Nature Environment and Pollution Technology
An International Quarterly Scientific Journal
p-ISSN: 0972-6268
(Print copies up to 2016)
e-ISSN: 2395-3454
Vol. 24 | No. 1 | Article ID B4210 | 2025
Original Research Paper
https://doi.org/10.46488/NEPT.2025.v24i01.B4210
Open Access Journal

Waste to Wealth: An Approach Towards Sustainable Construction from Pollutants

Kasturima Das†, Bikramjit Goswami and Girija T. R.
Dept. of Civil Engineering, Assam Don Bosco University, Azara, Guwahati, Assam, India
†Corresponding author: Kasturima Das; kasturimadas@gmail.com

Abbreviation: Nat. Env. & Poll. Technol.
Website: www.neptjournal.com

Received: 17-05-2024
Revised: 05-07-2024
Accepted: 14-07-2024

Key Words:

Sustainable products
Pollutants
Non-degradable pollutants
Green construction

Citation for the Paper:

Das, K., Goswami, B. and Girija, T. R., 2025. Waste to wealth: An approach towards sustainable construction from pollutants. *Nature Environment and Pollution Technology*, 24(1), B4210. https://doi.org/10.46488/NEPT.2025.v24i01.B4210

Note: From year 2025, the journal uses Article ID instead of page numbers in citation of the published articles.

ABSTRACT

The global construction industry faces significant challenges related to environmental sustainability and resource scarcity. Researchers are increasingly exploring innovative approaches to repurpose waste materials, aiming to mitigate environmental pollution while producing value-added construction materials. This paper reviews the sustainability of current methodologies for synthesizing construction materials from pollutants, considering industrial by-products, post-consumer waste, and pollutants as potential feedstocks. The evaluation focuses on various recycling, upcycling, and bioconversion techniques, assessing their environmental and technical feasibility. The paper also discusses case studies of successful implementations and emerging trends in the field to highlight practical applications and future research directions. Ultimately, the paper advocates for sustainable practices in the construction sector by promoting a circular economy model, where waste is transformed into valuable resources, fostering wealth development.

INTRODUCTION

Sustainable construction improves the environment by consuming less energy and making less waste in buildings. This makes the industry more resilient, uses fewer natural resources, and requires less maintenance. The materials used in the construction of structures under sustainable construction take social, economic, and environmental factors into consideration (Zavadskas et al. 2018, Figueiredo et al. 2021). They are significant in energy consumption and environmental impacts with their emphasis on fire performance, environmental impact, and structural performance. So, environmentally sustainable and green construction methods help make the construction industry more sustainable.

Ecologically friendly building materials have several benefits. They reduce energy consumption, waste, and harmful impacts on public health and safety in environmental ways. They make the industry resilient and better at using local resources; besides, they are more durable (Danso 2018). Sustainable building materials help to reduce life-cycle costs and have lesser adverse environmental impacts, apart from helping to enhance building health and safety. They also help to reduce harm to humans, lessen the effect of climate change, create less solid waste, improve thermal comfort and flexibility, cause more use of local resources, create homes for all, and use less upkeep. Finally, they reduce the financial stress and economic impact on buildings by increasing energy efficiency (Sahlol et al. 2021).

Sustainable building materials provide an important means of cutting pollution and damage to the environment. Their advantages, therefore, far outweigh their disadvantages, which include greater energy consumption, costs, and resource stress; further problems include carbon emission and design regulation. Among the many advantages are a smaller carbon footprint, involvement with the people, economic success, and resilience to climate change. Although there are disadvantages, including higher costs and the need for skilled labor, this would make construction project decisions more definite if these are realized in tandem with their advantages. Making sustainability a priority not only reduces ecological destruction but also leads to broader achievement of advancement toward a constructed environment that is more resilient and ecologically responsible (Porfiriev et al. 2017).

Research Gap: Currently, many housing corporations have shown tremendous promise in prioritizing sustainable construction. However, as a result of certain unavoidable requirements, be it skilled labor or complicated treatment processes involved with the usage of sustainable building products such as the acquirement of driftwood and chemical treatment of bamboo, construction projects become somewhat expensive, repelling both contractors as well as buyers from these initiatives. This calls for means of recycling waste in a way that not only saves and uplifts the environment but is also light on the pocket. The present study thus focuses on techniques that utilize plastic waste in a manner that not only reduces the landfill burden but also enhances structural stability as well as the strength of the constructed structure.

Objectives of the Study: Sustainable production of building materials from waste resources, like plastic, fly ash, and industrial by-products, by recycling through creative techniques like carbon capture and utilization constitutes a way of producing environmentally compatible substitutes from pollution. End products may be made by such creative techniques, which can be turned into strong and resource-efficient building components, thus reducing their footprint on the environment. The primary objectives of this investigation are

- To show the viability of turning waste resources into building materials that can be used.
- To illustrate the strength, resilience, and other important characteristics of materials synthesized from pollutants.
- To reduce the environmental pollution.

Impact of Sustainable Construction Materials on Building Resilience

Building resilience needs durability more than functional durability. Materials such as PVC increase vulnerability, enable stressor recovery, enhance environmental and life-cycle performance, and increase durability. This makes them resilient and constructive to all cities and helps in turning metropolitan areas into resilient cities. Since compressed plastic structural components are cheap and eco-friendly, they may significantly increase the earthquake resilience of a building due to their ability to insulate well against heat, sound, and moisture. In addition to significantly affecting energy use and environmental impacts, sustainable building materials reduce the amount of waste generated, improve industrial resilience, and increase usability (Porfiriev et al. 2017, Marjaba & Chidiac 2016).

