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Efficient Plastic Recycling and Remolding Circular Economy Using the Technology of Trust–Blockchain

Swikriti Khadke [1,†], Pragya Gupta [1,†], Shanmukh Rachakunta [1,†], Chandreswar Mahata [2], Suma Dawn [3], Mohit Sharma [4], Deepak Verma [5], Aniruddha Pradhan [6], Ambati Mounika Sai Krishna [7], Seeram Ramakrishna [8], Sabyasachi Chakrabortty [9], Gopalan Saianand [10], Prashant Sonar [11,12], Sajal Biring [13,14,*], Jatindra Kumar Dash [1,*] and Goutam Kumar Dalapati [7,14,15,*]

1 Department of Computer Science and Engineering, SRM University AP, Amaravati 522502, India; swikriti_khadke@srmap.edu.in (S.K.); pragya_gupta@srmap.edu.in (P.G.); shanmukh_r@srmap.edu.in (S.R.)
2 Division of Electronics and Electrical Engineering, Dongguk University, Seoul 04620, Korea; chandreswar@gmail.com
3 Department of Computer Sciences, Jaypee Institute of Information Technology, Noida 201309, India; suma.dawn@gmail.com
4 Institute of Materials Research and Engineering, Agency for Science, Technology and Research (A*STAR), Singapore 138634, Singapore; sharmam@imre.a-star.edu.sg
5 Department of Mechanical Engineering, Graphic Era Hill University, Dehradun 248001, India; dverma.mech@gmail.com
6 IBM India Pvt. Ltd., Kolkata 700156, India; pradhan.aniruddha@gmail.com
7 Department of Physics, SRM University AP, Amaravati 522502, India; mounikasai_ambati@srmap.edu.in
8 Center for Nanofibers and Nanotechnology, Faculty of Engineering, National University of Singapore, Singapore 117576, Singapore; seeram@nus.edu.sg
9 Department of Chemistry, SRM University AP, Amaravati 522502, India; sabyasachi.c@srmap.edu.in
10 Global Centre for Environmental Remediation (GCER), College of Engineering, Science and Environment, The University of Newcastle, Callaghan, NSW 2308, Australia; SaiAnand.Gopalan@newcastle.edu.au
11 Centre for Material Science, School of Chemistry and Physics, Queensland University of Technology (QUT), Brisbane, QLD 4000, Australia; sonar.prashant@qut.edu.au
12 Centre for Waste Free World, Queensland University of Technology (QUT), Brisbane, QLD 4000, Australia
13 Department of Electronic Engineering, Mingchi University of Technology, New Taipei City 24301, Taiwan
14 Organic Electronics Research Center, Mingchi University of Technology, New Taipei City 24301, Taiwan
15 Sunkonnect Pte Ltd., Singapore 637141, Singapore
* Correspondence: biring@mail.mcut.edu.tw (S.B.); jatindrakumar.d@srmap.edu.in (J.K.D.); goutam.d@srmap.edu.in (G.K.D.)
† Represent equal contribution.

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Abstract: Global plastic waste is increasing rapidly. In general, densely populated regions generate tons of plastic waste daily, which is sometimes disposed of on land or diverged to sea. Most of the plastics created in the form of waste have complex degradation behavior and are non-biodegradable by nature. These remain intact in the environment for a long time span and potentially originate complications within terrestrial and marine life ecosystems. The strategic management of plastic waste and recycling can preserve environmental species and associated costs. The key contribution in this work focuses on ongoing efforts to utilize plastic waste by introducing blockchain during plastic waste recycling. It is proposed that the efficiency of plastic recycling can be improved enormously by using the blockchain phenomenon. Automation for the segregation and collection of plastic waste can effectively establish a globally recognizable tool using blockchain-based applications. Collection and sorting of plastic recycling are feasible by keeping track of plastic with unique codes or digital badges throughout the supply chain. This approach can support a collaborative digital consortium for efficient plastic waste management, which can bring together multiple stakeholders, plastic manufacturers, government entities, retailers, suppliers, waste collectors, and recyclers.

Keywords: blockchain; circular economy; digital badge; supply chain; plastic recycling; circular premium; machine learning

1. Introduction

Imagining a world without plastics is nearly impossible. In the last half-century, there have been many radical changes on the planet's surface. Still, one of the most commonly observable is the universality and excess of plastic junk [1]. Presently, plastic has become a symbol of human ingenuity and absurdity. Although plastic is created as a remarkable material with various characteristics, capabilities, and challenges, we have ignored the management of plastic after its intended usage. Consequently, in 30 years, our oceans may contain more plastic than fish by volume. Often, illicit oil spills from ships and massive oil-refinery accidents in oceans grab our attention, and several studies have been reported to alleviate and manage these marine pollutions [2]. However, collective actions and responsibilities that are mutely poisoning or harming the entire marine ecosystem in plastic pollution are rare.

