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Utilization of Plastic Waste into Eco-Brick & its Comparison with Respect to Conventional Brick: A Review

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Abstract: The disposal of enormous quantities of plastic bottles has become a major environmental issue, and recycling them is proving difficult due to their non-biodegradable nature. In India, urban and rural area people use plastics in day-to-day life but they don't reuse them. The proportion of plastic junk in our environment is continually rising since plastic does not breakdown organically. Plastic garbage has recyclable characteristics that may be used to recycle it and create a new product that has a lower environmental effect. This paper spiel about both recycling of plastic bottle waste into Ecobrick as well as comparison with conventional bricks to overcome the problem of plastic disposal in environment.

Keywords: **Plastic waste, Eco-friendly, Thermoplastic, PET, Ecobrick.**

Introduction:

Trash is a widespread issue; nowadays, most nations throughout the globe are grappling with sustainable waste management, particularly plastics trash, which takes decades to disintegrate correctly. Worldwide plastic output now exceeds 300 million tones average annual [1]. According to estimates, there seem to be 150 trillion pieces of polyethylene in the ocean, between additional 250 million tonnes expected to add to the load of marine debris as the world's population grows [2]. After China, the United States is currently the second-largest producer of plastic garbage. In 2010, the United States accumulated around 37.83 million tonnes of plastic garbage, including over 2,75,000 tonnes of litter. The US burns around 6 times as much polyethylene garbage as it replenishes. The United States, along with other nations such as Canada and the United Kingdom, is infamous for exporting plastic waste to Asian countries in order to unload their problem onto someone else.

In the earlier, glass was commonly used to package meals such as milk and other liquids. They might be later returned to the manufacturer and used for the same purpose again. Glass bottles have been replaced with plastic bottles as a result of a shift in urban disposing culture, since they have progressively become one of the most landfill's most destructive items due to their slow decomposition. Recycling and reusing plastic bottles are two alternatives to plastic bottle disposal. Recycling necessitates the use of more energy to process the materials in order to produce something useful. Furthermore, the recycling process generates effluent and pollutes the air. As a result, the ideal alternative is reuse, which requires no more energy and does not contribute to pollution. The worldwide promotion of the plastic trash reduction campaign is presently underway.[3] According to the Central Pollution Control Board (CPCB), India's overall plastic trash collection and recycling rate is estimated to be 9205 tonnes per day (about 60% of total plastic garbage), with 6137 tonnes (40%) remaining uncollected and littered. As per a poll released in 2010, around 5% of all plastic garbage created in coastal nations dumped into the oceans. That is a significant sum to endanger marine life.[4]

- **Plastic**

  Petrochemicals are used to make plastics. These substances do not belong in the ecosystems that surround us. We know these compounds are hazardous to people because we smell plastics burning, according to scientific research.

  Plastics that are discarded, burnt, or disposed eventually breakdown into these toxic compounds. They eventually find their way to us, where they cause birth abnormalities, hormone imbalances, and cancer. Even specially designed disposal sites

aren't a viable option. These toxins will ultimately permeate into the biosphere, hurting our crops and families, whether it takes 10 years or a hundred.[5] The only way to lessen the dangers of plastic is to use it less and reuse it more.[6]

