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PRECAUTIONS IN PLASTIC WASTE RECYCLING FOR CONSTRUCTION IN VIETNAM

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Abstract
In daily life, a lot of household waste, industrial waste and construction waste are discharged into the environment. In this situation, recycling and using waste in construction is considered one of the most important solutions because of the benefits that cannot be ignored. The trend of using recycled materials in construction is receiving a lot of attention. This trend is aimed at partially solving the huge waste situation in the world. Through the synthesis of theoretical and experimental studies, and with the aim of manufacturing certain building components using recycled plastic waste, this article summarizes fundamental information about plastic waste recycling in Vietnam and globally, and from there addresses six issues that require attention when recycling plastic waste in construction in Vietnam.

Keywords: *Recycled materials, environmental pollution, recycling plastic waste.*

1. Introduction

Every day, a lot of household waste, industrial waste and construction waste are discharged into the environment. This waste is usually: Concrete, wood, asphalt, plaster, metal, brick, glass, plastic, soil, and stone. However, using recycled materials from these wastes is beneficial to the environment, helping to limit the exploitation of finite resources that are limited to produce new materials. The waste recycling process also helps to significantly reduce the amount of waste dumped in local landfills. For many years, local authorities, especially in large cities such as Ha Noi and Ho Chi Minh City, have had to deal with the problem of overloaded landfills or illegal dumping of waste everywhere. In addition to taking up a large space in landfills, most of the waste is difficult to biodegrade, some residual toxins can seep into groundwater, causing water pollution and soil pollution.

In most countries around the world, products made from plastic are becoming increasingly popular. The PVC, PP, HDPE, PET and nylon, which we commonly call "plastic" emerged 80 years ago and have since rapidly changed the world, quickly becoming prevalent in almost every aspect of life due to their outstanding advantages.

The worrying issue is that only 5% of plastic waste is recycled. The rest continues to exist in the environment, with an estimated 140 million tons of plastic waste already in the oceans, and nearly 13 million tons added annually, most of which comes from Asia. Vietnam is among the top 5 countries contributing the most to this problem. Plastic waste accounts for 80 to 85% of all types of waste in the sea, and in about 30 years, the amount of plastic waste in the oceans will equal the amount of fish if the current situation doesn't change [1].

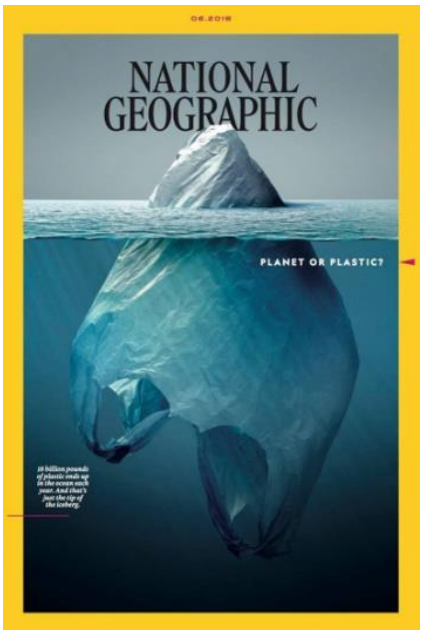

Figure 1. Cover of National Geographic June 2018 "Planet or Plastics?" by Vaughn Wallace. Source: National Geographic

Therefore, researching and proposing solutions for recycling plastic waste and using it in the construction industry as a substitute for traditional materials is extremely necessary. However, caution is needed

because recycling processes can also cause pollution, and recycled products may lead to a "reverse contamination".

(Source: internet)

Figure 2. A plastic waste dump (pollution risk)

2. Recycling plastic waste as construction materials and consequences

2.1. Situation of plastic product usage in Vietnam and other countries in the world

Plastic products are ubiquitous, from small, everyday items like candy wrappers, yogurt cups, straws, and plastic bags to large components and equipment in cars, ships, and airplanes. Human daily needs have driven an increase in production and trade, leading to the disposal of plastic waste into the environment at the end of its life cycle.