Building resilience is made possible through the use of sustainable building materials that include reclaimed wood, bamboo, recycled steel, and straw bales. These materials are durable, energy-efficient, and environmentally friendly, which makes the buildings very resilient against adverse weather conditions and natural disasters. Developers and engineers can make buildings resilient against natural disasters, climate change, and other hazards using these materials. These materials also promote the long-term sustainability of the built environment and are non-degradative, thus reducing the environmental impact of buildings. Such structures could be designed to adjust to environmental changes and remain usable and durable even after many decades. Incorporating resilience elements into sustainability programs helps reduce dependence on single sources of raw materials and the strategic location of the goods to reduce supply chain interruptions. In general, using sustainable building materials increases structural integrity, reduces the environmental impact, and brings about long-term sustainability, all of which increase building resilience (Satterthwaite et al. 2020).

Economic Advantages of Using Sustainable Construction Materials

Eco-friendly building materials are financially beneficial in many ways. Building materials of this nature have high productivity, high added value, and high resource efficiency in developing countries, which in turn promotes GDP development and economic growth. The building owner can enjoy an all-round long-term cost benefit because these reduce the life cycle costs of construction projects. They promote energy efficiency, which translates into reduced operating costs and electricity bills (Liu et al. 2020). Moreover, the use of sustainable materials serves to enhance the environment since it reduces the output of waste and carbon emissions, both of which enhance living and working conditions. Moreover, demand for properties made from sustainable building materials becomes higher since such materials attract eco-conscious renters and buyers (Eco-Tech Building Solutions 2024). This results in a higher market demand for and value of the property. Sustainable building materials make the property more marketable and attract higher levels of occupancy. Building owners and developers can reap monetary rewards through increased rental rates and property prices that come about because of this enhanced marketability (Marchese et al. 2018).

Such government incentives, for instance, include grants and tax concessions, among others. For instance, corporations like the Indian Green Building Council (IGBC) and Green Rating for Integrated Habitat Assessment (GRIHA) have stepped up to encourage such sustainable construction trends. Certifications received from both these corporations help get significant tax rebates as high as 3% to 7% on building materials, thereby bringing down the construction cost together with improved marketability. Such financial incentives increase the financial advantages of using sustainable building materials as they nudge developers and constructors to adopt more sustainable techniques. In this regard, it is important to consider any possible disadvantages associated with using the materials, such as higher prices of purchase, limited supplies in specific areas, and peculiar installation requirements. These factors can slow building schedules and budgets. In addition, some of the sustainable materials have special handling, storage, or disposal requirements, making the building process complicated (Ivanov 2018). However, the long-term savings, energy efficiency, market demand, and government incentives of using these sustainable building materials make them financially sound to builders and developers. By using sustainable methods and resources, the building industry may help to ensure environmental sustainability and economic growth.

Key Characteristics of Sustainable Construction Materials

Ecologically responsible construction is anchored by important characteristics of sustainable building materials. Key aspects are recyclability, resilience, resource efficiency, and waste and emission reduction, with added social, economic, and environmental factors holistically. Wood is a prime example of a sustainable material due to its outstanding acoustical properties, thermal insulation, and good strength-to-weight ratio. In addition, since wood is renewable and recyclable, it helps the building industry reduce carbon emissions (Asdrubali et al. 2017). Sustainable materials improve environmental stewardship further by reducing energy consumption, maintaining structural integrity, increasing fire safety precautions, and, finally, leading to lower operating expenses.

Economic metrics related to the longevity of the materials, maintenance costs, and running costs are also important aspects in determining the viability of sustainable materials. Human toxicity, climate change, waste, flexibility, thermal comfort, and utilization of local resources are a few examples of essential environmental factors. Social factors, including housing for all, are also quite critical (Bhuiyan & Hammad 2023). Sustainable building materials should also surpass technical performance criteria, have an impact in environmental terms, show resource efficiency, and encompass the perspectives of the stakeholders. A multi-criteria decision-making technique should be adopted while selecting the materials to strike a balance between long-term sustainability and cost-effectiveness.

The use of sustainable construction materials has many benefits, among which some of the most important are waste minimization, environmental preservation, social responsibility, and rigorous technical specifications. Waste generation and related environmental harm can be dramatically minimized by construction techniques, which prioritize the use of materials with the lowest ecological footprint and optimize resource efficiency. Moreover, by contributing to healthier and more equitable societies by using sustainable materials, they respond to issues of social equality. Additionally, building sustainably will open the door to innovation and development in the construction industry since they are designed to meet very strict technical specifications. Building sustainably speaks of the beginning of a potential journey toward an even stronger and more ecologically aware future.

Pollution and Pollutants in the Environment

Pollution from various kinds of sources, including errors in disposing of waste, the emissions of traffic, and industrial pollutants, threatens the environment and public health. The discharge of toxic chemicals into the air, water, and soil brings about an ecological imbalance that will soon prove detrimental to health. The substances of pollution vary; they can be biodegradable substances like organic waste or permanent ones like heavy metals and plastic garbage. To tackle pollution, all-encompassing approaches are needed, including legislative actions, advancements in technology, and public education initiatives. By reducing waste, conserving resources, and embracing clean energy, sustainable behavior is an example that becomes essential in reducing the adverse consequences of pollution and preserving the environment for future generations.

