

The Use of Blockchain Technology for Managing and Recycling Plastic Waste - The Plastic Bank Model-

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Abstract:

The study aims to highlight how blockchain technology can be used to reduce plastic waste to promote responsible consumption and achieve environmental sustainability. This is done by adopting recycling as part of the new trend towards a circular economy. Our study sheds light on a successful real-world model known as the "Plastic Bank," which allows participating consumers through this application to receive various rewards (financial, service-based, social) in exchange for collecting plastic waste. Additionally, it raises awareness about the importance of environmental sustainability to eliminate plastic pollution. A review of existing literature provides a foundation for presenting the "Plastic Bank" experience, which relies on blockchain technology. The study concluded that adhering to the practices imposed by sustainable development goals as part of a circular economy system encourages consumers, especially in developing countries, to engage in plastic waste collection by offering financial incentives. Therefore, the "Plastic Bank" focuses on countries and coastal communities aiming to achieve additional income and meet their social needs.

Keywords: Blockchain, Circular Economy, Waste Management, Plastic Waste, Plastic Bank Model.

JEL Classification Codes: G24, O13, Q53.

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1. Introduction:

The shift towards a circular economy serves as an alternative to the linear economy due to its ability to support the transition towards sustainable development. It represents a new business model aiming to reduce waste, increase resource efficiency, and achieve harmony between the economy, environment, and society. The circular economy seeks to maintain resources, materials, and products in circulation for as long as possible by preserving their value, enhancing social equality through job creation, and appreciating the value of waste. However, this requires new capabilities, skills, and business models necessitating the reevaluation of the ecosystem to integrate products providing sustainable benefits to customers. There is a need to leverage new technologies to adapt to increasingly changing conditions and respond to consumer demands for sustainable and environmentally friendly products.

Technological advancements, manifested in the Fourth Industrial Revolution or Industry 4.0, play a crucial role in achieving a circular economy. Blockchain technology has emerged under the Industry 4.0 umbrella, highlighted as a facilitator to overcome obstacles towards a circular economy, especially given the enormous potential of blockchain in this field. The ability to integrate technology to exchange information related to materials and supply chain processes transparently can minimize waste, increase circular resource flows, and create an enhanced platform for effective decision-making. This is due to the blockchain's capabilities to accelerate the progress of the circular economy in several ways. Information related to material sources, product origins, processes, energy usage, and relevant stakeholders can be maintained in blockchain ledgers. Along with tracking devices such as Global Positioning Systems (GPS), blockchains can facilitate the traceability of raw materials and products throughout the supply chain. These potential blockchain aspects form the foundation for reuse, recycling initiatives, and managing the performance of the circular economy.

Given the above, the research problem is crystallized in the following main question:

How does blockchain technology, through plastic waste recycling, achieve a circular economy and contribute to environmental sustainability?

To answer this main question, we will attempt to divide it into the following sub-questions:

- What is blockchain technology, and how does it work?
- How can blockchain technology be used to achieve a circular economy?
- To what extent does blockchain technology contribute to waste management?
- Has blockchain technology succeeded in collecting plastic waste through the Plastic Bank model?

Study hypotheses:

- **H1:** Blockchain technology is a technology that has recently emerged thanks to fintech ;
- **H2:** Blockchain technology is used in all fields to reach the environmental field ;
- **H3:** Blockchain technology contributed to the development of waste management systems ;

- **H4:** Blockchain technology has been able to achieve effectiveness, especially in developing countries, by obtaining a variety of benefits for participants.

Importance of the Study:

The importance of the study stems from understanding the current state of research on the use of blockchain in the circular economy, which should be of significant importance to both academia and industry. Especially with the new direction of countries economies emphasizing the necessity of achieving sustainable development goals.