Among the various types of plastic waste we need to reduce, one of the most abundant components is single-use plastic products like cups, water bottles, straws, and injection solution bags. On June 9, 2019, during the nationwide launch ceremony to combat plastic waste, Former Prime Minister Nguyen Xuan Phuc set the goal to strive for the entire country to stop using plastic bags and single-use plastic items by 2025. Thus, Vietnam strives to eliminate the use of single-use plastics by 2025. This has been a Government objective since 2019, but it is not an absolute ban for the entire country at present. Although there have been efforts and the issuance of numerous directives, policies, along with pilot activities in some areas, the implementation of this goal still faces many challenges and requires time to achieve.

The current single-use plastic policy in Vietnam is being strongly implemented according to a specific roadmap based on Government regulations, particularly Decree 08/2022/ND-CP. The current policy is directed toward the goal of 2026 to eliminate single-use plastics in major distribution and service channels, and by 2030, the production and import of these items will be completely ceased [3].

A "race" against plastic waste, especially single-use plastics, has also begun in Vietnam, starting in major cities. However, a question arises: What is a sustainable solution to replace single-use plastics? Are the widely used solutions—replacing them with biodegradable plastic products or eco-friendly products like paper or cotton bags—truly appropriate?

A solution to replace single-use plastics must meet criteria such as readily available raw materials, a low enough price to be accepted by the market, and minimal environmental harm after disposal. By this standard, the current solutions are not all environmentally friendly. Why is there such a paradox? Let's look at their material composition and production cycle. For example, to manufacture biodegradable plastics or plastic alternatives, land must be cultivated, which involves clearing natural vegetation and its associated ecosystems and using various chemical fertilizers and pesticides. All these activities lead to soil degradation and environmental pollution. According to a recent study funded by the UK's Environment Agency, the production of paper or cotton bags consumes significantly more water and energy than plastic bags [2].

Furthermore, a paper bag must be reused at least 3 times to ensure its environmental impact (in terms of water, energy use, and greenhouse gas emissions) is equal to or less than that of a plastic bag. For a cotton bag, this number is 131 times [4].

A recent study by the Danish Environmental Protection Agency, under the Ministry of Environment and Food, found that paper bags have an environmental impact more than 43 times greater than single-use plastic bags, and organic cotton bags have an impact more than 20.000 times greater. Simultaneously, the most environmentally friendly bag is a polyester bag reused at least 35 times. Thus, it is not easy to replace single-use plastic products with what we call "eco-friendly" products [4]. Therefore, the need to recycle single-use plastic bags and similar products is immediate and long-term.

It is also important to note that many single-use plastic products cannot be replaced by other products. For example, replacing plastic solution bottles with glass bottles is difficult because glass is more expensive, harder to transport, and its production and disposal have a greater environmental impact than plastic bottles. Moreover, some studies have

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suggested that using easily biodegradable organic materials for packaging can reduce food quality and potentially increase the risk of infection for consumers.

Another issue to consider is that when we use alternative products, industrial production processes still create plastic (from the petrochemical industry). If this plastic is not used, it will become waste and put significant pressure on the environment.

Another solution is to recycle plastic waste into alternative materials for the construction industry, a sector with a massive annual demand for materials. However, this recycling process still comes with certain consequences.

Through research and data synthesis, the popular types of plastic that are widely used in Vietnam, often identified through the numerical symbols on the packaging, are listed below by authors.

a) Safe plastic group

These are types of plastic that are considered safer for food storage and are often well recyclable:

PET (Polyethylene Terephthalate) - Symbol number 1:

Characteristics: Transparent, hard, durable, heat-resistant and gas-proof.

Applications: Mineral water bottles, soft drink bottles, cooking oil bottles, food trays.

Note: Usually recommended for single use only because repeated reuse can be harmful to health.

HDPE (High-density Polyethylene) - Symbol number 2:

Characteristics: High durability, good impact resistance, scratch-resistant and smooth surface.

Applications: Milk bottles, food containers, plastic bags, water pipes.

Note: Considered one of the safest plastics, does not contain toxic ingredients.

PP (Polypropylene) - Symbol No. 5:

Characteristics: High mechanical strength, hard, heat resistant, colorless, odorless and non-toxic.

Applications: Food containers, plastic cups, straws, medicine boxes, toys.

Note: Very safe, can be used to store hot food and easy to recycle.

b) Unsafe plastic group

These types of plastic can contain toxic substances and are difficult to recycle, so they are not recommended for use with food, especially at high temperatures.