Pollution is the discharge of harmful chemicals into the environment. Contaminants are the term we use for these harmful compounds. Some pollutants are naturally occurring, such as volcanic ash. Human activity can also cause them, like in the case of industry runoff or garbage. Pollutants are harmful to the quality of the air, water, and land (Ukaogo et al. 2020). Pollutants are the main source of environmental contamination; they may be classified into two categories:

biodegradable and non-biodegradable. Waste products that break down naturally without leaving behind any pollutants are known as degradable pollutants. Waste that is incapable of being broken down or destroyed by any biological activity is considered non-degradable pollution (Tian & Bilal 2020). On the basis of their persistence and rate of degradation, pollutant substances that humans have discharged into the environment are normally grouped into two broad categories: biodegradable and non-biodegradable (Wasi et al. 2013). Pollutants that are not biodegradable pose a threat to the environment. It is impossible to eradicate the majority of toxins from the environment, not even after billions of years. Reusing or recycling them to create new and valuable products might help eliminate this kind of non-biodegradable pollution.

Types of Pollutants

Biodegradable pollutants are those that can be metabolized by microorganisms, whether through chemical reactions induced in them or their disintegration. Some examples include certain chemicals such as some detergents and pesticides, as well as organic materials, such as sewage and food wastes. These contaminants will eventually become less harmful through biological processes inducing chemical reactions or degradation. However, they may degrade, and secondary products may be formed and, in doing so, may be just as dangerous in the end. Non-biodegradable pollutants include plastics, heavy metals such as lead and mercury, and some persistent organic pollutants like DDT (Mathew et al. 2017). These pollutants go through little biologically mediated processes and are laid down in the environment and bio-accumulated in species and increase in toxicity.

A multidimensional approach is required for such pollutants to be effectively controlled. This includes tight regulation, eco-friendly waste disposal techniques, advanced technology for pollution control, and public awareness campaigns to reduce the amount of pollution that originates (Al-Jebouri 2023). In addition, switching to more sustainable patterns of production and consumption is a need. This might ultimately reduce pollution and preserve the earth and all its inhabitants. Fig. 1 shows the difference between degradable and non-degradable pollutants. These variations highlight the serious environmental consequences of non-biodegradable pollutants, which have led to the development of new technologies for recycling non-biodegradable materials into useful products. This has the dual goals of reducing the pollution these hazardous pollutants cause to the environment and protecting the natural world for future generations.

Impact of Pollutants on Ecosystems

Pollutants pose a serious threat to ecosystems because they can upset the delicate balance and do much damage to the environment. Pollutants are a hazard, regardless of their biodegradability. Biodegradable environmental contaminants are easier to dispose of than non-biodegradable ones; an example of plastic, in particular, becomes a chronic hazard and is difficult to dispose of (Oberoi & Garg 2021). Because of inefficient manufacturing processes, improper disposal of garbage, and poor recycling processes, plastic, in particular, becomes a major hazard to ecosystems. The increasing availability of plastic refuse poses monstrous problems in waste management, especially in developing countries where populations are growing at a high rate. This is especially so in the case of plastic garbage that settles on land and in water (Godfrey 2019). Besides swamping the present waste management system, this plastic refuse befalls human beings and animals in ruin. Better waste management strategies, environmentally friendly production processes, and greater public knowledge are the ingredients of a global initiative to combat this hazard. The integrity of our ecosystems must be preserved for the betterment of our future generations, and we can only reduce the harmful effects of pollution by cooperating.

Pollution Management Strategies

Pollution control techniques must, therefore, have techniques that include removal, control, and prevention. Waste removal is one of the most crucial aspects of pollution control techniques. Waste management crews are very crucial to any municipality in terms of collection and disposal of residential waste. Separation of the garbage into degradable portions and those that are not is an important procedure at disposal grounds. Recyclable garbage is separated from non-degradable waste, such as bottles, plastics, and various products. Eggshells and other compostable waste are composted during the procedure. This systematic categorization helps ensure that resources are conserved and facilitates easier waste management. Moreover, it allows for material reuse and recycling in addition to waste management (Hoang et al. 2019). For instance, composting turns organic waste into organic compost that can enrich soil fertility and help with farming practices. Communities can significantly reduce the volume of waste they generate, which will help the environment and other generations to come to have a cleaner and healthier habitat.

The strategies required to control pollution in the environment

- Ensure effective garbage collection throughout municipalities. (Musella et al. 2019)
- Identify waste types, such as medical, electrical, or household (Reno 2015).
- Classify waste items as degradable or non-biodegradable (Alaudeen 2019).

- Degradable waste products have several applications, including fertilizer and residential consumption.
- Non-degradable garbage takes hundreds of years to disintegrate. As a result, the disposal of non-biodegradable garbage necessitates creativity and new technology, such as utilizing plastic to produce roads and construction materials (Subramanian 2019).

MATERIALS AND METHODS

The assessment plan of this study has been purely exploratory. The primary objective of this research study is to showcase the feasibility of altering waste materials into fully functional construction products without compromising on the strength and resilience characteristics of the same. In order to achieve this, the study mainly focuses on discarded plastic, which, when mixed with bitumen or sand, not only accommodates tonnes of the same but also enhances the strength parameters.

A thorough study was conducted reviewing the existing literature, conducting industrial visits and interviews with budding entrepreneurs of start-ups dealing with emerging technologies of ways and means to convert different types of non-biodegradable waste products be it glass or plastic, into valuable commodities. It was found in the survey that numerous types of daily wear commodities, be it textiles, shoes, carpets, toys, furniture, etc., get manufactured in bulk from waste plastic waste (Shuttleworth L., 2024). However, these products ended up back at the landfill sites within a very short period. Hence, the main focus of the study was to concentrate on products that were put well into use for a significant duration of time.