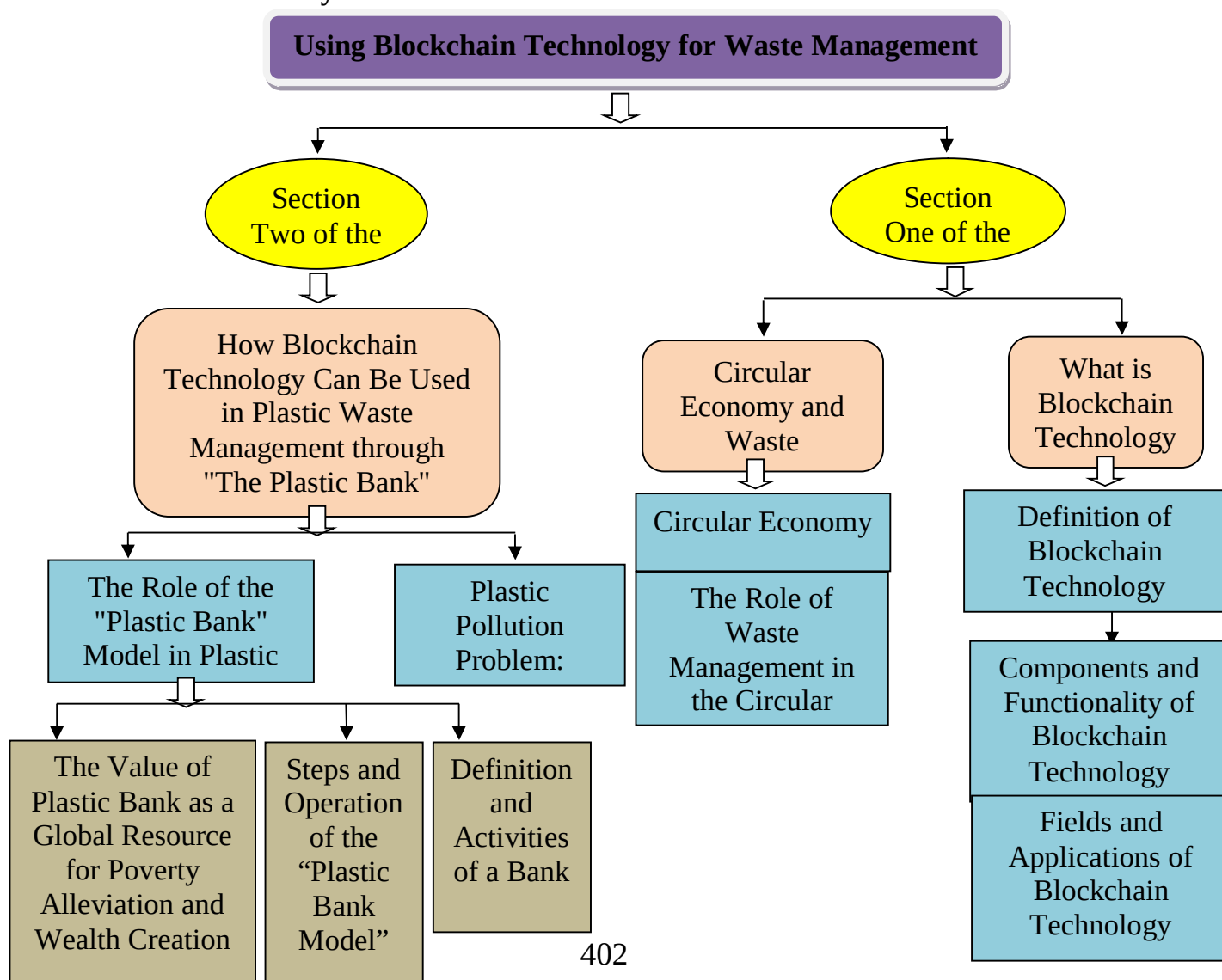
Objectives of the Study:

The study aims to clarify how blockchains can be a key factor in addressing the challenges facing the circular economy and stimulate ideas for effective plans and policies for adopting technology in waste management, which can help achieve both material and moral incomes contributing to environmental sustainability.

Methodology of the Study:

To grasp and cover various aspects of the topic, analyze its dimensions, and answer the posed problem, the descriptive method aligned with the theoretical side was adopted, along with the analytical method that allows for projecting theory onto reality. This was done through the conceptual framework of blockchain technology and its relationship with the circular economy to reduce waste, particularly plastic waste, which was the focus of our study, by presenting the Plastic Bank model.

Structure of the Study:



2. Literature Review

2.1 Overview of Blockchain

2.1.1 Definition of Blockchain Technology

Uncle's phrase of a structural project proposed in 2009 by a person named "Nakamoto Satoshi", in a paper entitled: "Bitcoin: A Peer-To Peer Electronic cash system", which dealt with bitcoin as an electronic monetary base in the blockchain system (kadouri & belahbib, 2023, p. 150).

Blockchain technology, also known as distributed ledger technology (DLT), is a decentralized database distributed among a network of computers worldwide. It stores information and data digitally in a way that no individual can erase or alter (Simanta, 2018, p. 23).

Blockchain is a system that records information in such a difficult way that it cannot be changed or hacked (Bencherif, 2023, p. 403).

Blockchain, or "blockchains" as some call it, is a new technology that allows the transfer and conversion of digital currencies (the first and most famous being Bitcoin) between two parties without the need for a third party. In this way, it resembles an electronic accounting record that is maintained by a group of people (validators) who confirm the transaction after reviewing the records they have (Belli, 2020, p 132).

