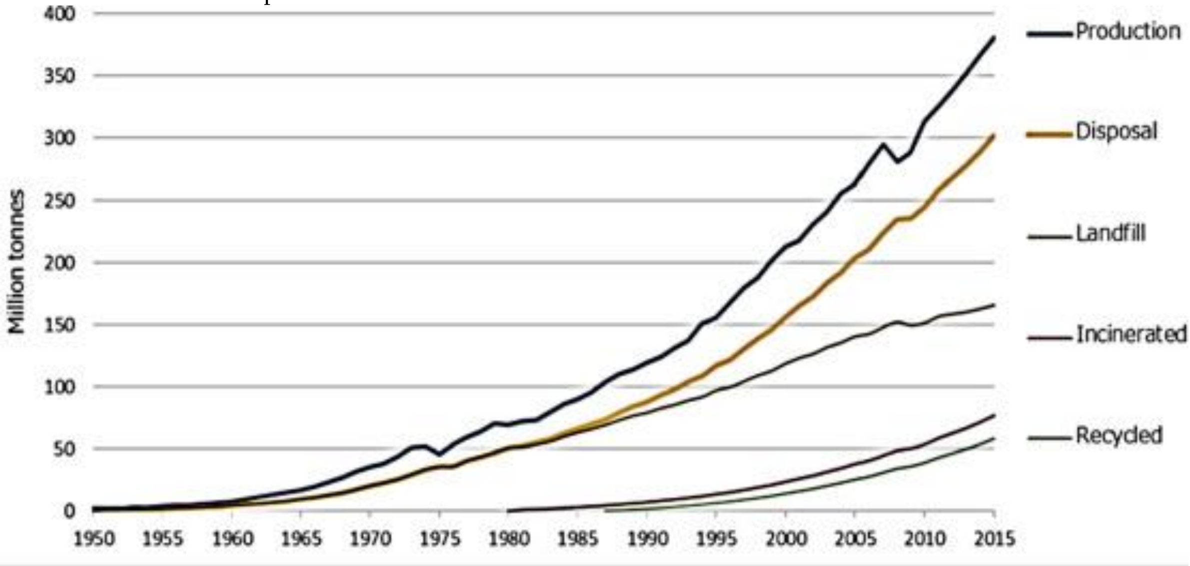

Figure 1. Annual Global Production and Disposal of Plastics (Ponmalar & Revathi, 2022).

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According to (Geyer et al., 2017; Rahman & Bhoi, 2021), Only 9% of the 6300 million metric tons of plastic waste that are produced globally are recycled, 12% are burned, and 79% are dumped in landfills and other natural areas, where they frequently end up in the oceans and endanger aquatic life. With India having increasing production rate of 1.5 to 2% annually, High single-use plastic usage increases the demand for virgin plastic, which raises carbon emissions and causes global warming, resulting in an imbalance in the climate (Ponmalar & Revathi, 2022).

Effect of microplastics on environment

One of the most crucial components of the terrestrial environment is the soil-plant system, which sustains the entire biosphere. Microplastics in soils, particularly agricultural soils, may have an impact on the growth of plants, including edible species, raising questions about food security (Campanale et al., 2022). Specifically, plastic trash is not biodegradable and its chemical composition remains stable for a number of decades in the environment, on land, and in water bodies (Ponmalar & Revathi, 2022). Due to its unchanging chemical composition over long period, the plastic waste needs to be reused in its solid state to promote a safe environment.

HANDLING OF PLASTIC WASTE FOR CLEANER ENVIRONMENT

Biodegradable plastics

Plastics classified as biodegradable can be broken down by microorganisms into CO_2, CH_4, and microbial biomass. Recent research has focused on biodegradable plastics (BPs) because of their potential for biodegradability and safety, which would be the most efficient way to handle the problem of environmental accumulation of plastic waste (Shen et al., 2020). Both fully degradable and destructive biodegradable plastics can be used in biodegradable products. Agricultural plastic mulches, single-use items, and packaging are the main applications for biodegradable plastics. Since many areas still use other types of plastics, the use of biodegradable plastics is not a permanent solution to waste disposal (Flury & Narayan, 2021).

