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Sustainable Construction Solutions: Evaluating the Use of Recycled Plastic in Paver Block

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Abstract

Waste is often seen as something negative, unwanted, and harmful. It includes materials that are discarded after use, like plastic waste, which not only harms the environment but also affects our daily health and productivity. Plastic waste, or plastic pollution, takes a long time to decompose more than 400 years. This project aims to reduce the cost of paver block production by replacing cement with plastic waste, helping both to cut costs in construction and to promote a cleaner environment. In this process, waste plastics, mainly LDPE (Low- Density Polyethylene), were collected from waste pickers, sorted carefully, and mixed with stone dust to create paver blocks in specific moulds. The study found that using locally available materials like plastic waste can make construction more affordable. The study recommends large-scale collection and production of plastic waste materials, raising public awareness about the use of plastic waste in construction. This could also help in the fight against climate change by reducing plastic pollution.

Kew words: Plastic Waste Recycling, Paver Blocks, Environmental Impact, Cost Efficiency

Introduction

Waste is anything that is discarded after its main use or has lost its value. What may be waste to one person might be useful to another. For example, scrap metal sent to a landfill is wronglyconsidered waste because it can be recycled. The word "waste" often brings up feelings of negativity and harm. Generally, waste is seen as unwanted by-products of human activities within the environment. Globally, about 2.01 billion tons of municipal solid waste is producedevery year, and this number is expected to rise to 3.40 billion tons by 2050. Poor waste management harms the planet by polluting oceans, blocking drains, and causing floods. It also affects our health, productivity, and the cleanliness of our surroundings.

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Waste management is an issue that impacts everyone, from individuals managing their waste to governments handling waste disposal services. With the rise of urbanization and economic development, the World Bank predicts a sharp increase in global waste generation. Currently,around 33% of the world's waste is mismanaged, amounting to about 2.47 billion tons per year,and this is expected to grow to 4.28 billion tons by 2050. Human activities have always produced waste, but the amount of waste started to grow significantly during the Industrial Revolution when people moved to cities in large numbers. This population growth led to an increase in both the quantity and diversity of waste, including materials like plastic, metal, andglass. Plastics, in particular, have become a major part of waste streams.

Plastic waste, or plastic pollution, refers to the accumulation of plastic objects such as bottles and packaging materials in the environment. This waste harms wildlife, habitats, and human health. In many countries, especially developing ones, plastic waste often ends up in the oceans,endangering marine life. While plastic is cheap and durable, it takes more than 400 years to degrade, which makes it a huge environmental problem. Reducing plastic usage and promotingrecycling are crucial steps in solving this issue.

In developing countries, poor waste management is often due to a lack of sanitation awareness.Waste management involves different concepts and methods, including the ***"3 Rs"***—Reduce,Reuse, and Recycle which aim to minimize waste. Waste management also involves scientificand technological approaches to properly handle waste from collection to disposal, ensuring minimal harm to human health and the environment.

The problem of plastic waste is becoming overwhelming, and the planet is struggling to cope with the increasing amounts of plastic produced. In response, this project focuses on convertingplastic waste into useful materials. The goal is to replace cement with plastic waste in the production of paver blocks, which will lower the cost of construction and promote environmental cleanliness. This project involved collecting LDPE (**low-density polyethylene**)plastics, melting and mixing them with coarse aggregates, and comparing the cost of constructing paver blocks using plastic waste versus cement.

The Theory of Waste to Wealth

Waste-to-Wealth refers to transforming waste from being seen as useless into something valuable and desirable. This concept involves taking waste that has served its purpose and finding ways to give it new value. In engineering, this transformation requires energy, while ineconomics, it involves

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production factors (Adetola et al., 2021). The key point is that waste is not considered wealth; otherwise, people would not discard it. Wealth creation involves costs, and not all waste can be transformed into something valuable. However, the idea behind Waste-to-Wealth is that waste management should go beyond just disposing of waste and instead focus on turning it into something useful, such as energy (Egun, 2012).

When waste is collected with care and processed properly, it can become a resource that boostslocal revenue, creates jobs, supports business growth, and strengthens the economy. Accordingto the Clark County Solid Waste Management Plan (2015), sorting and processing recyclablescreate 10 times more jobs than simply dumping waste in landfills or burning it. The biggest economic benefit comes from turning old products into new ones. Recycling-based manufacturing provides more jobs and better wages than just sorting recyclables. Additionally,reusing, recycling, and composting can save a lot of resources and energy that would otherwisebe used in producing, distributing, and selling new products.