Blockchain technology is also known as a distributed database in the form of a transaction ledger in the virtual currency "Bitcoin" over a secure network (Satoshi, 2008, pp. 1-9). The recording of these transactions is final and cannot be modified. New transactions are recorded and grouped in batches at regular intervals called "blocks". By creating a chain of blocks, the process is called "Bitcoin mining" (which adds all existing blocks and hence the name blockchain). Each block contains a "hash" of the previous block and this extends to the first block called the "Genesis Block". This makes it difficult to change any block after a certain period of time has passed since its creation, as any change to a block requires changing all subsequent blocks due to the need to recalculate the "hash" of each block to determine the hash of the previous block (Soltane, 2018, pp. 1-9).

2.1.2 Components of the Blockchain

Before discussing how the blockchain works, it is first necessary to understand the components of this chain, which are three elements as follows (Brooke, 2024):

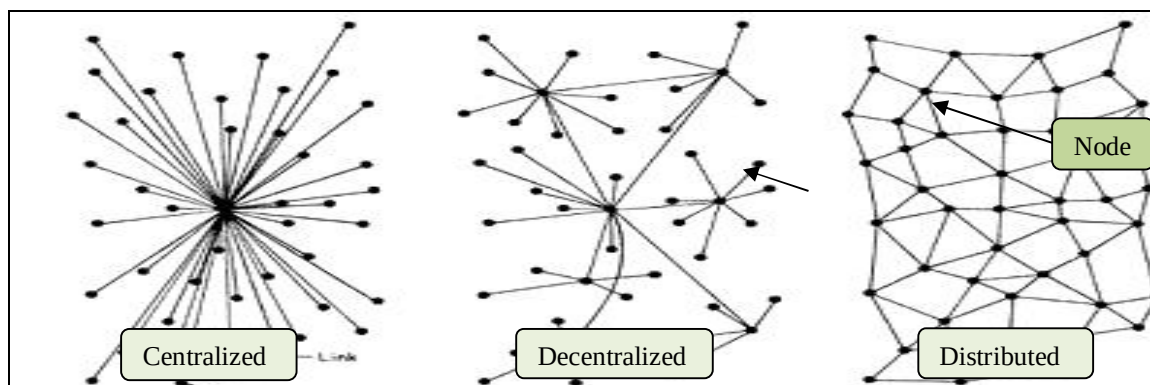
-Blocks: This is the element responsible for storing, preserving, and encrypting information in order to prevent it from being modified or deleted in the future after encryption.

-Mining Process: This is the process of creating a new block and adding it to the chain. It is one of the most difficult processes that can be solved to find the appropriate set to create the blocks.

-Nodes: These are the electronic devices that keep a copy of the chain and operate on the network using a unique alphanumeric user ID.

The following figure illustrates the types of databases and the differences between them:

Figure 1. Types of blockchain database



Source: (Yanowitz, 2018)

The figure above illustrates that a database can exist in three main forms as follows:

-Centralized Database: This refers to the method of collecting, storing, and managing data in a single location, authority, or organization instead of distributing it across multiple entities. This type facilitates easy and quick access to data, simplifies operations, enhances efficiency, and enables better-informed decision-making. Additionally, data centralization reduces information silos, facilitates visibility, and enables the prediction of the potential impact of trends or proposed changes across different departments. Examples of this include online database software, data warehouses, and data lakes (Tremblay, 2023).

-Decentralized Database: This is a database that does not have a central owner or single authority, unlike a centralized database. Its entire data is spread across multiple servers and controlled by several nodes or users. When data is modified by a single node, the changes are reflected across all computers in the network. Decentralized databases have proven to be more efficient due to (Inery, 2022).

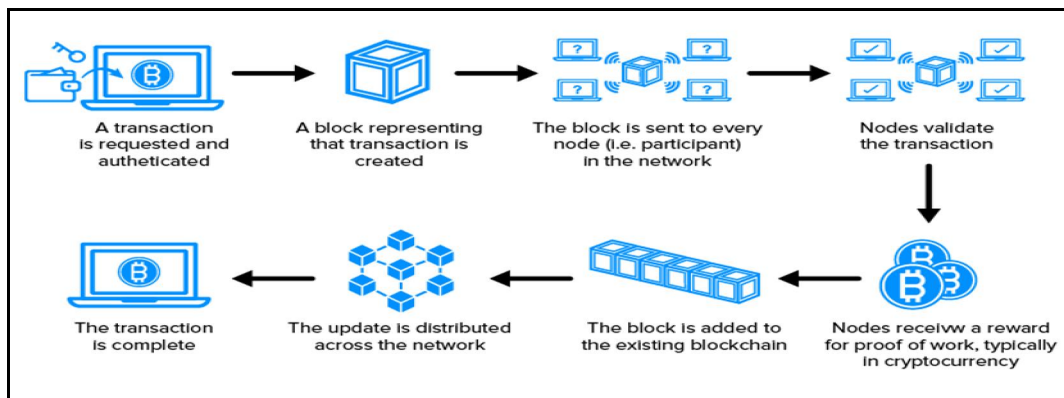
- **Decentralization:** The decentralized framework eliminates potential points of failure, as is evident in blockchain technology.
- **Distribution:** Data is distributed across multiple nodes, ensuring continuous data accessibility even if one or more nodes fail:
- **Security:** Decentralized databases employ encryption techniques to guarantee complete privacy and data security.
- **Scalability:** The resources of a centralized server are limited in centralized systems. As the number of clients increases, the server becomes overloaded and cannot perform well. However, in decentralized databases, capacity increases, allowing a larger number of users to access data simultaneously.
- **Immutability:** Stored data cannot be altered or tampered with, ensuring data integrity.