1.1. Classification of Plastics and Recycling Process

Plastics are typically labeled through the chemical shape of the polymer's spine and aspect chains; a few classifications are acrylics, polyesters, silicones, polyurethanes, and halogenated plastics. Plastics can also be functionalized through the chemical technique during synthesis, together with condensation, polyaddition, and cross-linking. The most prevalent type of marine debris found in our oceans and the Great Lakes is plastic [3]. Plastic waste can come in all shapes and sizes, but "microplastics" are those that are less than five millimeters in length (or about the size of a sesame seed). Microplastics come from several sources, including larger debris of plastic that degrades into smaller and smaller parts. In addition, very tiny pieces of processed polyethylene plastic are known as microbeads, a form of microplastic, applied to health and beauty products. According to industry estimates, an Indian consumes 11 kg of plastic every year. Though it is much less compared with other countries, it is still a problem for society [4]. There are different types of plastics present in the environment such as amorphous plastics and crystalline plastics, conductive polymers, biodegradable plastics, and bioplastics. The semicrystalline plastics consist of polyethylene, polypropylene, polyvinyl chloride, polyamides (nylons), polyesters, and a few polyurethanes. These are usually used in food jars, cosmetics boxes, and soft drink bottles. It is worth noting that natural polymers such as collagen, chitosan, fibroin, and hydrogel are conductive polymers mainly used for electronic devices, solar energy conversion, energy storage devices, tissue engineering, regenerative medicine, and biosensors [5]. Biodegradable plastics are plastics that degrade or smash down upon exposure to daylight or ultraviolet radiation, water or dampness, microorganisms, enzymes, or wind abrasion. These are usually used in shopping bags, compostable waste collection bags, trays, and punnets for fruit, meat, and vegetables. While maximum plastics are made of petrochemicals, bioplastics are made drastically produced from renewable plant substances such as cellulose and starch [6]. Bioplastics are used in medical applications that include implants such as screws, pins, or plates, as well as material for pills and capsules. It is worth noting that production, consumption, and plastic pollution have been increasing rapidly [7] and therefore, it is important to recycle plastics to maintain the sustainability of society.

Figure 1 shows a schematic diagram of the typical plastic recycling process. In plastic industries, it has been observed that most plastic product manufacturers preferred raw plastic materials instead of recycled ones because of the lack of information available regarding the quality, suitability, and complex process as shown in Figure 1. Most of the segregators are just segregating the plastics without knowing the impact of this on society. Thus, it is much sought-after to reduce plastic pollution.

Figure 1. The typical stages involved in plastic recycling.

1.2. Blockchain-Based Technology for Plastic Recycling and Circular Economy

Efficient recycling technology is essential to reduce plastic pollution. Many technologies have been employed to enhance plastic recycling. Among them, blockchain is promising for plastic recycling and circular economy (CE). Blockchain, a distributed ledger, consists of some ordered blocks which are unchangeable. This can be considered an exemplary way to push the transactions of their customers under the same blockchain technology. Because of the decentralized system and minimum transaction costs, most companies prefer blockchain technology [8]. The advantages of blockchain technology are decentralization, transparency, openness, and temper-proof constructions. Therefore, most industries or companies rely on this technology [9].

In this regard, Chidepatil and co-workers have developed a blockchain smart contract technique enabled with various sensors and AI-based algorithms. This technique helped them to identify good-quality recycled plastics [10]. Another most important concept was also recognized, known as the CE. The CE helps to understand our economy by introducing the rethink and redesign concepts. CE works on multiple levels such as micro to macro levels and provides economic opportunities as well as social and environmental benefits. Blockchain technology makes the CE stronger by introducing various information support systems [11].

Blockchain technology and the CE are the two emerging concepts that will revolutionize lives in the upcoming decades. The introduction of Industry 4.0 also changes the various organizational activities by providing different technological transformations. The inclusion of blockchain technology with the CE is one of the examples of this technological innovation. Furthermore, CE objectives are much supported by blockchain technology, as it provides transparent information and reliability [12]. The 3Cs which are of utmost importance in blockchain technology are (i) cooperation, (ii) coordination, and (iii) collaboration, which makes the decision-making process much easier and transforms the working culture of various sectors like agriculture, banking, supply chain, healthcare, etc., by providing high-level security and transparency [13].

Recently, an "IBM-Plastic Bank Activity Kit" was launched by IBM for solving plastic waste issues. The motive of this kit is to provide "grab and go resources" which encourage students or volunteers to come forward and talk about potential issues which are of primary concern to our society and environment. This activity kit also assists in teaching people about their plastic footprints and motivates them to reduce plastic waste globally and from their local premises/areas [14]. We all know that plastic recycling is a most critical and severe issue, but the introduction of blockchain technology attempts to minimize all the issues related to waste management and recycling. Blockchain brings greater transparency in the recycling sector that will help the decision-making process accurately [15]. The CE can be pushed forward through the utilization of digitalization. Concerning this, blockchain along with Artificial Intelligence (AI) and the Internet of Things (IoT) helps in developing and improving transparency and traceability [16].

Blockchain technology enhances the capital flow by minimizing the transaction costs, and reducing investment risk (inclusive liquidity risk), resulted in reduced capital cost and improved chances of investments with the running financial infrastructure [17]. In addition, Forrest and coworkers have reported that industrial contribution in fossil fuel-based plastic production may provide an economical and technical solution to restrict the plastic flow movement by incentivizing and converting it into a useful commodity and promoting polymer technology industries [18]. In this paper, we have discussed plastic production using machine learning and an Auto-Regressive Integrated Moving Average (ARIMA). In addition, we have discussed blockchain technology to boost plastic recycling and CE.

2. Statistics and Forecasting of the Plastic Waste Production Globally

We used machine learning techniques to predict plastic generation globally. For the prediction of plastic generation, we collected plastic generation data from previous years [19]. The statistics were generated using Python language, importing suitable packages. The Pandas library was used for the data structures and operations for analyzing numerical tables and time series. Matplotlib.pyplot is the collection of functions that make matplotlib work like MATLAB. The data was collected from the year 1950, and the production volume is in million metric tons as shown in Figure 2. It totaled as 368 million metric tons by 2019. The data concluded that plastic waste never decreased and grew progressively. As we are dealing with progressing data over time, ARIMA—an Auto-Regressive Integrated Moving Average is used to capture standard temporal structures in time series data, especially over trends of seasonality and noise. ARIMA has three components, i.e., AR-autoregressive term, I-differencing term, and MA-moving average term. AR refers to past values that are used for forecasting the next value. It is defined by parameter 'p'. The value of 'p' is determined by PACF (Partial Auto Correlation Function). MA refers to the number of past forecast errors that is used to predict the future values. It is represented by 'q', which is calculated using ACF plot (Auto Correlation Function). This pre-processing of data might consume lot of time. Auto ARIMA in this way is powerful because it automates this process and makes these calculations simple. Auto ARIMA considers the AIC (Akaike Information Criterion) and BIC (Bayesian Information Criterion) values generated to determine the best combination of parameters. AIC and BIC values are estimators to compare models. The lower these values, the better the model is.