The Concept of Sustainable Development

Development is described as a process where human abilities grow, enabling people to create new systems, solve problems, adapt to change, and work toward new goals (Peet, 1999, as citedin Du Pisani, 2006). Reyes (2001) explains development as a social condition in which a nationmeets the needs of its population through the rational and sustainable use of natural resources.

Todaro and Smith (2006) further define development as a multi-dimensional process that involves significant changes in social structures, attitudes, and institutions, alongside economic growth, reducing inequality, and eliminating extreme poverty. Sustainable development,therefore, is crucial because it ensures that development today does not prevent future generations from enjoying similar opportunities. In simple terms, sustainable development is atype of growth that can continue over time without exhausting resources or limiting future prospects (Stoddart et al., 2011).

Literature Review

Waste can come from various sources, including domestic, industrial, chemical, biological, ortoxic origins. Human activities, driven by rapid population growth and the exploitation of resources, significantly impact the environment by increasing waste production (Seik, 1997). The environment poses complex challenges, and humans must solve these problems to ensuretheir survival. One such challenge is environmental waste, which poses a threat to human health

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and well-being (Hilson, 2002). Efforts are being made globally to address this waste issue andensure environmental sustainability (Courchamp et al., 2017).

Waste is generally seen as undesirable and worthless material. In many developing countries, including India, poor waste management is often due to a lack of sanitation education(Asunogie, Momoh & Osagioduwa, 2022). Waste management covers various approaches andmethods, involving scientific, artistic, and technological strategies to control, dispose of, and convert waste into useful materials that benefit both humans and the environment. The core principle of waste management is built on the "3 Rs": reduce, reuse, and recycle, which prioritize minimizing waste (Bassey & Akpan, 2020).

Sanitation and waste management are closely connected. Effective waste management seeks to extract the most value from products while producing the least amount of waste (Bassey & Akpan, 2020). Proper management involves organizing waste-related actions at the right timeand with the right tools to achieve effective results. It encompasses the entire process from waste generation to its final disposal, including collection, transportation, treatment, and monitoring (Ivanova et al., 2016). The ultimate goal is to lessen the negative impacts of wasteon health, the environment, and overall aesthetics.

Low-density polyethylene (LDPE) bonded sand offers a resource-efficient solution by transforming wasted LDPE, such as water sachets, into a valuable local resource. Water sachetsmade from LDPE are particularly problematic due to limited recycling options, which pose public health and environmental risks. However, by using LDPE in combination with sand, a durable, lightweight material can be produced. This technology does not require water in the production process, making it more environmentally friendly. In Cameroon, for instance, a simple method has been developed to produce LDPE-bonded sand blocks and pavers, which serves as an example of a community-driven waste management solution. By converting plasticwaste into a usable product, this initiative holds the potential to address the global plastics waste crisis.

In developing countries, solid waste management is often inadequate, marked by low collectionrates and the disposal of waste primarily through dumping (Wilson et al., 2015). Nevertheless,waste materials in such contexts provide livelihoods to the informal sector, which thrives on entrepreneurial opportunities (Wilson et al., 2006). Plastic waste management, in particular, has become an urgent environmental and public health concern. Recycling infrastructure for plastic waste is often lacking, leading to uncontrolled disposal, especially in waterways. This causes severe problems, such as blocked drainage systems, urban flooding, and the spread of waterborne diseases like malaria due to

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stagnant water becoming a breeding ground for mosquitoes.

In India, for example, 56,000 tons of plastic waste were generated as of 2017, much of which polluted the environment, affecting both humans and animals. To mitigate the detrimental effects of plastic pollution, proper disposal and recycling in line with government regulations are crucial. Using plastic waste as a replacement for cement in construction materials not only offers an environmentally friendly solution but also presents significant economic benefits by reducing reliance on traditional materials and providing a sustainable alternative.

Plastic, despite being one of the most remarkable human inventions, poses serious environmental challenges due to its non-biodegradable nature (Bawar et al., 2023). Plastic pollution is now considered one of the most significant threats to modern society, contributing to environmental degradation and causing economic harm (Saikia and De Brito, 2012). The accumulation of plastic debris in the environment threatens marine life and disrupts efforts toward sustainability.

Research into plastic paver blocks (PB) made from low-density polyethylene (LDPE) and other recycled materials has demonstrated their potential as an eco-friendly alternative to traditional construction materials. Studies have shown that the compressive strength of LDPE-sand paverblocks can be improved by using finer sand particles. Specifically, sand with a diameter smallerthan 0.42 mm significantly enhances compressive strength compared to coarser sand (Bawar et al., 2023).