-Distributed Database: This is a collection of interconnected databases spread across a computer network or the internet. This database is managed by a management system that provides mechanisms to make databases transparent to users, and data is intentionally distributed among multiple nodes (see the aforementioned figure) so that all the organization's computing resources can be optimally utilized (sathyabama, 2020).

The core concept of blockchain technology lies in the fact that all recorded or managed transactions are performed by the beneficiaries themselves and are stored in thousands of interconnected devices around the world (decentralized data), which reinforces

the idea of security and trust in this technology. The following figure illustrates the steps and process of transaction entry into blockchain :

Figure 2. Steps of the transaction entry process into blockchain



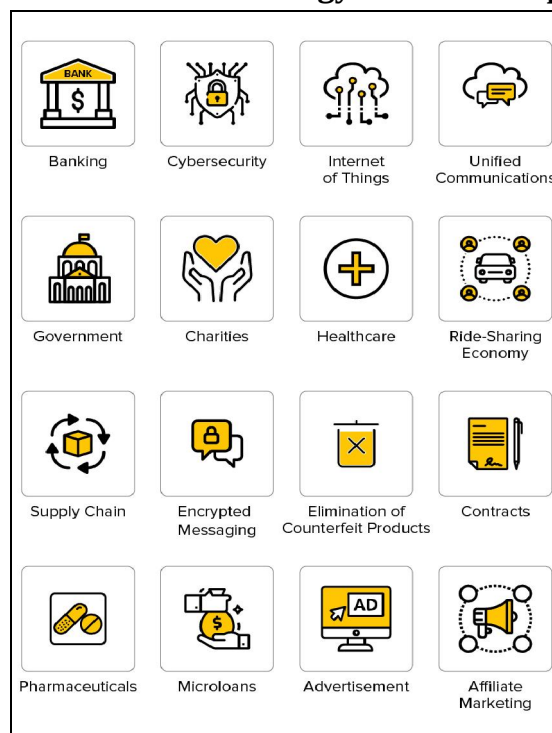
Source: (Chirag, 2021)

From the figure above, the process starts from the client (A), who selling crypto assets to client (B). The process is then recorded or stored with the other processes in the form of “block”, then the network members (Nodes) authenticate this block by encryption, and by this it is added to the next block chain, which is called “central records” or “blockchain”. Here all participating parties can access it, and finally the two clients are informed of the success of the operation.

2.1.3 Blockchain areas and applications

The use of blockchain technology have increased to include many sectors such as financial services, education, healthcare, government, management, travel, etc. and the following figure shows some of this applications:

Figure 3. Blockchain Technology Areas and Applications



Source:(Chirag C. , 2021)

From the figure above, we notice that blockchain technology has applicability in many fields because it is characterized by a number of characteristics, which are as follows (Paul, Aithal, Ricardo, & Surajit, 2021, pp. 191-192):

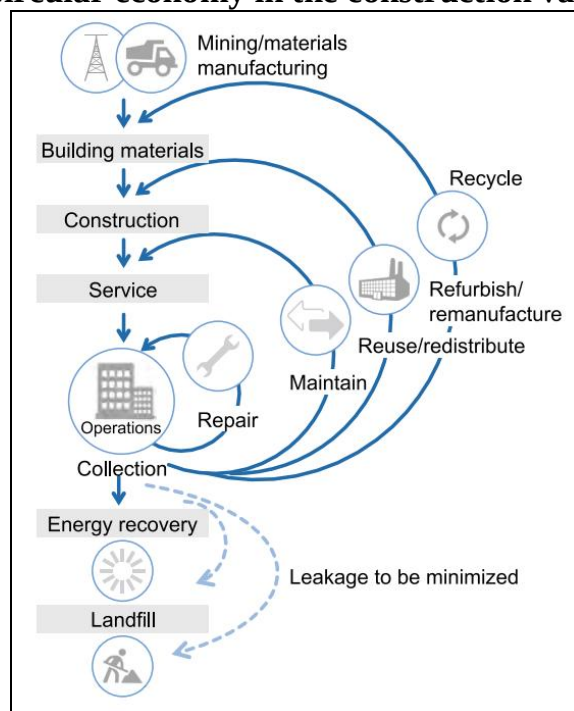
- You do not need a third party in transactions (decentralization), in addition to the lack of a specific entity that agrees or rejects transactions (Ayache, Fanazi, & Matlawi, 2020, p. 314);
- Manage and enhance the personal identity security;
- Anti-Money laundering ;
- Reducing the overall costs of transaction;
- Improving the security and efficiency of transactions;
- Changing the economic priorities and social construction (Charpentier & Johansson, 2017, p. 4);
- Reducing fraud ;
- Enabling participants, supervisors and regulators to effectively monitor and review.