The auto ARIMA from the pmdarima package is used to evaluate the effect of different kinds of orders. The objective here is to allocate a score (such as Akaike Information Criteria, AIC) for every order, and the goal is to minimize the AIC. Auto Arima gives out the best order by comparing AIC values, and with the best order that has minimum AIC, we train the model. In this case, the AIC value is 139.358 and BIC value is 141.482. The values of p (number of autoregressive terms), d (number of nonseasonal differences needed for stationarity), and q (number of lagged forecast errors in the prediction equation) are 1, 1, and 0, respectively. The result is depicted in Figure 3. The forecasted values of the waste that is going to be produced in the next 40 years range from 368 Mt to 1392 Mt. This shows that there is a ~62% increase in the plastic waste produced worldwide. In Figure 3, the portion of the graph plotted with red color shows the forecasted values generated by the ARIMA model.

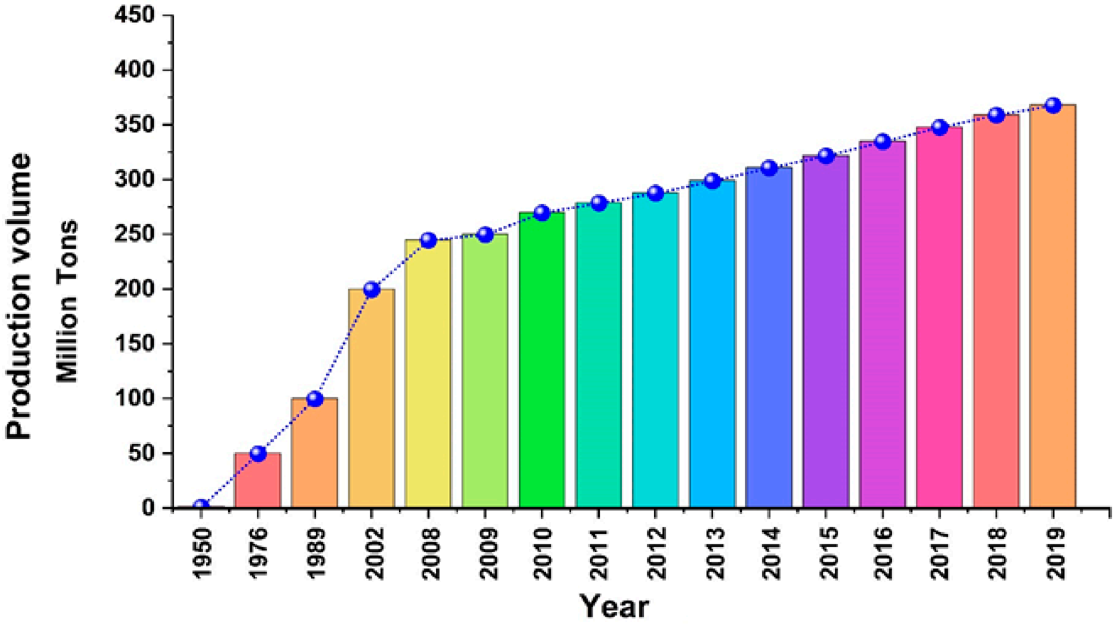


Figure 2. Plastic waste generation from 1950 to 2019.

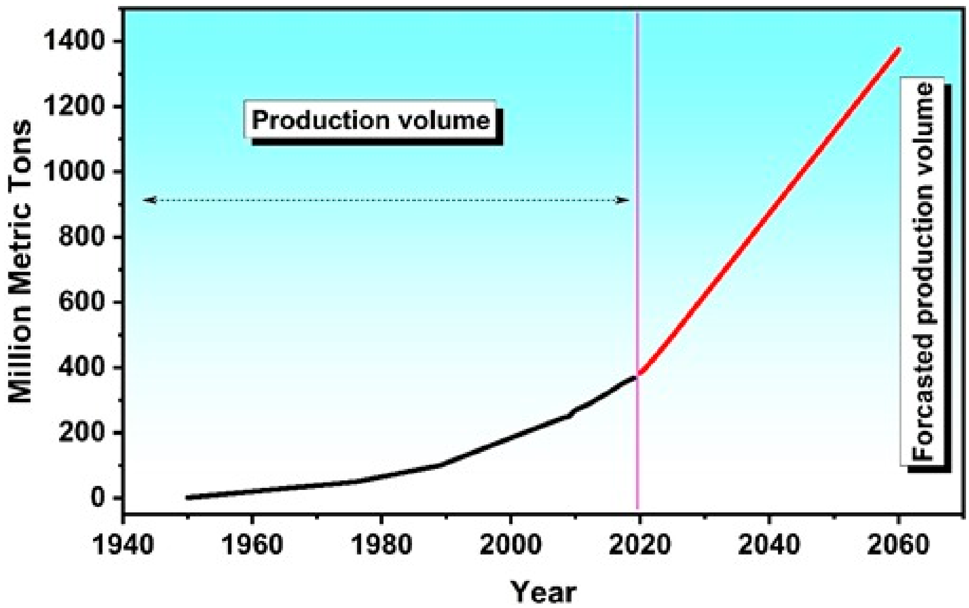


Figure 3. Forecasting of production volume with black being recorded data and red being forecasted data.