Non-Biodegradable Plastics

Pyrolysis is a method adopted in processing non-biodegradable wastes. It involves the breaking down of long chain polymers with the application of heat. This process can be with the use of catalyst (Catalytic Pyrolysis) or in the absence of catalyst (Thermal pyrolysis). The process involves the application of heat at ranging reaction temperature. The process seems costly and requires proper monitoring owing to the high temperature and toxic chemicals involved (Dwivedi et al., 2019).

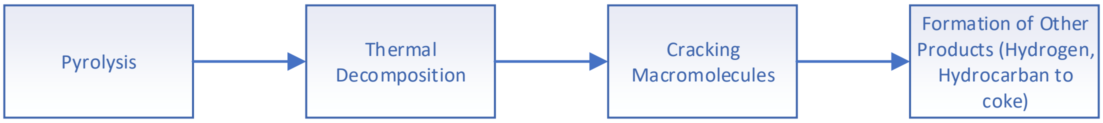

Figure 1: Pyrolysis Breakdown for non-degradable waste

Reuse of plastic waste for sustainable buildings

By conserving energy and resources, recycling materials, reducing emissions, realizing significant operational savings, and boosting workplace productivity, plastic bottles can contribute to green construction. The use of plastic bottle vertical garden ideas and growing plants. In this manner, one can utilize those used bottles that would typically discarded to grow plants indoors or outdoors and contribute to environmental preservation (Jalaluddin, 2017).

As seen in Table 1, plastic waste has been used as partial replacement of both fine and coarse aggregates with resulting concrete that is lightweight but lesser compressive strength compared o normal or conventional concrete.

Table 1: Some notable use of plastic waste in concrete

Researcher	**Replacement Material**	**Methodology**	**Observation**
(Bansal et al., 2017)	Bitumen replacement with waste plastic. Bitumen heated to 200ºC and 220ºC in pre-determined proportions	Bitumen at its best Contented with waste plastic (4%, 6%, 8%, and 10%) and crumb rubber (5 percent, 10 percent and 15 percent)	Increase in strength by 50%
(Eldin & Senouci, 1993)	Rubber particles are used in place of coarse and fine aggregate.	By replacing the aggregate and sand with rubber, 35N/mm^2 Portland cement concrete was determined.	For coarse aggregate, the compressive strength is reduced by 85% and the tensile strength is reduced by 50%. When crumb rubber is used in place of sand, compressive strength is reduced by 65%. (fine aggregate)
(Fahad et al., 2020)	Plastic waste used as replacement of coarse aggregate	Replacement of coarse aggregate with 0, 2.5, 5 and 10% of coarse aggregate.	Decrease in compressive strength by 12%, 29% and 47% for 2.5, 5, and 10% replacement respectively.
(Abubaker et al., 2017)	Waste rubber tyres as coarse and fine aggregate replacement	Tyres are cut into 20mm max size for coarse and crumb rubber as fine aggregates in 25m 50, 75 and 100%	Rubber-made concrete has a lower compressive strength than normal concrete and is advised for use in areas like landscapes and sports fields because of its elastic failure behavior.
(Khan & Singh, 2018)	Waste rubber as fine aggregate replacement	Replacement of fine aggregate in 0, 5, 10, & 15%	Decrease in compressive strength recorded,

Table 2: Plastics used in concrete: Their nature and usage, compiled from published works (Ponmalar & Revathi, 2022).