2.2 Circular economy and waste management

2.2.1 Circular economy:

Unlike the traditional model (linear economy), which means extracting raw materials from the soil to make products that are consumed and then ultimately disposed of. The circular economy is a model that keeps resources and products in use for as long as possible. Therefore, in particular term the circular economy reduce waste generation through repair, maintenance, reuse of products and recycling of materials. (CSTC, 2017, pp. 1-2), and the following figure makes this clear :

Figure 4. Circular economy in the construction value chain



Source: (Breene, 2016)

The idea of the circular economy is based on a broad study of three basic areas, including the following: (Zaimi & Benmalek, 2024) :

- **Producing and supplying goods and services:** Sustainable supply of resources (renewable or non-renewable), eco-design of goods and services, development of industrial and regional ecology, implementation of functional economy (use of service rather than possession of property);
- **Demand and consumer behavior:** through responsible purchasing, proper use of products, reuse and repair;
- **Waste management:** Waste management works to promote recycling, especially at the production and consumption levels because they are the main determinants of the volume of waste.

2.2.2 the importance of waste management in the circular economy

Due to the Inability of linear economy, and the increasing demand for raw materials and energy resources especially since most of them are not renewable and will run out within a few decades. In addition to this, the failure of waste management policies and the difficulty of controlling accumulated and widespread waste. Policies have gradually shifted towards recycling since 1975, and calling for rational consumption of resources and reduce waste production, through reuse products, relying on hierarchy of waste treatment methods. Thus, the view on waste has changed from a worthless, contaminated product into secondary raw material has two advantages; the first is a source of value creation, the second is to enable the governments to rely on waste recycling as a sustainable economic activity. Thus, the recycling has become the basis of circular economy whose importance must be enhanced in the future especially since the 2018 French map for the circular economy aims to recycle 100% of plastic in 2025. The circular economy aims to decouple economic growth from consumption of non-renewable resources, by reducing the consumption of resources and energy, as well as reducing the life of service, maintenance, repair, reuse and remanufacturing. However, the process of total recycling is not possible for several possible reasons, such as losses in the production cycles (uncollected waste, production process waste), and sometimes the impossibility of recycling (waste is too contaminated or made of different materials to be separated), Moreover, recycling is not a sufficient solution to the problem of preserving raw materials. Therefore, some conflict arises about the possibility of relying on the circular economy as a new economic model, for the transaction to a more sustainable society. On the one hand, there is a great expectation about the possibility of relying on recycling to avoid the risks resulting from resource depletion, and on the other hand, On the other hand, a group of obstacles emerge that make recycling a temporary solution that only delays the depletion of resources for some decades to come.(Boldrini, 2018, pp. 3-4).

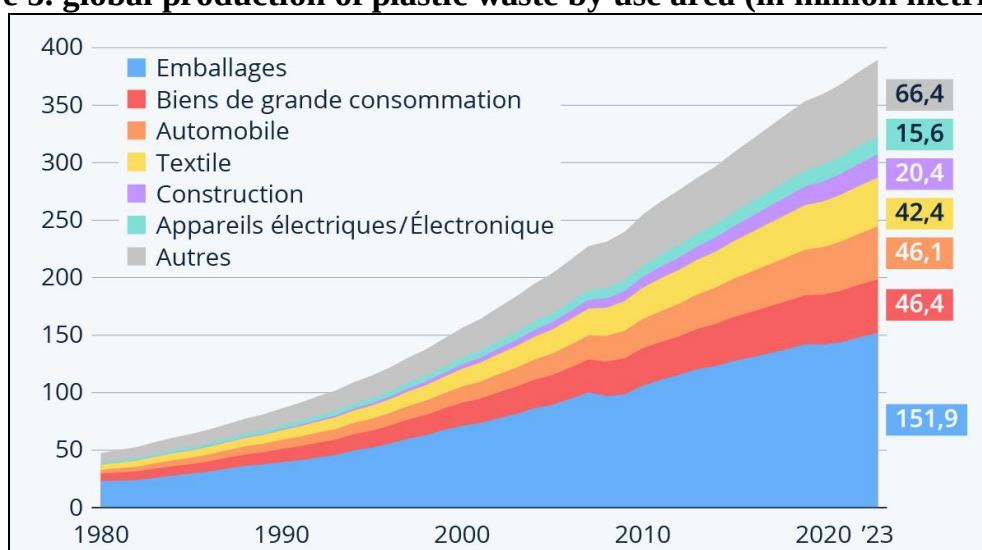
3. How to use blockchain technology to manage plastic waste through the “Plastic Bank”