There are three types of plastic waste disposals, namely recycling, incineration, and disposal. Recycling processes were negligible on a global scale until late 1987. Incineration and disposal were the only ways observed. Notable percentages of the recycling process were observed only after 1987, and humans achieved recycling 19.7% of the whole plastic waste in the year 2015. Disposal readings of the waste produced globally can be seen in Figure 4.

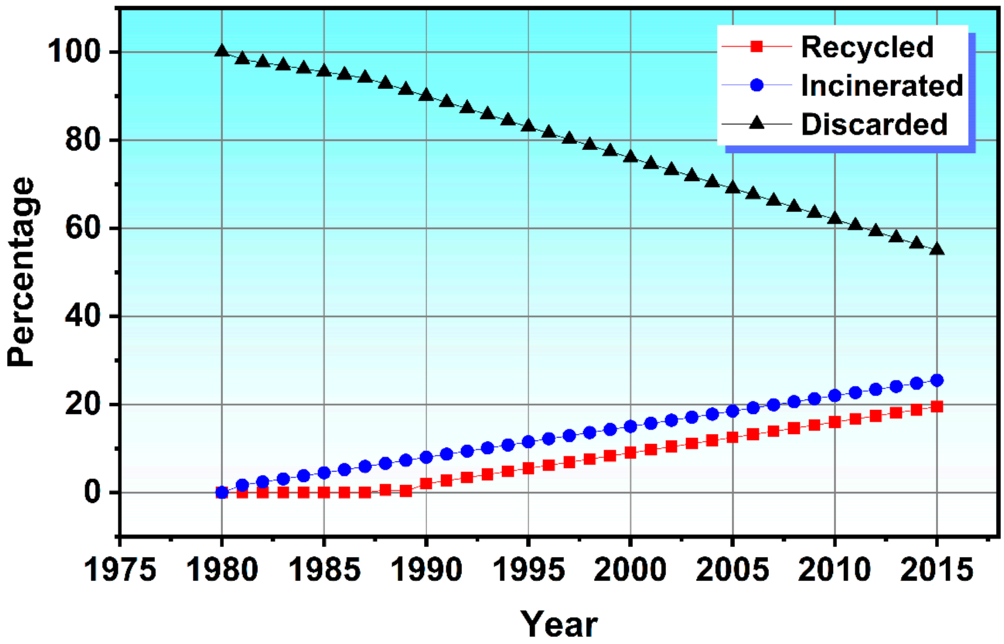


Figure 4. Global waste disposal readings.

The disposal percentages were decreased and replaced with recycling and incineration. Forecasting these percentages over a time series gives us an in-depth look into the chain of the plastic economy. Figure 5 shows forecasting of rates of recycling. In an ideal scenario where the disposals and incineration process are stopped and the ideal recycling process is achieved, with the current trend, it would take 60 years from now to achieve the ideal state. Since reducing incineration and disposal percentages to 0 and recycling to 100 is entirely ideal, we tend to achieve more regulated processes. According to the forecast, there exists an equilibrium point where all the three percentages tend to be similar. This point occurs around 2030–2034, as shown in Figure 6.

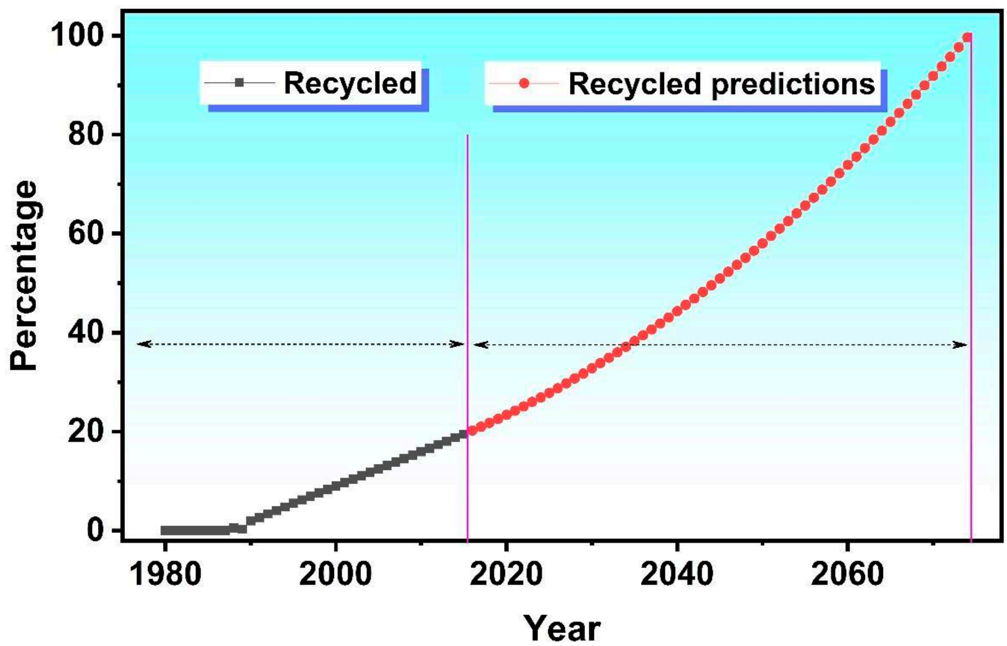


Figure 5. Forecasting of percentages of recycling rate.