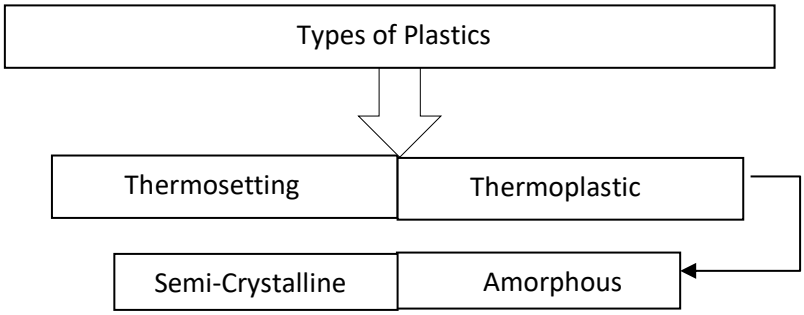


Fig.1 Type of plastic

Table.1 Type of Plastics and its uses

Type of Plastic	Full name	Used
1.PET	Polyethylene Terephthalate	Water bottles, jars, Caps
2.HDPE	High-Density Polyethylene	Shampoo bottles, Grocery bags
3.PVC	Polyvinyl Chloride	Cleaning Products, Sheets
4.LDPE	Low-Density Polyethylene	Bread bags, Plastic films
5.PP	Polypropylene	Straws, Hangers, yogurt cups
6.PS	Polystyrene	Take Away & Hard Packing Toys
7.OTHERS	Others	Baby bottles, Nylons, CDs

[4]

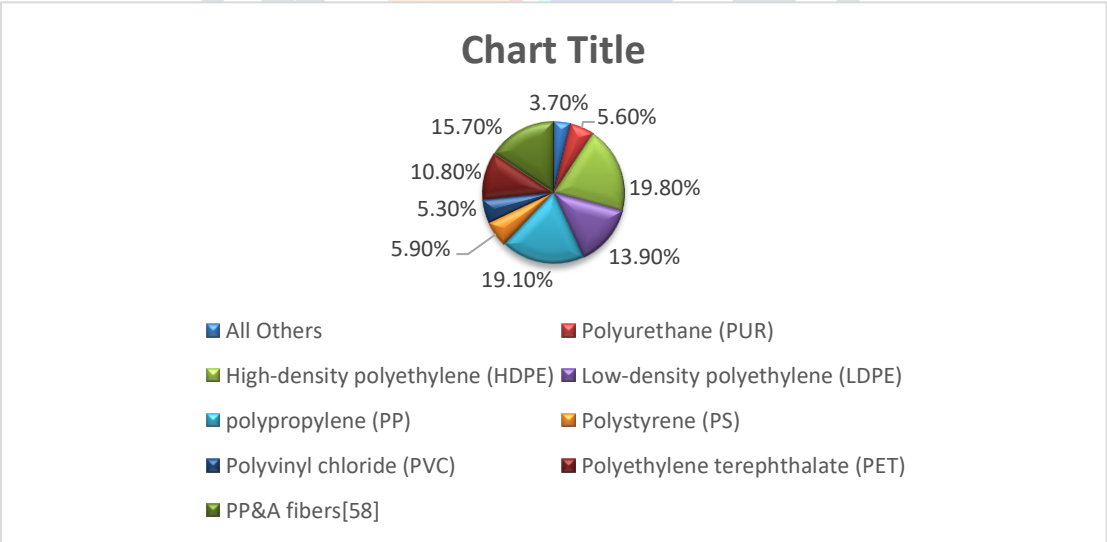


fig.2 Global plastic waste production by polymer type (2018**)**

- Table.2 Utilization of Plastic in India

Municipal solid waste generated annually	55-65 Mn tonnes
Plastic waste generated annually	3.3 Mn tonnes
Plastic waste generated daily	9200 Mn tonnes
Plastics Used for packing	43%
Avg. annual per capita consumption of plastic	11kg

Source – CPCB 2018-19 *Million Tonnes

- Table.3 Biggest Contributors of Plastics Waste Among States

STATES	TPA
Maharashtra	443724 TPA
Tamil Nadu	431472 TPA
Gujrat	408201.08TPA
West Bengal	300236.12 TPA
Karnataka	296380 TPA

Source – CPCB 2019-20 *Tonnes Per Annum

- **Plastic waste recycling classification**.