3.1 The problem of plastic pollution

A report by the Organization for Economic Cooperation and Development (OCDE) in 2022 showed that half of the plastic waste is produced by the countries of this organization. Its per capita is estimated at 221 kg in the United States, 114 kg in European countries, and 69 kg in Japan and Korea. The reason for this high plastic pollution is the insufficient collection and disposal of this plastic waste. The economic recession caused by the COVID-19 crisis appears to have contributed to a 2.2% reduction in plastic consumption in 2020. On the other hand, the amount of land-based plastic waste has increased due to the resurgence of litter abandonment, packaging consumption, and the use of plastic medical equipment such as masks. However, plastic consumption quickly rebounded with the outbreak of the global health crisis (Covid-19) and the recovery of economic activity in 2021. In this context, several key measures have been implemented to reduce plastic production, by innovating and improving product design and developing environmentally friendly alternatives, as well as improving waste management and developing recycling. Global production of secondary (recycled) plastics more than quadrupled between 2000 and 2019 from 6.8 million tons to 29.1 million tons, a rate of only 6% of total plastic production, this is why it is necessary to create a separate market for recycled plastic. Furthermore, secondary plastics can be made more competitive and cost-effective by setting minimum rates of incorporation of recycled materials and investing in improved recycling technologies (OCDE, 2022).

Since packaging represents 40% of the total plastic waste generated globally, reducing and recycling plastic bottles has become a priority in the fight against plastic pollution. Recently, progress has been made in this direction, which is clearly visible in the following figure:

Figure 5. global production of plastic waste by use area (in million metric tons)



Source : (Gaudiaut, 2023)

From the figure above, we notice that, The largest's share of waste is plastic (plastic waste), estimated at 151.9 million tons, Followed by other miscellaneous waste, at 66.4 million tons, then waste of mass consumer goods and automobile waste, at 46.4 million tons

and 46.1 million tons, respectively. While the share of textile waste reached 42.4 million tons. Industrial waste and waste electronic/electrical devices constituted the smallest share of the volume of waste production by sector, at 20.4 million tons and 15.6 million tons.

In order to provide a clear and comprehensive analysis, the following table displays the share of plastic waste produced and recycled around the world as follows:

Table 1. Change in the share of plastic waste produced that is recycled worldwide by region between 2000 and 2019 (%)

	<i>Inde</i>	<i>Chine</i>	<i>Europe</i>	<i>Amérique hors USA</i>	<i>Monde</i>	<i>Asie hors Chine et Inde</i>	<i>Océanie</i>	<i>Afrique subsaharienne</i>	<i>Moyen-Orient et Afrique du Nord</i>	<i>Etats-Unis</i>
2000	5.07	4.78	4.44	4.72	3.7	3.83	3.8	3.01	2.84	2.35
2001	5.52	5.21	4.86	4.97	3.99	4.08	3.96	3.16	2.98	2.46
2002	5.97	5.64	5.28	5.23	4.27	4.33	4.13	3.3	3.12	2.57
2003	6.41	6.07	5.71	5.48	4.56	4.59	4.3	3.45	3.26	2.68
2004	6.86	6.51	6.15	5.74	4.86	4.84	4.46	3.6	3.4	2.8
2005	7.3	6.93	6.58	5.99	5.15	5.08	4.62	3.74	3.54	2.91
2006	7.75	7.36	7.01	6.25	5.44	5.33	4.78	3.88	3.68	3.02
2007	8.19	7.79	7.43	6.5	5.74	5.57	4.94	4.03	3.82	3.13
2008	8.62	8.21	7.86	6.75	6.02	5.79	5.08	4.17	3.95	3.23
2009	9.05	8.63	8.28	7	6.31	6.02	5.23	4.31	4.08	3.34
2010	9.51	9.06	8.72	7.26	6.62	6.26	5.39	4.46	4.22	3.45
2011	9.97	9.5	9.17	7.52	6.94	6.5	5.55	4.6	4.36	3.57
2012	10.42	9.93	9.6	7.77	7.24	6.73	5.7	4.74	4.49	3.68
2013	10.86	10.36	10.01	8.02	7.54	6.96	5.86	4.88	4.63	3.79
2014	11.29	10.74	10.43	8.26	7.84	7.18	6.01	5.02	4.76	3.89
2015	11.76	11.22	10.88	8.55	8.16	7.43	6.2	5.17	4.9	4.01
2016	12.2	11.65	11.29	8.81	8.45	7.66	6.36	5.31	5.04	4.13
2017	12.62	12.04	11.68	9.05	8.75	7.89	6.52	5.46	5.17	4.25
2018	13.02	12.49	12.08	9.3	9.04	8.14	6.69	5.6	5.31	4.36
2019	13.33	12.8	12.38	9.55	9.29	8.35	6.87	5.72	5.45	4.49