Additionally, research by Nivetha et al. (2016) examined the reuse of quarry dust, fly ash, and polyethylene terephthalate (PET) in plastic paver blocks. Their study revealed that PET couldbe reused effectively by combining it with 50% quarry dust and 25% fly ash, producing a paverblock with acceptable strength levels. Six cubes were cast to measure compressive strength, and the results supported the feasibility of using solid waste materials for constructionpurposes.

In a related study, Joel and Ravikant (2015) explored the use of fly ash and waste glass powderas partial replacements for cement in rural road paver blocks. Their findings indicated that thesematerials could substitute cement without significantly compromising the strength of the blocks, offering an effective solution for sustainable construction in rural areas.

These studies highlight the growing potential of plastic paver blocks as a viable construction material that contributes to waste management while reducing environmental impacts.

Plastic pollution has evolved from a minor environmental issue into a major global concern, drawing increasing attention from researchers, media, and policymakers. In 2019, the United Nations labelled

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it a "planetary crisis" due to the widespread and lasting impact of plastics on the environment (MacLeod et al., 2021; Villarrubia-Gomez et al., 2018). The world generatesaround 2.01 billion tons of municipal solid waste annually, and this number is projected to reach 3.40 billion tons by 2050, with plastic waste being a major component (Kristina, 2023).

Canada stands out as the world's largest per capita producer of waste, generating an estimated metric tons of waste per person annually, most of which comes from industrial sources (Tiseo, 2023). Poor waste management systems not only pollute land and marine ecosystems but also disrupt daily life by clogging drains and contributing to health hazards.

The interconnectivity of aquatic ecosystems with terrestrial environments means that plastic waste in water systems can have cascading effects. Aquatic ecosystems are severely impactedby plastic litter, which, due to its durability and ease of transport by currents and wind, persistsfor long periods in the ocean (Eriksen et al., 2014). Plastic waste, which can reach counts of five trillion pieces weighing over 260,000 tons globally, threatens marine life at every level, from apex predators to plankton (Rahman et al., 2023). Marine animals ingest plastics, which cause physical harm such as blockages in digestive systems and internal damage, leading to reduced growth and even death (Naidoo & Glassom, 2019; Haetrakul et al., 2009).

Moreover, plastics can leach harmful chemicals into the marine environment (Rochman, 2015). Microplastics, which can penetrate body cells and even reach the brains of marine animals, pose severe health risks (Mattsson et al., 2017; Prüst et al., 2020). The issue of plastic pollutioncannot be viewed in isolation, as it compounds other threats to marine ecosystems, such as ocean warming, acidification, habitat destruction, and noise pollution (Rahman et al., 2023). Coral reefs and mangroves, vital ecosystems that provide essential services to both marine lifeand humans, are particularly vulnerable to plastic pollution in combination with these other stressors (Gall & Thompson, 2015).

As plastic pollution continues to rise, addressing the crisis will require concerted global effortsin waste management, environmental protection, and sustainable resource use.Research Methodology.

This study outlines a process for creating paver blocks using recycled Low-Density Polyethylene (LDPE) and quarry dust. Here’s a summary of the process and findings based onyour description:

Materials and Properties

1. **LDPE (Low-Density Polyethylene):**

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- **Plastic Bag Thickness:** About 50 microns.
- **Properties:**
  - **Melting Point:** 150°C
  - **Thermal Coefficient of Expansion:** 100-200 x 10^-6
  - **Density:** 0.910 - 0.940 g/cm³
  - **Tensile Stress:** 0.20 - 0.40 N/mm²

2. **Quarry Dust:**
   - **Properties:**
     - **Specific Gravity:** 2.62
     - **Grading Zone:** Variable depending on soil
     - **Fineness Modulus:** 2.952
     - **Water Absorption:** 1.80%

Process Overview

1. **Collection and Sorting:**
   - Waste plastics were collected by scavengers without a fixed perimeter area, sorted carefully to ensure only LDPE was used.

2. **Melting Process:**
   - **Drum Specifications:** 80 cm wide and 50 cm deep.
   - **Temperature Control:** Kept below 85°C to prevent burning.
   - **Procedure:**
     - Plastics were melted for about 20 minutes until they became liquid.
     - A measured amount of quarry dust was gradually added to the melted plastic while stirring continuously until the mixture resembled cement.

