International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-5, June 2019

Blockchain Based Waste Management

Preethi Gopalakrishnan, Ramaguru R

Abstract*: The environment is the most sought-after topic for discussion in global forums because of the alarming threat it faces. Waste Management is one of the major challenges after global warming that affects the environment and harmony of nature. Government and non-governmental organisations are working towards solutions for better waste management. Though in present-day technology is part of waste management, it is not an integral part of waste management in many countries. Current technology only helps in reducing manual intervention by automating waste collection and transportation. It also helps in the disposal of non-useful waste and recycles/reuse useful waste by converting them into raw materials. People are the major part of the waste management cycle, so without their involvement, it is extremely difficult to make any technology-based system successful. People's involvement in waste management would increase if they are incentivized for proper segregation of wastes, reusing, recycling, disposal and even for spreading awareness. The supportive technology should automatically monitor waste management cycle, record important actions and react accordingly. Blockchain Technology with smart contracts, Artificial Intelligence and native cryptocurrency are sought after to address the challenges faced by the waste management industry. Blockchain provides immutability through cryptographically secure and distributed ledger method, incentivization and settlement in real time through native cryptocurrency. In this paper, we have analyzed the existing blockchain based solutions for waste management and how effective these solutions are in addressing the challenges the waste management industry faces.

***Index Terms*: Waste Management, Blockchain, Ethereum, Cryptocurrency, Blockchain for waste management**

I. INTRODUCTION

Waste management is one of the serious issues to be focused in today's world. Waste management has links to other global challenges like health, climate change, poverty reduction, food & resource security and sustainable production & consumption [1]. Government agencies, Non-governmental organizations, legal bodies, technology companies are contributing in their own ways to tackle the problems in the waste management industry. Various study reports and our own practical experiences show that waste management could be handled with the right mixture of all stakeholders working on the same platform. It is very important to understand the waste management life cycle and the multi-fold challenges posed at each level before anyone attempt to come up with technology backed solutions. According to the United Nations (UN), waste management entail activities including (a) collection, transport, treatment and disposal of waste, (b) control, monitoring and regulation of the production, collection, transport, treatment and disposal of waste and (c) prevention of waste production through in-process modifications, reuse and recycling. Figure 1 shows the various stages waste goes through before it is getting disposed at landfill.

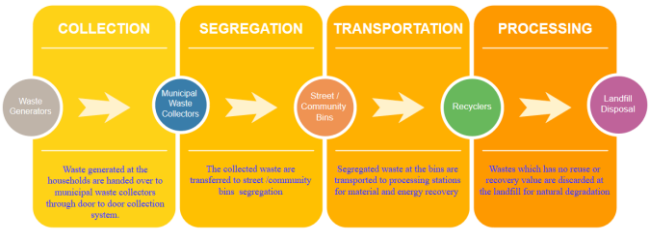

Fig. 1. Waste Management Cycle

Waste management is not a responsibility of one person or organisation rather it is a collective responsibility of every single individual who generates waste. Below we are describing some major challenges ahead of us to be addressed.

A. Lack of awareness and enforcement

One of the main reasons behind the improper waste management starts with a lack of awareness. The individuals generating the wastes lack awareness on why and how to segregate wastes, waste collectors and handlers lack awareness on how to process the useful wastes and disposal of the non-useful wastes. In general, there is a lack of awareness about the impacts of improper waste management on health and the environment. The waste management rules of 2016 in India says the source segregation of waste has been mandated to channelize the waste to wealth by recovery, reuse and recycle [2].

B. Lack of waste segregation at source

The main sources of waste are households and industries were segregation of waste at source are required. Presently, most of the waste reaching the community or municipality bin are not properly segregated as biodegradable and non-biodegradable waste. In a few cases, the government does not provide proper infrastructure to the common public for disposal of the segregated waste. Government has framed rules as waste generator will have to pay 'User Fee' to waste collector and 'Spot Fine' for littering and non-segregation but following of rules is very mere.