Source: Prepared by researchers based on: (Statista, 2024)

Tracking the size of the share of plastic waste produced and recycled by region from 2000 to 2019, recognizes the magnitude of the marked change from year to year even in slight proportions. Global growth rates do not reflect the actual activity of each region in the management of plastic waste, which we see clearly in the share of plastic waste and recycling in the world in 2000, estimated at 3.7%, which rose to 9.29% in 2019. But in comparison with India, China and Europe's share, which achieved higher rates than its counterparts in 2019, it reached 13.33%, 12.8% and 12.38% respectively, it recognizes the level of awareness that has reached these communities that have achieved positive results to eliminate plastic pollution and achieve additional incomes. This is the opposite of what we

see in the United States of America and the Middle East and North Africa region, which achieved the lowest rates at 4.49% and 5.45% respectively.

3.2 The role of the “Plastic Bank” model in plastic waste management

3.2.1 Definition of the nature and activities of the bank

The Plastic Bank aims to introduce the true value of plastic, which makes it receive great attention as a raw material instead of just environmentally polluting waste. This is through its PlasticBank® application in which it uses Blockchain technology to securely carry out these plastic transactions. As soon as the first savings account is opened, each member (individuals, companies) receives a digital wallet for the application, which is why it was called the “Plastic Bank”. Plastic Bank is also a for-profit social financial technology by investing its profits in its interest collection, Develop and maintain recycling infrastructure, develop technology to trace materials and create social, environmental and economic impact(plasticbank, Frequently asked questions about Plastic Bank, 2024).

3.2.2 Steps and method of work of “plastic bank”

In order to subscribe or work on the “Plastic Bank” application, you must follow the following steps (plasticbank, 2024):

- **The first step:** subscribe (individuals/ companies) to the plastic collection box, with the aim of With the aim of helping support communities through the process of cleaning up the environment.

- **The second step:** Plastic collection by Subscribed members, after determining the method by which they will be paid by choosing one of the following methods:

- Get income.
- Zero loans (interest-free loan).
- Education.
- Social benefits.

-**the third step:** Track the process by checking the exchanges made via that bank's Blockchain platform.

- **The fourth step:** After completing the previous steps, Plastic collection contributes to:

- Providing raw material for manufacturing plastic products ;
- Offsetting the demand for plastic consumption;
- Increasing the possibility of replacing virgin materials with recycled plastic ;
- Creating a circular economy for plastics.

Figure 6. The most important achievements of Plastic Bank

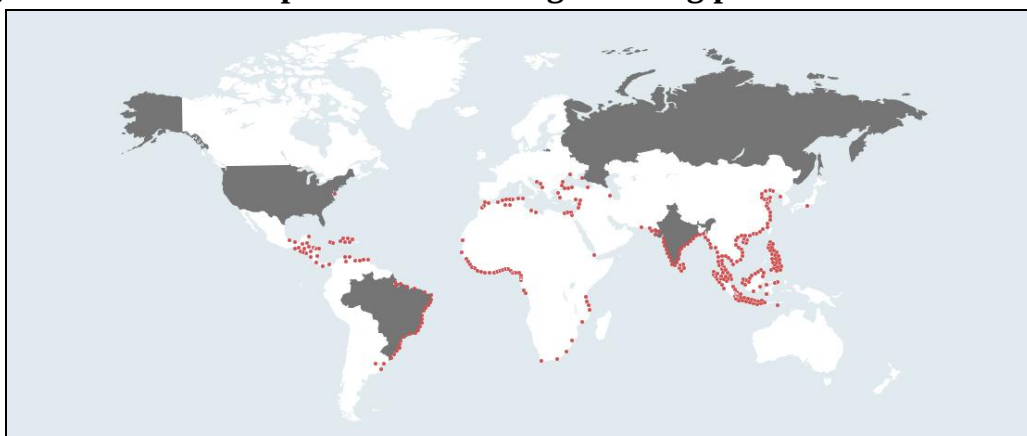


Source: Prepared by researchers based on : (plasticbank, 2024)