PVC (Polyvinyl Chloride) - Symbol No. 3:

Characteristics: Can be hard or flexible, cheap.

Applications: Water pipes, electric cables, raincoats, food wrap, flooring.

Note: Contains toxic substances such as phthalates, should not be used to store food, especially hot food. This type of plastic is also very difficult to recycle and pollutes the environment.

PS (Polystyrene) - Symbol No. 6:

Characteristics: Light, hard, easy to shape and low cost.

Applications: Foam boxes for fast food, disposable plastic cups and plates.

Note: Can release carcinogenic styrene when exposed to high temperatures. Very difficult to recycle.

Other plastics - Symbol No. 7:

This group includes many different types of plastic such as Polycarbonate (PC).

Applications: Water bottles for children (formerly), other hard plastic bottles.

Note: Some plastics in this group, such as PC, may contain BPA (Bisphenol A, an industrial chemical used primarily to make certain plastics and epoxy resins) which is harmful to health, so use with caution.

2.2. Recycling plastic waste for construction: issues requiring attention

The presence of single-use plastics in plastic waste puts pressure on environmental managers. Every year, we produce around 300 million tons of plastic, half of which is single-use. So, how should we deal with single-use plastic? In terms of composition, single-use plastics are often produced with petroleum-based additives. This complicates the recycling process, and to solve this problem, we have to add certain materials and chemicals, not all of which are environmentally friendly [4, 5].

Not just Vietnam, but the entire world is struggling to find a solution to the plastic waste recycling problem. Besides encouraging the use of paper bags and biodegradable plastic, recycling plastic is a noteworthy solution. Recently, a company in Scotland came up with a unique plastic waste recycling idea: turning it into a paving material for roads [1].

Toby McCartney (CEO of MacRebur - Waste Plastic Roads), the founder of the project to recycle plastic waste into asphalt, said that his recycling plant

collects plastic waste from various sources, mostly bottles, plastic bags, and other difficult-to-recycle plastics. After being shredded, the plastic pieces are mixed according to the company's proprietary formula. The resulting material is then packaged and sent to asphalt manufacturers. There, the recycled plastic is mixed in a special ratio to replace bitumen, the black, petroleum-based component in asphalt that binds the crushed stones together.

Figure 3. Classification of plastic waste in household waste in Vietnam (semi-manual and incomplete) [5]

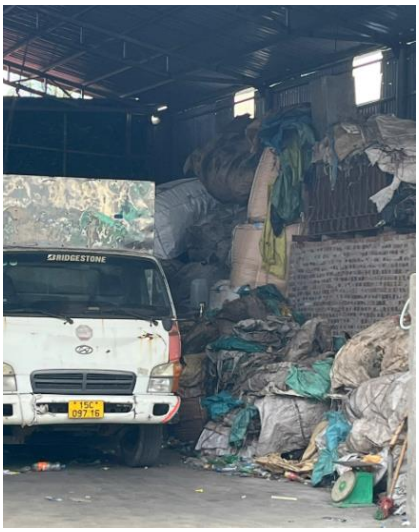

Figure 4. A plastic waste shredding and grinding facility in Trang Minh, Hai Phong, Vietnam (small-scale, difficult to control pollution)

Meanwhile, in Vietnam, public awareness of the importance of environmental protection in general, and the dangers of plastic waste in particular, has increased significantly in recent years. In 2019, a project related to plastic waste also attracted a lot of attention: a project by a group of five students from the University of Transport and Communications to make paving bricks from plastic bags. The students washed and dried the plastic bags before processing them. After heating the plastic bags to create an additive that can increase the product's durability, they carefully mixed the ingredients in a calculated ratio. This mixture was heated in a pan to 180-220°C. Once it reached a certain level of adhesion, the mixture was poured into a mold and compacted with a hammer and rammer to create the final product.

Figure 5. Challenges in classifying plastic waste for recycling (variety of plastic types, visual similarity of different plastic, incompatibility, toxicity, opacity) [3]

A very concerning issue is that many countries, in the name of environmental protection, have been transferring their plastic waste to other nations. According to The Guardian, the U.S. ships over 1 million tons of plastic waste abroad each year. Malaysia has been a record recipient of U.S. plastic waste, and 55% of this is not properly managed—meaning it is simply dumped in open-air sites. Indonesia and Vietnam, meanwhile, have 81% and 86% of their waste, respectively, managed improperly [4].