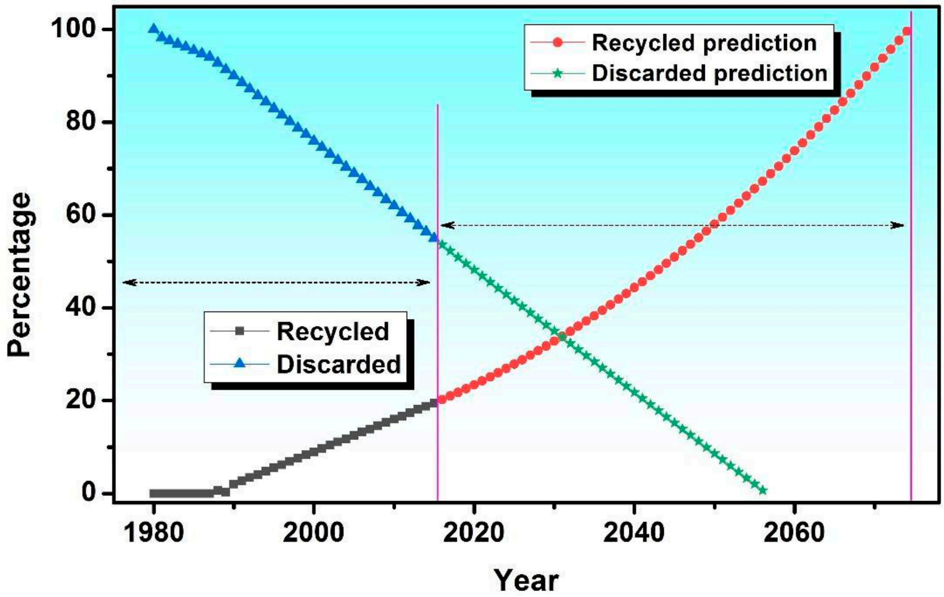


Figure 6. Forecasted data explaining the transition state and equilibrium point around 2030–2034.

As of the year 2034, statistically, there might be growth in the recycling process, but the incineration percentages tend to have the same growth. The reason disposal percentage decreases over the time period is due to the increase in recycling process efficiency, increase in land occupancy, and awareness over the plastic decomposition period and incinerating approaches. A transition can be observed where demand for recycled plastics increases in the journey of technological advances. The efficiency of plastic recycling increases due to an increase in the awareness of recycled plastic quality in manufacturers. Secondly, when the raw material feedstock prices increase to a point where the production of virgin plastic feedstock is not economically profitable, manufacturers tend to work with recycled plastics. This change in feedstock prices takes more time, and hence we boil it down to the point where we say, "prevention is better than cure". In this process, poorer nations tend to incinerate the stock rather than recycling, leading to totally different environmental pollution scenarios. According to the statistics, this change might occur after the 2050s where the disposal rate is very low, but the incineration percentage might play a major role on par with recycling.

3. Blockchain Technology and Circular Economy

The price of the recycled plastic feedstock is comparably less than that of the virgin feedstock, and the quality of the recycled feedstock comes into to question. Secondly, the quality of the recycled substances is not good. Manufacturers assume that there is a decrease in the quality of the plastic when it undergoes the recycling process, and although there exists a level of truth, exceptions are possible and the information regarding the quality needs to be supported. The other challenge is the cost of recycling. Reprocessing plastics is less cost-effective than dumping or incineration. Due to the demand for recycled plastics being low, there is less motivation for plastics' CE. The challenges can be overcome by regulating waste to energy conversion and increasing the cost of dumping. Finally, these all come down to increasing the demand for the recycled polymers. This challenge can be faced by providing reliable information about the feedstock's quantity, quality, cost, and sustainability.

By transforming the regenerative product–service structure, co-opting customer capabilities will accelerate the global shift toward a CE. The central issue lies in how it is possible to motivate customers to engage and participate more effectively in product reuse and recovery processes. The missing link that allows such consumer empowerment to achieve a CE tomorrow could be blockchain. The introduction of blockchain technology provides peer-to-peer CEBMs (Circular Economic Business Models) with an unmatched driver to succeed. Platforms supported by blockchain allow peer-to-peer transactions without any intermediaries. This means that, through a decentralized or globally distributed network, customers can transact and pay each other directly and safely.

Trusted peer-to-peer models make it possible for customers to close the manufacturing economy circle, circulate, and recapture value from their underutilized properties. There are infinite opportunities provided by blockchain technology, including the value one may attach in a blockchain marketplace to a cryptocurrency or 'coin'. There are different classifications of the plastics based on their constituent components, such as reusability, synthesis process, etc. For the CE of plastic waste, we classified plastic into three types: recyclable, non-recyclable, and complex or unknown. The types of plastics considered here are as per the European classification described in European Commission 1997 [20]. Table 1 shows the opportunity of blockchain for plastic recycling and circular economy.

Table 1. Categorization of opportunities from blockchain applications for the circular economy.

Application Category	Opportunities from Blockchain Technology	Examples	Reference
Resource Efficiency Enhancement	To make sharing economy models attractive by removing middlemen and/or creating a blockchain-based identity system. To enable direct financing of sustainable projects.	Sharing economy: Arcade City, Lazooz	[21]
Resource Tracking	To record transactions openly, indefinitely, and immutably, enhancing the transparency and trust in the information provided. To empower consumers in their consumer decisions.	Certification: PEFC (Programme for the Endorsement of Forest Certification) FSC (Forest Stewardship Council) and BHP Billiton Resource tracking: IBM collaboration with Nestlé, Unilever, and Walmart	[22]
Resource Pricing	To create more efficient credit management platforms. To create a cap-and-trade system considerably automatized with smart contracts against politicians chasing their political agendas.	Carbon credit management platform: IBM-Energy Blockchain Lab collaboration	[23]
Complementary Currency	To create financial accounting and macroeconomic systems with different rules from the current monetary systems.	Cryptocurrencies: Solar Coin, Eco Coin, Earth Dollar, BitNatura	[24]

The first step toward the plastic CE is to understand the actual potential for creating value. For this, we decided to follow a process that we call as Total Costing Method (TCM). In TCM, we account for the costs incurred at each step of the circular economy starting from the waste collection point to the destination. The waste material starts its journey to reach the final goal at a location such as the recycling plant, incineration plant, or landfill. There are two stages that incur costs, namely, logistics and processing. Depending on how much the process adds (or removes) value, “we have 5 types of processes, namely, upgrading, closed-loop recycling, downgrading, waste-to-energy, and dumping” [10]. Critical stages that will increase plastic recycling efficiency using blockchain are shown in Figure 7. The increase in the cost of the material is going to be step-by-step from the point of waste collection to their respective destination. Even if they are just going to be dumped, we must consider logistics and environmental costs. It is extremely difficult to estimate the latter as plastics take no less than 400 years to degrade, and most of it still exists in some form or other after being dumped on land or in the ocean.