3.2.3 The value of plastic as a global resource for eradicating poverty and creating wealth

Most low-income communities around the world rely on economical options that are packaged in single-use plastic when making purchases, such as water bottles, bags, etc. This excessive consumption of cheap goods that are easily disposed of leads to the spread of plastic pollution around the world, we also find that the majority of developing countries lack infrastructure and plastic recycling programs, In addition to, insufficient systems for industrial waste Which leads to the accumulation of huge amounts of plastic waste in the environment. Although residents of developed countries also create large amounts of plastic waste, but they have better waste management infrastructure and plastic recycling centers. This is shown in the following map:

Figure 7. The most important countries generating plastic waste in the world



Source :(Plasticbank, 2024)

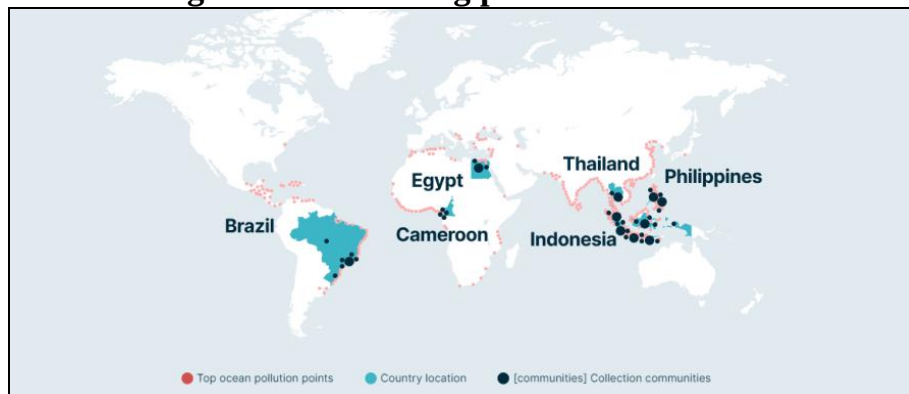
From the map above, we notice that the United States of America occupies first place as the country that produces the most plastic waste, with an annual production of 34 billion kilograms. Then India comes in second place with 26.3 billion kilograms of plastic waste, followed by China with 21.6 billion kilograms, Brazil with 10.6 billion kilograms, Indonesia with 9.1 billion kilograms, Russia with 8.4 billion kilograms, Germany with 6.6 billion kilograms, and the United Kingdom with 6.4 billion kilograms, and finally Mexico with 5.9 billion kilograms.

Before entering a new country or society, the Plastic Bank evaluates a set of factors on which it depends on making its decision, such as: the amount of plastic leaking into the oceans, the level of poverty, population density, the level of infrastructure, access to local processors and their capabilities, and infrastructure. Logistics, the presence of coastal communities looking for additional income. The following map shows the short-, medium- and long-term expansion path set by the bank as follows:

Figure 8. Plastic bank extension range

Source : (Plasticbank, 2024)

When the Plastic Bank enters any country or society, it interacts with its members (Families, business owners, cooperatives, community centers, schools). To discover the most desired and unmet social needs of these communities, which helps it localize its model and adapt its social programs to be more impactful :

Figure 9. Stimulating plastic communities

Source : (Plasticbank, 2024)

4. conclusion

Blockchain technology is one of the technologies that has become popular recently, and has been used in many diverse fields, and even to help solve some current environmental problems.

Results of the study:

- Blockchain technology can be relied upon to provide applications for decentralized energy systems, innovative financial tools, supply chain monitoring and tracking applications, and token -commodity trading applications;
- Blockchain technology helps in finding environmental solutions in different ways to enhance sustainability;
- Adoption of emerging technologies such as blockchain requires the development of digital infrastructure;
- The blockchain-based waste recycling process allows ensuring that waste is managed, recycled, and disposed of in an environmentally friendly manner;
- Blockchain technology is used to create a transparent and efficient waste management and recycling system;

- The Plastic Bank app uses cloud computing and blockchain technology to generate revenue from ocean plastic;
- The Plastic Bank is establishing collection points in many developing countries as part of its sustainability initiative;
- Using the decentralized application "Recycle to Coin" (RTC), based on Blockchain technology; Individuals and companies can access a system of rewards and incentives for recycling plastic bottles and cans;
- The RTC system encourages individuals to recycle more and obtain rewards by using the points accumulation feature provided by the application.

recommendations:

- the necessity of adopting specific policies that help design future systems that prevent environmental risks, especially with the advancement of Blockchain technology and the digital technologies associated with it;
- Spreading change behaviors and promoting a culture of recycling by relying on social, media, and other means;
- Trying to dispense with plastic by using other alternatives such as paper;
- Changing the real value of plastic materials used in packaging;
- Changing the real value of plastic materials used in packaging and packing from waste to assets, and creating economic, social and environmental standards that enable market mechanisms to enhance this value (transfer and exchange).

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