In 2018, the U.S. sent 83,000 tons of plastic waste to Vietnam. There are clear signs that this waste originated from the U.S., for instance, a bag of Hershey's York Peppermint Patties with an American label.

A new study published in May 2019 by an environmental research group named Gaia stated, "The impact of the commercial plastic waste train to Southeast Asia is astounding—water pollution, crop destruction, respiratory illnesses from exposure to burning plastic, and the increase of organized crime at plastic import sites. These nations and their people are bearing the economic, environmental, and social burden of the pollution, which can be 'passed down' to the next generation" [4].

As mentioned above, the process of recycling plastic into construction materials in Vietnam is gradually becoming a potential solution for waste management and promoting a circular economy. Although still in the initial stages, many projects and

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initiatives are being implemented nationwide. Notable Applications and Projects

• Ecobricks: This is a simple and effective method adopted by communities. Plastic waste is cleaned, shredded, and tightly packed into plastic bottles to create solid bricks. These bricks can be used for non-load-bearing structures like boundary walls, public benches, or decorative features.

• Decking and Construction Materials: Some companies have invested in technology to transform plastic waste into floorboards, wall panels, or other construction materials. For instance, a project in Phu Quoc, in collaboration with the Netherlands, is processing plastic waste to produce planks for walkways, balcony floors, and piers for resorts.

• Concrete and Road Material Mixtures: Studies in Vietnam and worldwide have shown that adding recycled plastic particles to concrete mixtures can improve certain mechanical properties and thermal insulation performance. Some pilot road projects have used recycled plastic to partially replace traditional asphalt, which helps reduce CO2 emissions and enhance durability.

However, the plastic recycling process in Vietnam still faces numerous challenges.

• Massive Plastic Waste: Vietnam is one of the world's largest consumers and disposers of plastic waste, with approximately 1.8 million tons of plastic waste released into the environment annually [6].

• Low Recycling Rate: Despite the large amount of waste, only about 10-33% of plastic waste is collected and recycled. The majority is either landfilled, incinerated, or directly discharged into the environment, causing serious pollution [6].

• The Informal Sector: Plastic recycling activities in Vietnam primarily take place in the informal sector, through a network of waste collectors. They play a crucial role in collecting plastic from households and delivering it to small-scale recycling villages.

• Domestic Raw Material Shortage: Despite the massive volume of plastic waste, many formal recycling enterprises rely on imported plastic scrap because domestic supply is unstable, difficult to sort, and of inconsistent quality.

As was shown in Figure 2 - Figure 5: The sorting and processing of plastic waste in Vietnam are mostly done manually and on a small scale.

Construction is an economic sector that consumes significant natural resources (sand, stone, pozzolanic soil, etc.) and energy. Gradually shifting towards the use of recycled materials will reduce the consumption of these natural resources and address some of the issues mentioned in the four challenges above

Recycling plastic into construction materials can solve the problem of a large amount of plastic waste. However, from a scientific perspective, while this is the right direction, its widespread application still has many drawbacks. Based on the actual conditions in Vietnam, below are the authors' recommendations on this issue.

1) The process of sorting and washing raw materials consumes a lot of labor and clean water, and wastewater treatment is very difficult;

2) The presence of residual pollutants in recycled products [7, 10];

3) The recycling process uses additives that can be toxic to the environment [8, 9];

4) The recycling process, if not controlled with strict procedures, runs the risk of generating toxic gases and dust, which also cause environmental pollution, in some cases even more severely than the landfill process [11, 12];

5) Currently, there are no specific solutions for disposing of or processing building components made from recycled plastic when they reach their end-of-life (after 10, 20, or 30 years). Whether to landfill or continue recycling remains an issue requiring further study;

6) The legal policies on this issue are either non-existent or incomplete. Research and applications are still small-scale and spontaneous.

3. Conclusion

In this article, the problem of plastic waste in life and the recycling of plastic waste as construction materials as well as the consequences of the recycling process and the use of this material are generalized. The choice of solutions for the production and application of this material suitable for the conditions of Vietnam needs to be carefully considered, contributing to reducing environmental pollution and improving the quality of life.

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