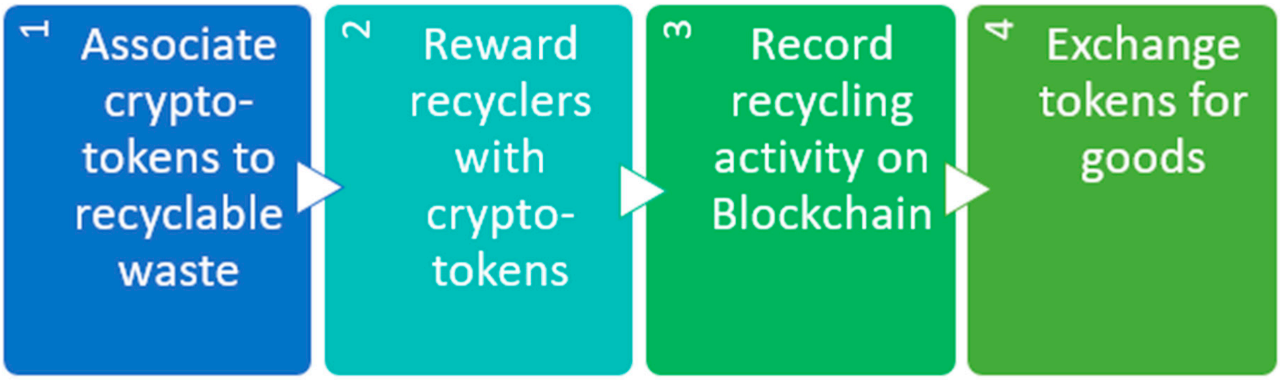


Figure 7. Stages that will be added to the recycling process after implementing blockchain.

The growing production of recyclable products and limited consumer buy-ins are putting immense pressure on recycling industries. The recycling industry needs new approaches and technologies to square up to their progress and advancements. Blockchain-powered projects might soon be able to change how recyclers approach their work by providing better information and incentives across the supply chain. Blockchain technology has gone far beyond its beginning in banking and cryptocurrency. Annual global spending on blockchain applications has almost tripled since 2017. Annual spending on blockchain solutions will reach nearly $16B by 2023, according to CB Insights. Blockchain, being one of the top technologies, can indeed change the world, and the change has already begun. Many enterprise companies are already implementing and innovating their very own version of blockchain [25]. Even though small-scale recycling plants and start-ups have limitations to capitalize on their initial investments, as explicated in the benefits of current technology, small industrial ventures can be created to adopt the mentioned blockchain technology. The economic benefits can be perceptible after the creation of a potential supply chain and condensed but robust recycling mechanisms.

Most transaction systems maintain a single, centralized copy of transactions and accounts. In contrast, blockchain propagates the transactions and accounts across all the key points in the network, which means every location (node) has all the necessary data storage to function autonomously. Blockchain is a type of database. Blockchain is the way data is structured. Blockchain collects information in groups which are known as blocks. Blocks have certain storage capacities and when one gets filled, it is chained onto the previously filled block, forming a chain of data known as the “blockchain”. As it is implemented in a decentralized nature, it makes an irreversible timeline of data. Transactions done on the blockchain network are approved by a network of thousands of computers. The validators on the network are like cameras that reach a consensus that they notice the same thing happening at the same time [10]. Hence, the verification process is free from all human involvement, which results in less human error and an accurate record of information. Each block contains a previous hash, data, nonce, and hash. Previous hash is an attribute which connects the current block with the previous block. Nonce is the proof of work or the algorithm used, and hash is like a digital fingerprint—it is a fingerprint of the current block. This technique was originally described in 1991 by a group of researchers and was intended to timestamp digital documents so that it is not possible to backdate them or tamper with them. However, it went by mostly unused until Santoshi Nakamoto adapted it in 2009 to create a digital cryptocurrency called bitcoin. Quick features and applications of blockchain are shown in Figure 8.