- Primary recycling, which involves re-extrusion of homogenous plastic, is not suitable for post-consumer trash. Secondary recycling involves sorting garbage and reprocessing it into pellets that may be used to replace virgin plastics on the market. For more complicated mixed wastes, tertiary recycling is necessary, since the polymers must be depolymerized into basic molecules that may be utilized as a raw material for primary plastic manufacturing. When evaluating possibilities for plastic treatment and reuse, all procedures each had their own ecological implications that must be evaluated.[7]

- Table.4 Plastic waste recycling classification

Type	Description	Disadvantages
Primary	Industries wasted plastic wastes are re-extruded. Post-consumer plastic wastes were not included since this procedure requires a high degree of uniformity.	Post-consumer plastic wastes are ineligible for use.
Secondary	The recoverable plastics are mechanically recycled. These are polyethylene wastes collected from (retail) customers that are separated and recycled into single polymer pellets, granules, or flakes that are intended to replace virgin plastic on the marketplace.	Plastic wastes must be clean and dry, ideally consisting of only one type of plastic polymer
Tertiary	Plastic wastes are depolymerized and broken down into monomers and other basic chemical components that can be utilized as raw materials for primary plastic production using pyrolysis and/or hydrolysis processes. This produces oil and gas, which may be used as a fuel.	High energy consumption due to heat requirements. Uses chemical reagents with negative environmental impacts

[7]

- **Ecobrick**

An ecobrick is a PET bottle that has been solidly filled with clean, dry used plastic. To encapsulate plastic and generate reusable construction blocks, Ecobricks are hand constructed to a specified density.

- Table.5 Property of PET material

Colour	White or light cream material
Density of plastic	1.33220 gm/cm^3
Melting point	255 to 265 ˚C
Solubility	Insoluble in water

[6]

❖ **Manufacturing of Ecobrick**

- **Clean, Save & Dry Plastic**

  Ecobricks are constructed of dry and clean polyethylene. Begin by separating plastic from the rest of belongings. Some ecoterrorists carry a bottle with them everywhere they go. Others put their biodegradable plastic in a container until they have time to deal with it. If plastic has any food, grease, or dirt on it, make sure to wipe it clean. Microbiological proliferation and the formation of methane in an ecobrick are both caused by dirty plastic. Because Ecobricks are frequently utilized in household furnishings, try to avoid unattractive & distended bottles. It's also crucial that the plastic be completely dry. Microbial development can also be aided by wet and damp plastic. Ecobrikers employ a variety of techniques to dry their cleaned plastic, ranging from washing machines to clothes lines.[8]

- **Selection of bottles**

Plastic bottles come in a variety of sizes, including 500 ml, 750 ml, 1 liter, 1.25 liter, and 2-liter bottles. The most optimal bottle size was discovered to be 500 ml. This decision was made for a variety of reasons. Manually packing a bigger bottle is really tough. When packaging the bottle by hand, the pressure applied by the stick to condense the plastic into larger bottles is difficult to achieve. Bigger bottles can also come in a range of sizes due to their larger capacity, which allows them to alter the form of the bottle. The 500 ml bottle guarantees that the bottles' geometry is typically uniform.[8]

- **Packing Material**

  It is ideal the trash used as packaging material be made of plastic. Some people advocate utilizing any home garbage, although most non-plastic household waste does not decompose as quickly as plastic. Any material degradation can affect the compaction of garbage within the bottle, compromising the structural integrity of the brick. Cling film and food wrappers are examples of plastic that may be utilized. The plastic used to fill the bottle must be generally clean and dry at all times. This is critical because food particles can lead to the formation of mold and other uncontrollable germs. The bulk of food packaging/garbage, on the other hand, only requires a simple shake to eliminate the majority of the contaminants.[8]

- **Tamping of material**

  When producing Eco-bricks, it's best to maintain a fixed number of taps (rods/long wood) on hand to compress the plastic into the bottle; each piece of plastic will require around 4 to 6 taps. When making a brick, it takes less work to crush the plastic at first, but as more is added, it becomes clear that the trash requires greater energy to compress. The 4–6 taps are merely a recommendation; once tapping the procedure starts, Ecobrikers realize that they need more taps to compressed the plastic products.[8]