RESULTS AND DISCUSSION

Non-Degradable Pollutants

Non-biodegradable pollutants bring another factor to environmental unsustainability as they defeat the natural processes of degradation. Examples include plastics, heavy metals, and other synthetic substances that persist for many years in ecosystems. Hundreds of research studies have evidenced the consequences of their accumulation, which are very dangerous to the well-being of fauna and flora. Not only do these contaminants harm the soil and water bodies, but through the food chain, they also harm humans. Novel and new-age technologies are required to overcome this problem. Non-biodegradable pollutants are often unmanageable by common methods of waste management (Dharmasiri 2019). Novel approaches are required that range from thermal treatment and chemical degradation to bioremediation. To control the production and use of these contaminants, stringent legislation and policies must be enforced. Solutions for overall development require the cooperation between different governmental, industrial, and research bodies. The protection of ecosystems and human health in future years will require society to find and implement workable solutions that mitigate the dangers non-biodegradable pollutants pose to the environment and human health.

Recycling of Non-Degradable Pollutants

Recycling non-biodegradable pollutants involves the conversion of persistent waste materials into some valuable commodities, hence reducing the environmental impact. The process depends on novel methods such as chemical degradation, thermal transformation, and biological attenuation in the conversion of pollutants into less toxic compounds or their repurposing to useful benefits. Advanced technology and sustainable practices are crucial for the management of these pollutants like plastics, heavy metals, and synthetic derivatives. By the side, supporting principles of circular economy, restricted use of single-use products, and strict regulations can aid in reducing the formation and accumulation of non-biodegradable pollutants (Burelo et al. 2023). Governments, industries, and research organizations need to collaborate in the establishment of viable recycling methods and the promotion of sustainable waste disposal. Supporting the recycling of non-biodegradable pollutants can reduce environmental degradation resource conservation, and protect the health of ecosystems and populations.

Conversion of Non-Degradable Pollutants to Useful Products

Methods that innovatively convert non-degradable pollutants into useful products include the conversion of non-degradable waste materials into reusable products. The techniques of chemical transformation, thermal treatment, and bioremediation break non-degradable pollutants into less harmful components or convert them into valuable products (Guzik et al. 2021). Many materials are known as Polymers, and at present, polymers are making a substantial contribution to our daily activities. Due to their widespread and regular use in numerous industries, polymer production and disposal increased tremendously over time. In that regard, however, polymeric wastes are heavier than organic wastes, and most of them do not degrade (Dwivedi et al. 2019). This is polymeric waste, which can be restored to full-use products as raw materials for the plastic industry, construction works, and recycled plastic products. The main component of sewage sludge ash is silty material with occasional sand-sized particles. It is a byproduct of dewatered sewage sludge burning in an incinerator. Large amounts of organic sludge are produced as a byproduct of the treatment process as a result of the sewage treatment facilities' fast development. This massive amount of sludge is dried, ground into a powder, and utilized as a raw ingredient to make cement, which is used in concrete buildings (Lynn et al. 2015). Due to their stability, durability, and stress resistance in structures, plastic bottles are also utilized in the construction industry to create bricks and cement mixtures, among other materials (Dadzie et al. 2020).

Converted Products Used in the Construction Field

Products used in construction fields include a wide variety of materials that are necessary for constructing buildings and other infrastructure. These include wood, steel, concrete, and different composite materials made for certain uses. Concrete is a versatile and long-lasting construction material. Steel provides flexibility and strength, which are essential for structural frameworks. Wood is still an abundant resource that is used for flooring, finishing, and framing (Oyedele et al. 2014). Waste from many sources is being used to make a range of building materials. For example, post-consumer waste from households, companies, institutions, and industries is recycled and reused in construction. Examples of these materials 5 include plastic bags for plastic strips, which are commonly used on soil embankments, grounded polyethylene, and as a component of Trex and plastic lumber. Newsprint is used in cellulose insulation, wallpaper, asphalt road surfaces, and color boards. Additional recycled post-consumer goods include rubber tiles manufactured from unused tyres, wool insulation made from recycled textiles, ceiling boards made from recycled plastics, carpet, and carpet pads made from recycled post-consumer fabrics, and so on (Bolden et al. 2013). Waste from building projects may also be used to create new materials or components for other goods. Reducing the net quantity of waste produced by building operations is done effectively (Thomas et al. 2013). Fig 1 shows the classification of the recycled construction materials.

Different Construction Products from Different Pollutants

The construction industry's depletion of natural resources has increased research efforts to promote the use of recyclable waste items, such as scrap tires, as an alternative to non-renewable materials. Waste tires (whole tires, tire shreds, or tire chips) have many unique properties that are useful in engineering applications, particularly geotechnical engineering applications, such as low density, low earth pressure, good insulating properties, good drainage capability, long-term durability, and high compressibility. Tyre waste is used for concrete due to its strength, chloride resistance, and sound barrier (Mashiri et al. 2015).

Rapid changes in equipment production have reduced electronic product costs, leading to consumers discarding old products and embracing new technology. This has resulted in a substantial volume of electronic garbage, which includes computers, mobile phones, televisions, printers, laptops, and home appliances, and is expanding at approximately three times the rate of the global population (WHO 2023). Plastic is one of the most common materials used in electrical gadgets, accounting for around 21% (Kumar et al. 2018). Waste glass material cut from electronic-grade glass strands was utilized as fine aggregate in concrete. Recently, asphalt binders were experimentally changed using electronic waste from recovered computer plastics to increase asphalt binder performance vs standard asphalt binders, and waste printed circuit board powder was employed as an additive in cement mortar (Paul & Gnanendran 2016, Kumar & Bhaskar 2015). Waste plastic bags are used to substitute cement in the manufacturing of building bricks and concrete blocks. Incorporating plastics into concrete blocks not only ensures safe disposal but may also increase concrete qualities such as tensile strength, chemical resistance, drying shrinkage, and creep (Abdel Tawab et al. 2020). Instead of using cement, plastic waste is used to make roof tiles. To make roof tiles, a combination of river sand and polyethylene terephthalate (PET) plastic is utilized. The gained characteristics are marginally superior to those of regular cement (Bamigboye et al. 2019).