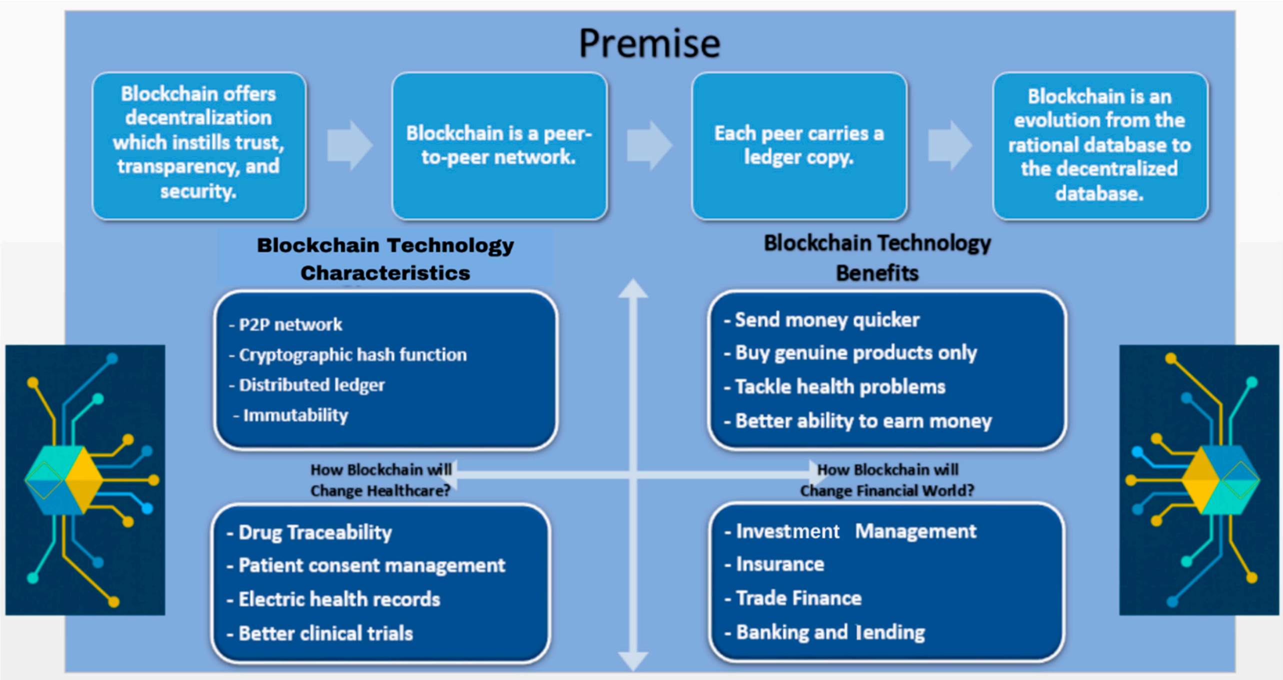


Figure 8. General features and applications of blockchain.

Blockchains are extremely useful for tracking materials across all types of supply chains. Blockchain can help connect major refining companies with a new mode of plastic recycling as a way to reinvent current supply chains. Using this technology, plastic recycling can be made more sophisticated, returning the raw material into the manufacturing process. This will create a complete CE for waste that has become a scourge to the planet [26]. Blockchain technology has all the key technical features including decentralization, distrust, chronology, anonymity, group maintenance, open-sourcing, being programmable and dispersed, unchangeable encrypted data, safety, and reliability. It is hopeful that blockchain technology can bring vast changes and can change the current forms of human social activities. This technology has been implemented and has achieved positive practice and application in many fields including banking, finance, security, insurance, express, notarization, medicine, music, crowdfunding, dispersed data, intelligent manufacturing, and the IoT. Using the methods of encrypting data, time stamping, distributed consensus, and economic incentives, blockchain technology can achieve decentralized trust-based point-to-point transactions, cooperation, and coordination [27]. It will be easy to predict the scope and need for this technology in the current market for plastic waste recovery and recycling (Table 2).

Table 2. Mapping of blockchain applications for waste recovery and recycling.

Category of Application Functions	Blockchain Application	Provider (Country)	Target Materials	Reference
Resource Efficiency Enhancement	Excess Materials Exchange	Excess Materials Exchange (The Netherlands)	Any excess materials and under-used products	[28]
	ShareRing	ShareRing (Australia)	Any excess materials and under-used products	
	IBM Blockchain Platform	IBM (US)/Plastic Bank (Canada)	Plastics	
Resource Tracking	Circularise	Circularise (The Netherlands)	Waste electronic devices	[29]
	European waste transportation on blockchain	Dutch Ministry of Infrastructure & Water Management (The Netherlands)	Waste moved between Netherlands and Belgium	
	Foodchain	Foodchain Spa (Italy)	Food waste	
	Troventum	Troventum Limited (Malta)	Solid recyclable household waste	
	IBM Blockchain Platform	IBM (US)/Plastic Bank (Canada)	Plastics	
Resource Pricing	Cycled	Cycled (Norway)	Household waste	[30]
Complementary Currency	Augoraa Tech Lab	Ethereum Foundation (Switzerland)	Plastic waste	[31]
	Cycled	Cycled (Norway)	Household waste	
	Zafeplace Blockchain Platform	Zafeplace/Empower (Norway)	End-of-life plastics	
	NatureCoin	NatureCoin (Canada)	Disposable waste (including plastics, tins and cans)	
	IBM Blockchain Platform	IBM (US)/Plastic Bank (Canada)	Plastics	[32]
	Recreum	Ethereum Foundation (Switzerland)	Glass, plastic, aluminum, used batteries, paper, wood	[33]
	RecycleToCoin	BCDC.Online Limited (UK)	'Single-use' plastic bottles and aluminum cans	
	Swachhcoin	Swachhcoin (India)	Recyclable waste from households and industries	[34]

4. Prospective Proposal on Plastic Recycling and Blockchain Mechanism

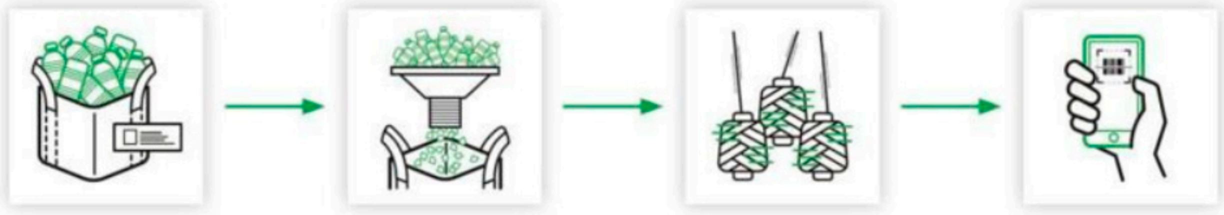
The potential idea is to utilize an approach wherein recyclers can keep track of generated waste as it moves through the various chains. The concerned authorities/corporations can further generate information on comparative recycling efforts through a platform that works by tracking recycling activities across a local recycling supply chain on the blockchain. When this will be publicly available, consumers can also use the ledger information to make more informed purchasing decisions. The blockchain can be utilized to track individual items through the recycling supply chain by creating physical markers like QR codes or digital badges on plastic products as shown in Figure 9a. After scanning the code, information will pop up on the screen as shown in Figure 9b. All the information will also be stored in digital codes using blockchain so that no one can change it at any point in time. This will help to create a timeline or map of each product as it moves through the chain. Hence, the data produced will be helpful for manufacturers and recyclers to select items and to predict what is likely to fall out of the recycling supply chain [35].