Manuscript published on 30 June 2019.
* Correspondence Author (s)
Preethi Gopalakrishnan, Dept. of Civil Engineering, Sri Krishna College of Engineering and Technology, Coimbatore, India
Ramaguru R, TIFAC-CORE in Cyber Security, Amrita School of Engineering, Coimbatore, Amrita Vishwa Vidyapeetham, India

C. Excessive Generation

The waste generated increases day by day in boundless ways. Waste generation is proportional to income per capita of the country. In low-middle income countries, increase in population has increase in waste generation. According to the statistics released by the Ministry of Human Resource Development, Government of India for the year 2016, 62MT of waste is generated annually in the country, out of which plastic wastes accounts to 5.6 MT, 0.17 MT accounts for biomedical waste, hazardous waste contributes to 7.90 MT and 1.5 MT from e-waste. Also, the per capita waste generation in Indian cities ranges from 200 grams to 600 grams per day. The actual fact is that 43 MT p.a is collected from which only 11.9 million is treated and the remaining 31 million is dumped to landfill sites, which means that only about 75-80% of the municipal waste gets collected and only 22-28% of this waste is processed and treated. It is estimated that waste generation will increase from 62MT to about 165 MT in 2030 [2].

D. Lack of scientific landfills

Present day landfills available are not constructed scientifically as it contaminates groundwater and pollutes the air through methane gas emission. Bad odour, fire explosion, scavenging of animals are among other issues encountered in landfill sites. The number of available landfill sites is not on par with the country's demand. More than 70% of collected urban waste is dumped straight into the landfills.

E. Lack of Technology in tracking waste flow

Waste generators and waste handlers do not know how and where the wastes are handled once they leave their bin. There is no proper tracking system for waste management. Though technology like RFID is used for waste management, its usage is limited. In current waste management system, data are entered manually which would lead to data error creating inconsistencies and wrong data entry & manipulation of data for the financial gains. Additionally, official letters are passed as physical paper that could get lost during the transit.

F. Lack of Accountability

Once the waste leaves the hands of generators, they never take the accountability of it. Because of which littering of waste in streets and public places are too high.

Blockchain is a decentralized, distributed, immutable, computation and information sharing platform that enables multiple authoritative domains, who do not trust each other to cooperate, coordinate and collaborate in a rational decision-making process [3]. Blockchain is the underlying technology that enabled Bitcoin Cryptocurrency which was introduced by "Satoshi Nakamoto"[4]. Blockchain is an ever-growing list of timestamped blocks chained together by cryptographic hash. Blocks can only be appended to this chain which makes the blockchain immutable. To modify a block high computational work and confirmation from other nodes in the network is required, which is practically not possible. Blockchain is also known as Distributed Ledger Technology (DLT) which means the data is maintained by the network of computing nodes, not by a single entity. The information is shared and available to everyone, meaning the blockchain is transparent. Blockchain has been seen to have more potential than just a cryptocurrency platform and now has a broad range of applications including but not limited to finance, healthcare, government, manufacturing and distribution. Use cases of blockchain in various domains include supply chain management, startup fundraising, electronic voting, education credentialing, power generation and distribution, etc. The paper is structured as follows: section 2 discusses the existing solutions of waste management using blockchain. In section 3, we have analyzed the existing solutions and section 4 concludes the paper with the future work.

II. BLOCKCHAIN FOR WASTE MANAGEMENT

In this section, we will discuss on the existing blockchain based solutions for waste management.

A. Swachhcoin

Swachhcoin [5] is a blockchain based approach for micromanagement of wastes primarily from households and industries and converting them into useful products in an efficient and eco-friendly manner. Electricity, paper, steel, timber, precious metals, glass plastics are some of the high economic value outputs from the processed wastes. The swachh ecosystem is a Decentralised Autonomous Organization (DAO), governed autonomously on the basis of predefined instructions in the form of the smart contracts. Swachhcoin employs multiple cutting-edge technologies to implement an iterative process cycle, which over a period of time will make the system completely autonomous, efficient and productive. This iterative process cycle focuses on the data exchanged between various actors in the ecosystem, analyse these data and provide suggestions in real time based on predictive methods.