3. **Molding and Curing:**
   - **Mold Preparation:** Molds and tables were oiled to prevent sticking.
   - **Molding Process:**
     - The mixture was poured into block molds and leveled to ensure uniform block sizes and weights.
     - Blocks were set in the mold for two minutes before removal.
   - **Curing:** Blocks were allowed to cure for 12-24 hours before use.

This process offers a practical solution for utilizing waste LDPE and quarry dust, transformingthem into durable paver blocks suitable for construction purposes. It addresses the challenge ofplastic waste by recycling it into a valuable material, thereby contributing to waste managementand environmental sustainability.

Findings

The study aimed to replace cement with plastic waste in paver blocks to reduce production costs and promote environmental cleanliness. Here are the key findings:

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1. **Plastic Waste Composition:**
   - **Types of Plastics Collected:**
     - 56.3% were used/empty bottles.
     - 23.1% were plastic plates and rubbers.
     - 13.9% were nylon waste.
     - 6.7% fell into other categories.
2. **Usefulness of Plastic Waste:**
   - 72.1% of the collected waste was very useful.
   - 19.4% was partially useful.
   - 8.5% was not useful due to melting temperature requirements.
3. **Environmental Impact:**
   - Recycling 1 ton of plastic cleans approximately 300 m² of land by 45%.
   - Thus, 87.5 tons of plastic could clean around 26,250 m².
   - A 7% reduction in plastic waste in water bodies improves the survival and healthof aquatic animals.

Conclusion

1. **Cost Efficiency:**
   - Using plastic waste in construction can be economically viable and supports sustainable development goals by reducing reliance on traditional building materials and addressing climate change.
2. **Environmental Benefits:**
   - Recycling plastic waste for construction can significantly benefit both the environment and human health by reducing plastic pollution and conserving cement.

Recommendations

1. **Mass Collection and Production:**
   - Establish a system for large-scale collection and production of plastic waste paver blocks. Government incentives, such as low-interest loans and grants, should be offered to encourage investment in this sector.
2. **Public Awareness Programs:**
   - Increase public awareness about the benefits of using plastic waste for construction. Promote the environmental and economic advantages of paver blocks made from recycled plastics.
3. **Incentives for Paver Blocks Use:**
   - Provide tax rebates and exemptions for businesses producing or using plastic waste paver blocks. This will help maintain the business and reduce plastic waste in the

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environment.

4. **Sorting Incentives:**

❖ Implement financial incentives for sorting plastic waste at collection points. Encourage households and small-scale collectors to properly separate plastics from other waste materials.

This approach will not only help manage plastic waste effectively but also support the development of sustainable construction materials.

References

[1]. Anujith, S., Shahana, S., Subahan, S., Thasneem, A., and Abibasheer, B. (2019). Cost Effective Residential Building Using Plastic Bottles - A Home for the Future. International Journal of Emerging Technologies in Engineering Research (IJETER) 7(6) 5 – 13

[2]. Ashraf A., 2016. Thermal conductivity measurement by hot disk analyser. <https:// www.researchgate.net/publication/271840994> (accessed 13.8.17).

[3]. Asunogie, O.F &Ozekhome, M.C. (2022). Sanitary Facility for Urban-Public Use and Management – The Need for One in Area-3 of Auchi Polytechnic, Auchi, Edo State. International Journal of Scientific Research and Engineering Development-– Volume 5 Issue 2 (630 - 641)

[4]. Asunogie, O.F., Momoh, S., &Osagioduwa, M. (2022). Public Opinion on Auchi's Solid Waste Management. Direct Research Journal of Public Health and EnvironmentalTechnology: Vol. 7(7) 85 - 94.

[5]. Awaja, F., Gilbert, M., Kelly, G., Fox, B., Pigram, P.J., 2009. Adhesion of polymers. Prog. Polym. Sci. 34, 948–968.

[6]. Bassey, A. B. and Akpan, R. W. (2020). The arts of converting waste to wealth: towards environmental sustainability in Nigeria. Central Asian Journal of Environmental Science and Technology Innovation 1(3): 159-167.

[7]. CHUDLEY, R., GREENO, R., Butterworth & Heinemann (2007) 'Building Construction Handbook' (6th ed.).

[8]. Consoli, N.C., Montardo, J.P., Prietto, P.D.M., Pasa, G.S., 2002. Engineering behaviorofa sand reinforced block with plastic waste. J. Geotech. Geoenviron. Eng. 128, 462–472.