(**a**) (**b**)

Figure 9. (**a**) Digital codes on plastic with multiple benefits. (**b**) Information stored in digital code.

Recycling and reusing products is essential for the creation of green supply chains, and this database offers benefits for the companies and businesses whose top priority is eco-friendliness and green production. The best possible product information could be provided for working in businesses in all sustainability-minded organizations by individual product tracking. Scanning the special barcode on plastic products will give all the information about the raw material, life cycle, and degradation behavior.

The key issue for the global recycling supply chain is the already created plastic or accumulation of plastic in oceans and forests. According to IBM, "the majority of ocean plastic comes from countries with inefficient recycling systems". This can be potentially resolved by creating recycling supply chain mechanisms which can reward stakeholders/members for efficient waste collection. Such recycling mechanism incentives can encourage the collection and segregation of plastic waste which would otherwise escape the giant recyclers. Figure 10 shows a pictorial representation at various levels from waste collection to segregation and further barcoding for customer utilization. The platform using blockchain in plastic recycling will be created and connected with supermarkets wherein the stores can offer returns for waste plastic collections while purchasing goods. Small scale agencies can recruit personnel to collect plastic waste from cities and bring it back to stores for segregation, quality checks, and collection for recycling. In this way, a closed sustainable recycling loop is formed using a CE to support individuals as well as recyclers. The proposed loop will implement plastic recycling as a globally recognizable and tradable scheme that can support small-scale businesses or individuals with a cleaner environment [36,37]. Humans have progressively produced eight trillion kg of plastic, the majority of which still exists in the environment as waste. Worth roughly 50 cents/kg, we are potentially unleashing a four trillion-dollar value. The suggested platforms would add rewards and incentives along with a cleaner environment. In this decentralized marketplace, companies can buy and sell recycled plastic and earn plastic credits that will make them "plastic neutral".



Level 1 **Level 2** **Level 3** **Level 4**

Figure 10. Pictorial representation of the process of collection till the hands of the consumer.

It is also worth noting that the in circular model, the priority should be (i) traceability throughout the production chain; (ii) efficient use of energy; (iii) standardized and globally accredited safe working procedures and risk assessments; (iv) investment in innovative and sustainable technology platforms; and (v) a circular strategy. Firms should focus on incrementing their green reputation not only by amendments in the supply chain, but also by adopting a systematic approach to promote strategic initiatives. To establish the accurate deployment of resources, traceability is essential. This strategy of total transparency by adopting the blockchain will allow consumers and investors to understand and easily analyze the potential impact. Digitization in the plastic recycling industry can aid traceability. This implementation will encourage the return/recycling of products that are no longer desired or usable. Introducing new technology might increase the price of the product, and this difference in price from the natural price can be termed as "the circular premium" [38]. Incentives are necessary to foster a circular model, and this might help in accepting circular premium among consumers.

Blockchain technology has many benefits; however, it still needs technology improvements in various ways. There are certain limitations to implement this blockchain technology. A coding flaw or loophole is one of the important points in this regard. Other key issues are limited scalability platforms and large energy consumptions [26,39]. The organizations need to maintain the personal data and protection of privacy information as well as maintaining restricted sharing of confidential information in public ledgers. Moreover, there is a need to create knowledge-based data banks and public awareness, which can be utilized in operational blockchain technology [40]. Blockchain provides a high level of fault tolerance by running the blockchain on every node to maintain consensus. This makes data stored on the blockchain unchangeable. This is an advantage as well as a disadvantage of blockchain, because the authentic request for data modification requires an extensive effort and huge cost. In addition, as each node repeats the same task to reach consensus, it requires high energy consumption making each transaction costly and requires high time per transaction, raising a question on its scalability. Nevertheless, the proposed model will provide benefits to stakeholders of the entire supply chain. The implementation of such a model globally will enhance the model's nature and create progress in customer behavior and enhance revenue.

5. Conclusions

The suggested blockchain-based platform can be implemented in various nations with an autonomous waste collector and storage system. This process can be expanded to individual collectors and storage systems. The project sets the stage for a paradigm shift by providing them with the requisite resources, technology, and rewards where plastic can be turned from 'trash' into an invaluable resource. The solution is to design robust recyclable end-of-life items for closed-loop recycling. The proposed blockchain technology will produce tamper-proof ledgers that trace the life cycle of ocean-bound plastics, from waste pickers to recycling hubs, where they are processed as plastic pellets and ultimately sold to businesses. The blockchain enables transactional data to be distributed, protected, and publicly shared; it serves as the perfect bedrock technology for the project. It aims to introduce a plastic credit scheme that allows businesses to invest in plastic technologies and encourage them to spend the same investment on recycled plastic to become 'plastic neutral' in the recycled industry. The novel process will be created by incorporating a reward-based blockchain scheme with the collaboration of global businesses and local waste collectors. The proposed model further allows the effective sharing of databases among various supply chains to create a CE.

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