Below are some of the tools and technologies that are part of the swachhcoin ecosystem

1) SwATA (Swachh Big data): Data management and transparency are one of the concerns in the waste management industry. With tons of waste generated, collected, transported, treated and finally disposed off. There is enough data equally generated. SwATA is a customized application which collects, stores and analyses these data to provide suggestions for various improvement activities like optimisation of routes, maintenance cycles, report generation. The data generated in a domain like waste management is unstructured, SWATA uses NoSQL based approach and virtual data filter at the collection points resulting in highly structured data available for processing by the SWATA application. SwATA employs the most advanced and reliable method called prescriptive analysis. Blockchain is employed to provide the data immutability.

2) SwATEL (Swachh Adaptive Intelligence): SwATEL is referred to as the brain of the entire ecosystem, as this provides the communication and coordination capabilities between various types of equipment and machinery within the ecosystem and make them intelligent. SwATEL uses customized application of Adaptive Intelligence (AI) to make decisions based on previous learning in real time almost like humans.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

These decisions could trigger actions that be physical or digital, which is recorded on the blockchain. AI has two major aspects namely deep learning and neural network.

3) SwIOT (Swachh Internet of Things): Internet of Things (IoT) helps us to control each and everything that is connected to the internet. In waste management, we have multiple stakeholders, multiple entities, the collection and transportation vehicles, collection bins, treatment plants, landfill site could be connected and controlled through IoT based network.

4) SwBIN (Swachh Bins): Proper and maximum collection of waste would enhance the waste management process. SwBIN is like our normal dustbins but most advanced technical and attractive features like automatic closing and opening of the lid, free WiFi services, decentralised advertisements. Each waste generator is assigned with a Unique Identifier (UID). Whenever the waste is deposited, SwBIN will identify the user with the QR representing the UID and measure parameters like quantity and quality of waste deposited to calculate the rewards points. These points are stored on the blockchain. This reward will be paid as Swachh Tokens to the users. SwBIN through the SwIOT will communicate to the waste service providers on the status of the wastes in the bin. Swachh Foundation proposes to use the advertisement to recover the cost of the SwBIN installed across geographies. The collected wastes are transported to the waste collection/processing agencies.

5) Blockchain and Smartcontracts: Swachhcoin for their current workflow and requirements identified Ethereum [6] as their Blockchain solution with the support of smart contracts forming a Decentralised Autonomous Organisation. Through the DAO Smart contract, Swachhcoin enables Autonomous Philanthropy.

6) Swachh Tokens: Swachh Tokens (SCX) [7] are utility tokens which a user receives as a reward for proper waste management practices. These tokens could primarily be used for platform-specific settlements. Additional to payments these tokens also provide powers to the token holders for suggesting NGOs for receiving funds or vote for major decisions concerning the platform. Swachhcoin platform proposed to created 400 Million swachh tokens, out of which 69% of tokens were issued through crowdsale.

Figure 2 shows the workflow of Swachhcoin blockchain ecosystem.

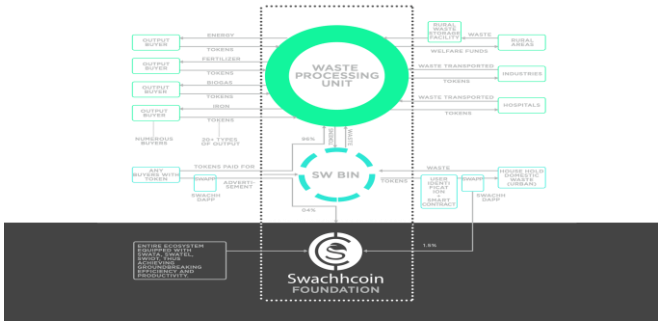

Fig. 2. Swachhcoin Workflow [5]