[9]. Courchamp, F., Fournier, A., Bellard, C., Bertelsmeier, C., Bonnaud, E., Jeschke, J.M., Russell, J.C., (2017). Invasion biology: specific problems and possible solutions. Trends. Ecol.Evol., **32**(1), 13-22. https://doi.org/10.1016/j.tree.2016.11.001

[10]. Electrical services for building construction https://epdf.pub/design-of-electrical-services-for-buildings-4th-edition.html

[11]. Fewtrell L, Kaufmann R.B., Kay D., Enanoria W., Haller L., and Colford, J.M.C., Jr. (2009) Water, sanitation, and hygiene interventions to reduce diarrhea in less developed countries: A systematic review and meta-analysis, The Lancet Infectious Diseases, Vol. 5,
Issue 1: 42–52

[12]. Ganesh Tapkire. Satish Parihar. PramodPatil. Hemra, R.Kumavat. (2014). Recycled Plastic used in Concrete Paver Block. International Journal of Research in Engineering and Technology, 3(09).

[13]. Gu, L., Ozbakkaloglu, T., 2016. Use of recycled plastics in concrete: a critical review. Waste Manage. 51, 19–42. Hassn, A., Aboufoul, M., Wu, Y.,

[14]. Hilson, G., (2002). The environmental impact of small-scale gold mining in Ghana: identifying problems and possible solutions. Geogr. J., **168**(1), 57-72. https://doi.org/10.1111/1475-4959.00038

[15]. Ivanova, D., Stadler, K., Steen-Olsen, K., Wood, R., Vita, G., Tukker, A., Hertwich, E.G., (2016). Environmental impact assessment of household consumption. J. Ind. Ecol., **20**(3), 526-536. https://doi.org/10.1111/jiec.12371

[16]. Jambeck, J.R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan,R., Law, K.L., 2015. Marine pollution. Plastic waste inputs from land into the ocean.Science 347, 768–771.

[17]. Joel Santhosh. RavikantTalluri. (2015). Manufacture of Concrete Paving Blocks with Fly Ash and Glass Powder. International Journal of Civil Engineering and Technology, 6(4), 55-64.

[18]. Kivrak, S., Tuncan, M., Onur, M., Arslan, G., Arioz, O., 2006. An economic perspectiveof advantages of using lightweight concrete in construction. Our world in concrete and structures. [Online] http://www.cipremier.com/page.php?377 (accessed 13.8.17).

[19]. Konstantinos K., Dimitrios E. A., Efstathios K., Kyriaki K., Junior L., Nickolas J. T. and Constantinos S. P. (2022). Transforming Waste to Wealth, Achieving Circular Economy. Circular

ISBN Number: 978-93-95305-66-2
Economy and Sustainability 2:1541–1559.

[20]. Kristina, N. J. (2023). How do we turn waste to wealth? Edited by Danish ArchitectureCenter. Nordic Innovation, Stensberggata 27, NO-0170 Oslo. www.nordicinnovation.org.retrieved on 9th June,2023

[21]. Lenkiewicz, Z., Webster, M., 2017. Making waste work: a toolkit, community waste management in middle- and low-income countries. [Online] <https://wasteaid.org.uk/toolkit/making-waste-work/>.

[22]. Nivetha, C. Rubiya, M. Shobana, S. Vaijayanathi, G. (2016).Production of Plastic PaverBlock from the Solid Waste. ARPN Journal of Engineering and Applied Science. 11(2).

[23]. Poonam Sharma. Ramesh kumarBatra. (2016). Cement Concrete Paver Blocks for Rural Roads. International Journal of Current Engineering and Scientific Research, 3(1), 114-121.

[24]. Sebille, E., Spathi, C., Gilbert, A., 2016. The ocean plastic pollution challenge towards solutions in the UK. Grantham Institute Briefing paper No. 19. [Online] <www.imperial.ac.uk/grantham/publications> (accessed 10.8.17).

[25]. Seik, F.T., (1997). Recycling of domestic waste: early experiences in Singapore. Habitat.Int., **21**(3), 277-289. https://doi.org/10.1016/S0197-3975(97)00060-X

[26]. WHO (2005) Sustainable Development and Healthy Environments, Water, Sanitation and Health, Geneva, World Health Organization

[27]. Wilson, D.C., Rodic, L., Modak, P., Soos, R., Carpintero, A., Velis, C., Iyer, M., Simonett,. Global Waste Management Outlook. Report. UNEP DTIE, ISBN: 978-92-807- 3479-9. 2015.