- **The methodology for new packaging**

  When starting the packing procedure, ensure you have the right ‘stick' for the task. It must be capable of reaching the bottom of the bottle while avoiding the risk of shattering. It must also have a diameter that will fit inside the bottle and have enough friction to reach the bottle's inner rims. The stick must be long enough to guarantee that one can maintain a firm grasp on the stick until it reaches the bottom of the bottle. Given the various lengths of 500 ml bottles available, a metal rod with a diameter of 12–16 mm and a length of 350–500 mm is recommended. A wooden stick might be used instead, but the metal's weight minimizes the amount of physical effort required to load the waste. This boosts the force that is given to the bottle, making production easier. Starting with little amounts of garbage and alternating between adding plastic and compacting it with the stick is the best way. The bottle must be rotated while pressing down while compacting with the stick to ensure that the trash is equally crushed throughout the container.[8]



Fig.3 Flow chart of steps to manufacture eco-brick

- Table.6 Weight of the bricks

Bottle Volume	Target Weight
330ml	110g
420ml	140g
500ml	167g
900ml	300g
1L	333g
1.5L	500g
2L	666g

[9]

- **Properties**
- **Wall Stability from a Structural Perspective**

Research was done on a wall with a height of 3 meters and a thickness of 300 millimeters. The wall was built out of air-filled bottles and then evaluated for structural integrity. The results showed that the wall can withstand nearly half the load of individual blocks, which might be attributable to mortar interlocking.[10]

- **Insulation from sounds**

The sound absorption coefficient (α) is the ratio of the sound energy absorbed by a material (E) to the net sound energy previously diffused and hitting the surface of the specimen (E_0).
It's written as: $\boldsymbol{\alpha = E\ E_0}$.
Ecobricks sound insulation properties were tested in a study. The sound index cannot be calculated unless a whole room of eco bricks has been created. The investigation was carried out to determine the sound reduction index. Eco-bricks, cement blocks, and sand bricks were compared. When compared to sand bricks and concrete blocks, the eco-bricks have the lower sound absorption index.[10]

- **Thermal Shrinkage**

Eco-bricks might be utilized in walls and roofs as nonstructural materials. As a result, it's critical to track any volumetric changes in Eco-bricks as a result of temperature variations that might compromise the structural parts' integrity. To account for these changes, radial thermal shrinkage, r, is calculated using Equation 1.

$$\Delta\varepsilon r = r_{final} - r_{initial} \mid r_{initial} \quad (1)$$

Where $r_{initial}$ and r_{final} are the radius of the Eco-brick measured at a certain height at the start and end of the thermal shrinkage test, respectively. The shrinkage calculation and thermal shrinkage test technique for Eco-bricks were developed from a standardized test for measuring longitudinal shrinkage of plastic tubes. [11]

All samples were tagged at three distinct heights: 1) at the cap, 2) in the middle part, and 3) towards the finish. Following that, a three-stage approach was used to determine radial changes in Eco-bricks as a result of temperature differences. First, at room temperature (23.5°C), the diameters of each sample were measured at the precise heights noted on each sample. The samples were then immersed in water for 48 hours. Heaters were used to modify the temperature of the water, which was then regulated automatically by a thermostat. The water's temperature profile was 35°C for the first 24 hours and 65°C for the next 24 hours. Third, samples were chilled to room temperature (23.5°C) for 24 hours. Then, at the particular heights noted on each sample, final diameters were determined.[11]

- **Comparison between Conventional Brick & Eco-brick**

J. Taaffe et al. conducted experiments to characterise some of the features of bricks, such as compression testing, sound insulation evaluation, and light transmission, and compared them to typical building materials and circumstances.