Plastic Type	**Density (kg/m^3)**	**Specific Gravity**	**Water Absorption (%)**	**Melting point & Softening point (°C)**	**Decomposition Temperature (° C)**	**Thermal Conductivity @ 25°C W/mK**
Polyethylene	910 - 925	0.92	0	105 - 115	289 - 335	0.4
Polypropelene	900 - 990	0.99	0	140 - 160	271 - 329	0.11
PVC	1380	1.2	0	100 - 260	200	0.19
PET bottles	1300 - 1400	0.91	0.001	160 - 260	300 - 570	0.15
HDPE	930 - 970	0.95	0.001 - 0.01	130 - 180	390 - 490	0.44
MPBW (made with plastic bag waste)	530	0.87	0	100 - 120	289 - 335	0.4
Polystyrene	1050	1.05	0	110 - 140	300 - 350	0.033
Polyamide 6	1084	1.084	0	233	350 - 500	1.95
Linear low-density polyethylene	910 - 925	0.92	0	123	370 - 465	0.32
Low-density polyethylene	915 - 945	0.92	0	115	370 - 450	0.33
Crushed plastic bottles	920	0.8	less than 0.2	170 - 180	300 - 570	0.24
HD-PET (Thermoplastics	940	0.889	0.02	125	260	0.43
LLDPE + red dunes sand	750	1.54	2.75	115	400	0.33
Virgin PP granule	900	0.9	0	230	400	0.11
Recycled PP granule	900 - 920	0.915	0	165	2400	0.11
HDPE granule	957	0.95	0	120	460	0.4

Source: (Ponmalar & Revathi, 2022)

The use of waste plastics in concrete as seen from various related works in Table 2 shows different characteristics and types with each one having unique density, melting point, thermal conductivity and specific gravity.

Effect of concrete produced with plastic on density

Concrete made from waste plastic has a lower density than conventional concrete, on average (Hameed & Fatah Ahmed, 2019). There is similar specific gravity of (0.9–1.34 g/cm^3 and 0.51–1.2 g/cm^3) respectively between plastic and rubber when used as aggregate replacement (Fahad et al., 2020; Li et al., 2020). This is due to the lower weight of plastic material compared to the aggregate replacement.

Effect of plastic on strength of concrete

The compressive strength of concrete reduces with an increase in plastic bottle fibre. According to Ali et al. (2021), the compressive strength of concrete is reduced when observed after 28days up to 70% reduction was reported.

There is an initial increase in flexural strength of concrete incorporating plastic as a partial replacement rises to 5% while further increase displays a reduction in flexural strength. When plastic is used as a partial replacement for aggregate in concrete, the split tensile strength of the concrete increases between 1% and 7% (Hameed & Fatah Ahmed, 2019).

CONCLUSION

The quest to produce a greener environment and safe water body has necessitated the use of plastic waste material as a concrete material in order to control its hazardous impact in the ocean and environment. Even though plastic production has been increasing with little efforts in recycling, the huge dirt in the environment warrants proper handling. Concrete strength tends to reduce with addition of crumb-rubber owing to differences between the modulus of elasticity and relatively poor interfacial transition. The use of recycled rubber tyres and plastic bottles improves the strength and overall durability of bituminous concrete.

It is evident that plastic and rubber waste can be used in the production of light weight concrete for sustainable building without any environmental hazard. Apart from its basic use in biodegradable and growing of plants indoor and outdoor, proper management of plastic waste will reduce the harmful effect on human environment, aquatic life and ocean body at large.

RECOMMENDATIONS

As a discrete reinforcement, mixed plastic works well. When used as a replacement for coarse aggregate, PET aggregates have a lower elastic modulus and a lower density of concrete.

Higher workability due to plastic's low water absorption capacity. When compared to other replacement ratios, 10% replacement of coarse aggregate with plastic results in higher compressive strength and modulus of elasticity. With plastic addition, flexural strength is reduced, as is split tensile strength, which accounts for about 8-11 percent of the resulting compressive strength.

To reduce pollution of the environment caused by large amounts of waste generated by plastics, recycling of biodegradable plastics is required, and when the cost of producing facilities for pyrolysis treatment is prohibitively expensive, the use of this waste as light weight concrete is recommended.

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