Role of Engineering in the Conversion

The creation of waste is an unavoidable byproduct of human activity. Engineering takes care of the transformation of non-biodegradable pollutants into building materials, for example, by designing new technologies for resource recovery and valorization of waste (Bala et al. 2022). Thus, waste materials such as plastics, industrial wastes, and sewage sludge can be changed into high-value products like aggregates, composites, and bricks. Advanced technologies, such as pyrolysis, hydrothermal carbonization, and chemical conversion, are used in this conversion. Engineers design these processes in such a way that they are environmentally friendly, scalable, and effective. These processes are optimized by using innovative catalysts, reactors, and purifying techniques and, at the same time, convert the highest possible amount of waste and have the lowest possible consumption of energy and emissions. Additionally, engineers calculate life cycle analyses to aid in environmentally responsible decision-making and environmental impact assessment of these products (Peng et al. 2023). With technical knowledge, society can increase the demand for building materials in an environmentally sustainable and circular manner.

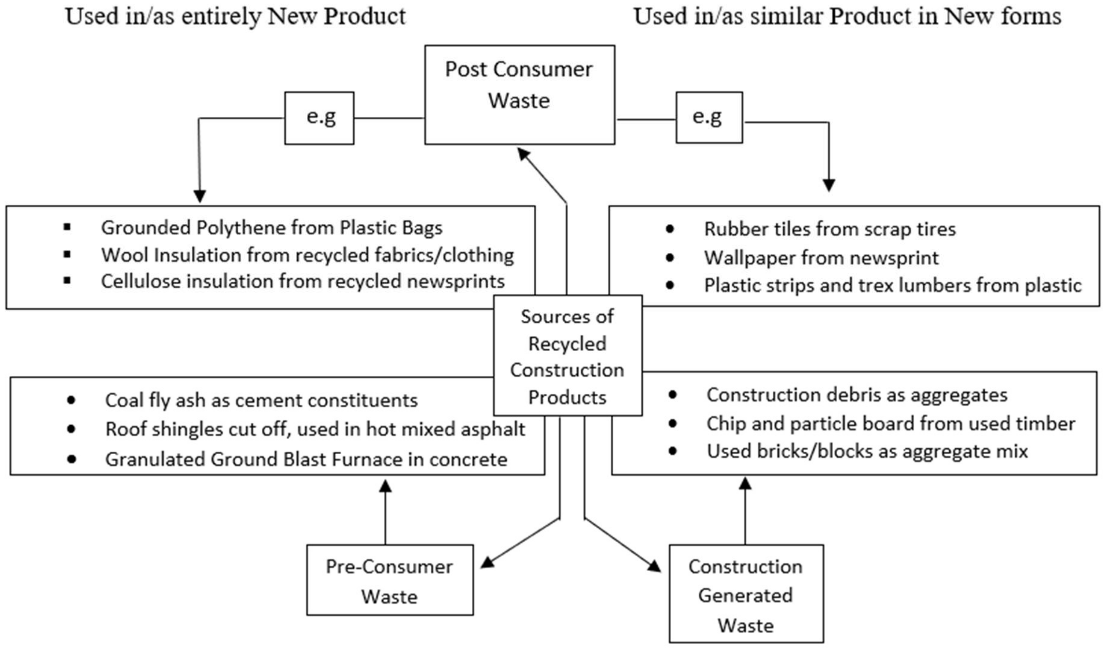

Fig. 1: Recycled construction material classification.

Adopting the 3R concept (Reduce, Reuse, and Recycle), as supported by well-known international organizations, is a strategic step toward environmentally friendly waste management techniques. A lot of emphasis on reduction, reuse, and recycling increases not only waste reduction but also the growth of a circular economy. This approach has enormous promise because it focuses on the use of cleaner manufacturing techniques and the valorization of wastes, which, in other words, means the process of the transformation of thrown-away resources into useful materials and energy sources. The garbage valorization approach is the process of converting waste into useful goods, including materials, fuels, and chemicals. It is a critical step towards minimizing the environmental impact of waste with creativity and resource efficiency (Abdel-Shafy & Mansour 2018). Resource recovery of energy, materials, or products is an integral part of tertiary and quaternary recycling. From this angle, one of the important avenues for resource recovery from plastic waste is the thermolysis of thermoplastics. In a chain reaction that involves the processing of low molecular weight molecules, thermolysis sets off a process that is of paramount importance in this regard. Three principal methods can be considered in the development of this chain reaction: pyrolysis, hydrocracking, and gasification. Pyrolysis involves the decomposition of materials through high temperatures without oxygen. Hydrocracking involves the use of hydrogen to break down large molecules into smaller ones (Okan et al. 2019). Gasification converts materials into synthesis gas, opening a range of flexible applications. From these perspectives, the effectiveness of the thermolysis technology in mitigating the problems presented by plastic waste is based on these approaches.

The base processes in which the working of this technology is based are three basic processes in thermolysis: gasification, hydrocracking, and pyrolysis. These processes can break down large molecular long-chain polymers into goods suitable for high-temperature building applications (Zhang et al. 2021). Pyrolysis breaks organic material, in the absence of oxygen, into biochar and bio-oil. Hydrocracking uses hydrogenation and converts the heavier hydrocarbons into simpler ones to produce diesel and gasoline. Carbonaceous materials are gasified to produce synthesis gas that is a flexible fuel precursor. All these, when combined, provide creative ways to use resources sustainably and make it easier to produce the materials needed for high-temperature building requirements.