- Table.7 Bottle and brick weights, as well as compressive stresses at failure [12]

S.no	Bottle weight (g)	Brick weight (g)	Compressive force (kN)
Specimen 1	26	250	35.1
Specimen 2	25	247	34.6
Specimen 3	26	258	39.3
Specimen 4	27	260	40.1
Specimen 5	25	251	35.3

- Table 7.1 Compressive strength at failure, as calculated.[12]

S.no	Compressive force (kN)	Area (m2)	Strength (MPa)
Specimen 1	35.1	0.0136	2.59
Specimen 2	34.6	0.0136	2.55
Specimen 3	39.3	0.0136	2.90
Specimen 4	40.1	0.0136	2.96
Specimen 5	35.3	0.0136	2.60

- Table 7.2 Specific strengths of Eco-bricks.[12]

S.no	Pressure (MPa)	Bulk mass per unit volume (kg/m3)	Specific strength (kN m/kg)
Specimen 1	2.59	500	5.18
Specimen 2	2.55	494	5.17
Specimen 3	2.90	516	5.62
Specimen 4	2.96	520	5.69
Specimen 5	2.60	502	5.19

PET bottles had previously been regarded as an addition for constructions units; however, Eco-bricks may also be utilised for ornamental reasons in communal places such as parks. Other conceivable uses include determining the effectiveness of Eco-bricks in stabilizing soil, or as barriers.[12]

- **Conclusion**

From the study it can be stated that Eco-bricks have compressive strength that is comparable to that of ordinary bricks. When sufficiently compacted, PET bottles filled with domestic plastic garbage can be used as a construction material in place of conventional bricks. When compared to conventional bricks, the strength metrics of filled plastic bottles are on the upper end. The eco-bricks are lightweight and have the same thermal qualities as regular bricks.

REFERENCES

1. Ariyani, D., Warastuti, N., & Arini, R. N. (2020). Ecobrick Method To Reduce Plastic Waste in Tanjung Mekar Village, Karawang Regency. *Civil and Environmental Science Journal (CIVENSE)*, *4*(1), 22-29.
2. World Economic Forum, "The New Plastics Economy Rethinking the future of plastics," 2016.
3. Gawande, S. M., Gholap, V., Dimble, M., Gondkar, M., & Jamdar, V. Waste Plastic Bottles Offering Innovative Material with Sustainable Application in Safe Guard Tree.
4. Kumar, R., Kumar, M., Kumar, I., & Srivastava, D. (2021). A review on utilization of plastic waste materials in bricks manufacturing process. *Materials Today: Proceedings*, *46*, 6775-6780.
5. Kamble, S. A., & Karad, D. M. (2017). Plastic bricks. *Int J Adv Res Sci Eng*, *6*(4), 134-138.
6. Raut, A., Patel, M. S., Jadhwar, N. B., Khan, U., & Dhengare, S. W. (2015). Investigating the application of waste plastic bottle as a construction material: A review. *Journal of Advance Research in Mechanical & Civil Engineering (ISSN: 2208-2379)*, *2*(3), 86-99.
7. Alhazmi, H., Almansour, F. H., & Aldhafeeri, Z. (2021). Plastic waste management: a review of existing life cycle assessment studies. *Sustainability*, *13*(10), 5340.
8. Taaffe, J., O'Sullivan, S., Rahman, M. E., & Pakrashi, V. (2014). Experimental characterisation of Polyethylene Terephthalate (PET) bottle Eco-bricks. *Materials & Design*, *60*, 50-56.
9. "Use Your Plastics to Make an Ecobrick and Save the Environment." *Use Your Plastics to Make an Ecobrick and Save the Environment*, www.familiesonline.co.uk,20Mar.2022, https://www.familiesonline.co.uk/local/shropshire/in-the-know/use-your-un-recycable-plastic-to-make-an-eco-brick-and-save-the-environment.
10. Sharma. H. (2017). Innovative and Sustainable Application of PET Bottle a Green Construction Overview. *Indian Journal of Science and Technology*, 10(16), 1–6.
11. Antico, F. C., Wiener, M. J., Araya-Letelier, G., & Retamal, R. G. (2017). Eco-bricks: a sustainable substitute for construction materials. *Revista de la Construcción. Journal of Construction*, *16*(3), 518-526.
12. Taaffe, J., O'Sullivan, S., Rahman, M. E., & Pakrashi, V. (2014). Experimental characterisation of Polyethylene Terephthalate (PET) bottle Eco-bricks. *Materials & Design*, *60*, 50-56.