CASE STUDIES

Case Study 1 - Plastic Roads

Waste management efforts in Kerala provide a challenge to the environment and human health, particularly with the usage of plastic rubbish. The state government has introduced new measures, one of which is the creation of roadways through recycled plastic material for garbage management and infrastructure development. The Public Works Department took an important step by re-laying portions of several roads in the Thiruvananthapuram district with a combination of plastic garbage and asphalt. This brings two advantages together: It recycles spent plastic, and the road becomes stronger and longer-lasting. The PWD has entered into a tie-up with the Clean Kerala Company Ltd, which is a state enterprise responsible for plastic garbage collection, to feed this eco-friendly road construction exercise across the state. This tie-up will buy an additional 15 tons of plastic granules in a month and will show a concerted attempt to use more recycled material in infrastructure activities. Kerala is taking positive steps to undo plastic pollution and enhance infrastructure at the same time through cooperation between government agencies and creative applications. This green approach shows the resolve of the state to protect the environment and the people's welfare.

The CKC is the state's principal agency for processing plastic waste. It carefully collects all plastic waste, including carry bags and other plastic materials, from all sources. These polymers are broken into granules. While the bigger plastics are sold to CKC, those smaller than 50 microns, which are unfit for standard recycling, are processed by combining with bitumen to enhance road construction. Presently, the CKC buys granulated plastics from thousands of places in Kerala at Rs. 15 per kilogram. The agency, therefore, sells these shredded plastic granules to the contractors at a little higher price of Rs. 20 per kilogram. The contractors utilize the granules, in addition to asphalt, to build roads. About 1,700 kg of plastic waste is used to create one kilometer of road, which helps in long-term infrastructure development and helps in effectively resolving plastic pollution issues. The unique partnership of government entities like the Public Works Department and Clean Kerala Company Ltd in the state of Kerala gives an example of an aggressive strategy for reducing plastic pollution and improving the infrastructure. This use of recovered plastic in road building outlines a sustainable solution to environmental and public health issues and sets a good example for others (Gupthan 2017).

Case Study 2 - Bricks from Plastics

There have been numerous steps taken in the last few years toward the conversion of plastic garbage into valuable resources, primarily in highly developed countries. There is, however, a potential path for the creation of new building materials based on plastic waste, as the construction sector dominates most nations and uses enormous amounts of raw material. Recent reports stated that there are advances in combinations of plastic with sand, which are applied for the manufacturing of plastic sand bricks. These, together with further civil engineering applications of these innovative building materials, are very exciting. The composition of plastic sand bricks is fifty-five to sixty-five percent of the weight of plastic sand bricks, plastic comprises twenty-nine to thirty-nine percent, and there are also crushed glass bottles and paper shredded at one percent and five percent, respectively. Interestingly, each brick uses approximately 250 grams of plastic, so the production of bricks involves a significant reduction in plastic pollution. For instance, 2,50,000 kg of plastic garbage will be used to make 10,000 bricks. The approach is not only an urgent answer to the need to decrease plastic pollution but also ensures long-term satisfaction of the needs of the construction industry. The use of plastic sand bricks means a change of thinking in favor of the circular economy, which transmits trash into valuable resources. Besides, they contribute to a reduction in environmental degradation and the preservation of natural resources so that, in the ever-continuing global effort to decrease the levels of plastic pollution and move toward a more resilient, resource-efficient future, they become an innovation and sustainability beacon (Ursua 2019).

The innovative use of recycled plastic bottles in construction as building bricks holds a sustainable solution in multiple ways. The bricks have superior attributes than regular bricks, including reduced thickness and weight, good heat and noise insulation, and an equal strength and durability of traditional materials. In turn, only 20 plastic bottles are needed to make one brick, therefore limiting the amount of plastic waste to be seen in the environmental landscape while consuming less energy than the other recycling methods. Manufacturing them is easy without washing, sorting, or adhesives, hence easing the production process and also creating less stress on the environment. Other than structural applications, plastic bricks can be used for wall fillers, fences, and non-load-bearing walls with proper insulation properties and practicality in building construction. This creative method solves ecological issues without forgetting to depict the possibility of converting trash into useful building material. This creative method solves ecological issues without forgetting how garbage can be turned into useful building material (Lois Zoppi 2019).

LIMITATIONS OF THE STUDY

The main emphasis of the current study is on the product that could be curated/recycled from discarded plastic waste and is not much concerned with its particular types such as LDPE, HDPE, PVC, PET, etc. It does not focus much on the pros and cons of the segregated plastic types and whether they can be clubbed together for recycling.

CONCLUSIONS

In conclusion, it is possible to satisfy the demands for infrastructure while also improving the environment by using a sustainable method of turning rubbish into construction materials. The use of garbage reduces the destabilizing effects of trash collision on ecosystems and human health by recycling waste to useful sources. It also saves exhausted natural resources and sustainability for a long time. Advanced and state-of-the-art technologies such as carbon capture and utilization make them turn pollutants into high-quality building materials that are safe and efficient. Adopting this pattern shift would make everyone embrace a circular economy model in which trash is considered a source of wealth instead of waste. In addition, the massive use of environmentally friendly building materials pressures many industrial actors to make eco-friendly procedures a priority. This leads to a change in the model of systemic change in the direction of a greener future. An integrated effort between policymakers, academics, and business people is a cardinal virtue that must be done to encourage advances and overcome current hurdles. Ultimately, we would be able to build robust infrastructure in the presence of a beneficial environment for the next generation if we incorporate sustainability into material synthesis processes. This review centers on the need to move toward a circular economy ideology, wherein waste should be considered an asset and not something that should be removed to contribute toward a more successful and green society.

IMPLICATIONS FOR FUTURE RESEARCH

Plastic Bricks that are currently manufactured are typically used for road pavements, footpaths, residential compounds, etc. So far, there has been very minimal research when it comes to manufacturing construction units/blocks that can be used to replace RCC in terms of strength and durability. Thorough research can be done on the same based on such plastic bricks that can be well utilized for building construction. Such an innovation will not only curb the current scenario of plastic pollution but will also lead to earthquake-resilient and affordable housing globally.

REFERENCES

Abdel-Shafy, H.I. and Mansour, M.S., 2018. Solid waste issue: Sources, composition, disposal, recycling, and valorization. *Egyptian Journal of Petroleum*, 27(4), pp.1275-1290.

Abdel Tawab, O.F., Amin, M.R., Ibrahim, M.M., Abdel Wahab, M., Abd El Rahman, E.N., Hassanien, R.H., Hatem, M.H. and Ghaly, A.E., 2020. Recycling waste plastic bags as a replacement for cement in the production of building bricks and concrete blocks. *Journal of Waste Resources and Recycling*, 1(2), p.202.

Al-Jebouri, M.M., 2023. Modelings of infectious diseases and cancers under wars and pollution impacts in Iraq with reference to a novel mathematical model and literature review. Open Journal of Pathology, 13(3), pp.126-139.

Alam Bhuiyan, M.M. and Hammad, A., 2023. A hybrid multi-criteria decision support system for selecting the most sustainable structural material for multistory building construction. *Sustainability*, 15(4), p.3128.

Alaudeen, S.S., 2019. Degradable and Non-Degradable Waste Separation Using Intelligent Approach. *International Journal of Emerging Technology and Innovative Engineering*, 5(5).

Asdrubali, F., Ferracuti, B., Lombardi, L., Guattari, C., Evangelisti, L. and Grazieschi, G., 2017. A review of structural, thermo-physical, acoustical, and environmental properties of wooden materials for building applications. *Building and Environment*, 114, pp.307-332.

Bala, S., Garg, D., Thirumalesh, B.V., Sharma, M., Sridhar, K., Inbaraj, B.S. and Tripathi, M., 2022. Recent strategies for bioremediation of emerging pollutants: a review for a green and sustainable environment. Toxics, 10(8), p.484.

Bamigboye, G.O., Ngene, B.U., Ademola, D. and Jolayemi, J.K., 2019, December. Experimental study on the use of waste polyethylene terephthalate (PET) and river sand in roof tile production. *Journal of Physics: Conference Series*, 1378, p 042105.

Bolden, J., Abu-Lebdeh, T. and Fini, E., 2013. Utilization of recycled and waste materials in various construction applications. *American Journal of Environmental Science*, 9(1), pp.14-24

Burelo, M., Hernández-Varela, J.D., Medina, D.I. and Treviño-Quintanilla, C.D., 2023. Recent developments in bio-based polyethylene: Degradation studies, waste management and recycling. *Heliyon*, 9(11).

Dadzie, D.K., Kaliluthin, A.K. and Kumar, D.R., 2020. Exploration of waste plastic bottles use in construction. *Civil Engineering Journal*, 6(11), pp.2262-2272.

Danso, H., 2018. Identification of key indicators for sustainable construction materials. *Advances in Materials Science and Engineering*, 2018, pp.1-7.

Dharmasiri, L.M., 2019. Waste management in Sri Lanka: challenges and opportunities. *Sri Lanka Journal of Advanced Social Studies*, 9(1), pp.72-85.

Dwivedi, P., Mishra, P.K., Mondal, M.K. and Srivastava, N., 2019. Non-biodegradable polymeric waste pyrolysis for energy recovery. *Heliyon*, 5(8), p.654.

Eco-Tech Building Solutions 2024. Why Contractors Are Choosing Sustainable Materials. Available at https://ecotechnology.ca/blogs/featured-posts-1/building-green-why-contractors-are-choosing-sustainable-materials. Accessed on 16 Jan 2025.

Figueiredo, K., Pierott, R., Hammad, A.W. and Haddad, A., 2021. Sustainable material choice for construction projects: A Life Cycle Sustainability Assessment framework based on BIM and Fuzzy-AHP. *Building and Environment*, 196, p.107805.

Godfrey, L., 2019. Waste plastic, the challenge facing developing countries—ban it, change it, collect it? *Recycling*, 4(1), p.3.

Gupthan, M., 2017. Kerala Hits the Plastic Road! Available at https://www.onmanorama.com/news/kerala/kerala-hits-the-plastic-road.html. Accessed on 16 Jan 2025.

Guzik, M.W., Nitkiewicz, T., Wojnarowska, M., Sołtysik, M., Kenny, S.T., Babu, R.P., Best, M. and O'Connor, K.E., 2021. A robust process for high-yield conversion of non-degradable polyethylene to a biodegradable plastic using a chemo-biotechnological approach. *Waste Management*, 135, pp.60-69.

Hoang, T.C., Black, M.C., Knuteson, S.L. and Roberts, A.P., 2019. Environmental pollution, management, and sustainable development: Strategies for Vietnam and other developing countries. *Environmental Management*, 63, pp.433-436.

Ivanov, D., 2018. Revealing interfaces of supply chain resilience and sustainability: a simulation study. International Journal of Production Research, 56(10), pp.3507-3523.

Liu, Z.J., Pypłacz, P., Ermakova, M. and Konev, P., 2020. Sustainable construction as a competitive advantage. *Sustainability*, 12(15), p.5946.

Lois Zoppi, B.A., 2019. Turning plastic waste into building materials. Available at https://www.azobuild.com/article.aspx?ArticleID=8308. Accessed on 16 Jan 2025

Lynn, C.J., Dhir, R.K., Ghataora, G.S. and West, R.P., 2015. Sewage sludge ash characteristics and potential for use in concrete. *Construction and Building Materials*, 98, pp.767-779.

Marchese, D., Reynolds, E., Bates, M.E., Morgan, H., Clark, S.S. and Linkov, I., 2018. Resilience and sustainability: Similarities and differences in environmental management applications. *Science of the Total Environment*, 613, pp.1275-1283.

Marjaba, G.E. and Chidiac, S.E., 2016. Sustainability and resiliency metrics for buildings: Critical review. *Building and Environment*, 101, pp.116-125.

Mashiri, M.S., Vinod, J.S., Sheikh, M.N. and Tsang, H.H., 2015. Shear strength and dilatancy behavior of sand–tyre chip mixtures. *Soils and Foundations*, 55(3), pp.517-528.

Mathew, B.B., Singh, H., Biju, V.G. and Krishnamurthy, N.B., 2017. Classification, source, and effect of environmental pollutants and their biodegradation. Journal of Environmental Pathology, Toxicology and Oncology, 36(1).

Musella, G., Agovino, M., Casaccia, M. and Crociata, A., 2019. Evaluating waste collection management: the case of macro-areas and municipalities in Italy. *Environment, Development and Sustainability*, 21, pp.2857-2889

Oberoi, G. and Garg, A., 2021. Single-use plastics: A roadmap for sustainability? *Supremo Amicus*, 24, p.585

Okan, M., Aydin, H.M. and Barsbay, M., 2019. Current approaches to waste polymer utilization and minimization: A review. *Journal of Chemical Technology & Biotechnology*, 94(1), pp.8-21.

Oyedele, L.O., Ajayi, S.O. and Kadiri, K.O., 2014. Use of recycled products in UK construction industry: An empirical investigation into critical impediments and strategies for improvement. *Resources, Conservation and Recycling*, 93, pp.23-31

Paul, D.K. and Gnanendran, C.T., 2016. Characterization of lightly stabilized granular base materials using monotonic and cyclic load flexural testing. *Journal of Materials in Civil Engineering*, 28(1), p.04015074.

Peng, X., Jiang, Y., Chen, Z., Osman, A.I., Farghali, M., Rooney, D.W. and Yap, P.S., 2023. Recycling municipal, agricultural and industrial waste into energy, fertilizers, food and construction materials, and economic feasibility: A review. *Environmental Chemistry Letters*, 21(2), pp.765-801.

Porfiriev, B.N., Dmitriev, A., Vladimirova, I. and Tsygankova, A., 2017. Sustainable development planning and green construction for building resilient cities: Russian experiences within the international context. *Environmental Hazards*, 16(2), pp.165-179.

Reno, J., 2015. Waste and waste management. *Annual Review of Anthropology*, 44, pp.557-572.

Sahlol, D.G., Elbeltagi, E., Elzoughiby, M. and Abd Elrahman, M., 2021. Sustainable building materials assessment and selection using system dynamics. *Journal of Building Engineering*, 35, p.101978.

Satterthwaite, D., Archer, D., Colenbrander, S., Dodman, D., Hardoy, J., Mitlin, D. and Patel, S., 2020. Building resilience to climate change in informal settlements. *One Earth*, 2(2), pp.143-156.

Senthil Kumar, K., Premalatha, P.V., Baskar, K., Sankaran Pillai, G. and Shahul Hameed, P., 2018. Assessment of radioactivity in concrete made with e-waste plastic. *Journal of Testing and Evaluation*, 46(2), pp.574-579.

Senthil Kumar, K. and Baskar, K., 2015. Recycling of E-plastic waste as a construction material in developing countries. *Journal of Material Cycles and Waste Management*, 17, pp.718-724.

Shuttleworth, L., 2022. 26 Innovative Recycled Plastic Products to Inspire You. *ClimateSort*. Available at https://climatesort.com/recycled-plastic-products/ Accessed on 16 Jan 2025.

Subramanian, M.N., 2019. *Plastics Waste Management: Processing and Disposal*. John Wiley & Sons.

Thomas, C., Cimentada, A., Polanco, J.A., Setién, J., Méndez, D. and Rico, J., 2013. Influence of recycled aggregates containing sulfur on properties of recycled aggregate mortar and concrete. *Composites Part B: Engineering*, 45(1), pp.474-485.

Tian, K. and Bilal, M., 2020. Research progress of biodegradable materials in reducing environmental pollution. *Abatement of Environmental Pollutants*, 16, pp.313-330.

Ukaogo, P.O., Ewuzie, U. and Onwuka, C.V., 2020. *Environmental Pollution: Causes, Effects, and the Remedies*. Elsevier, pp. 419-429.

Ursua, J.R.S., 2019. Plastic wastes, glass bottles, and paper: Eco-building materials for making sand bricks. *Journal of Natural Allied Sciences*, 3(1), pp.46-52.

Wasi, S., Tabrez, S. and Ahmad, M., 2013. Toxicological effects of major environmental pollutants: an overview. *Environmental Monitoring and Assessment*, 185, pp.2585-2593.

World Health Organization (WHO) n.d. Electronic waste (e-waste) Available at https://www.who.int/news-room/fact-sheets/detail/electronic-waste-(e-waste) Accessed date 16 Jan 2025.

Zavadskas, E.K., Šaparauskas, J. and Antucheviciene, J., 2018. Sustainability in construction engineering. *Sustainability*, 10(7), p.2236.

Zhang, F., Zhao, Y., Wang, D., Yan, M., Zhang, J., Zhang, P., Ding, T., Chen, L. and Chen, C., 2021. Current technologies for plastic waste treatment: A review. *Journal of Cleaner Production*, 282, p.124523.