B. Recereum

Recereum [8] is a blockchain platform for turning waste and recyclables into real value. This blockchain establishes direct communication between the individual users and the waste collecting organisation. Recereum blockchain rewards the individual household users the blockchain's native cryptocurrency Recereum coins from the cost saved through proper waste sorting. Recereum ecosystem is operating on the largest public blockchain Ethereum. Blockchain records the rewards (token transfer) from one account to another account. The main applications as stated in the Recereum whitepaper is smart contracts, payments and supply chain management. Recereum tokens (RCR) [9] are ERC20 based tokens issued on Ethereum platform. With an exchange rate of 1 ETH for 300 RCR, Recereum will issue 7,999,000 RCR, in which 65% will be sold to the public. Recereum blockchain workflow is shown in figure 3. Recereum blockchain solution could be integrated into existing waste collection methods like a vending machine and battery collection machine. Recereum mainly addresses the waste sorting and related areas in waste management cycle.

C. Plastic Bank

Plastic Bank [10] is a blockchain based application with the mission to prevent the flow of plastic into the ocean, by monetizing people. The plastics collected through this initiative are recycled and sold as Social Plastic. These are Plastic Bank verified plastic that provided a premium for the collector as rewards. These rewards are distributed, authenticated and stored using Blockchain technology to provide the safest and most trusted means to deliver a globally scalable social impact.

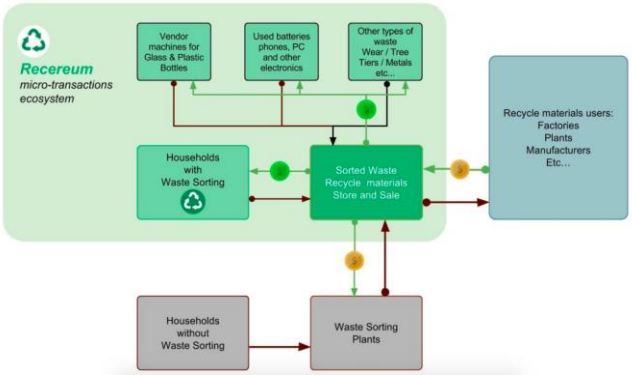

Fig. 3. Recereum Blockchain Workflow [8]

III. ANALYSIS AND OBSERVATIONS

All the existing blockchain solutions discussed in the Section 2 are mostly based on public Ethereum blockchain [6]. Below are some of the observations:

1. Looking into Swachhcoin, it is based on Decentralized Autonomous Organisation (DAO) which operates through smart contracts. But the DAO itself, because of the vulnerabilities existed in the smart contracts allowed attackers to drain funds from the DAO. This resulted in forking of Ethereum. The blockchain technology and smart contracts running on it are still maturing to handle real world issues like waste management. At this stage, it is extremely important not to be ambitious to address all the issues through blockchain and technology alone.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

2. The discussed blockchain solution swachhcoin uses IoT based system, we understand the IoT based system generates a lot of data which should also be stored onto the blockchain. At the time of writing there is no suitable consensus algorithm for IoT based network [11],[12] operating in real time, though some of the use cases in waste management domain is not that time critical
3. Additionally, the existing solutions does not consider all the challenges posed by waste management. The blockchain based solution provides accountability, openness and transparency in the process and data management, security to data through immutable feature of blockchain, incentivization through cryptocurrency for waste segregation, spreading awareness. But it does not address the law enforcement and violation aspects which is predominantly missing in waste management.

IV. CONCLUSION AND FUTURE WORK

In this paper we have discussed the waste management workflow and challenges faced in the waste management life cycle. We have explained about blockchain technology and have highlighted the advantages of using blockchain to tackle these challenges. We have also discussed major existing waste management solutions based on the blockchain like Swachhcoin, Recereum & Plastic bank and listed our observations based on our analysis. As a future work, we propose to build a blockchain solution called **Thui-mychain** based on IoT, Artificial Intelligence (AI) and our native cryptocurrency **Naanayam** based incentivization delicately for waste management that would include the United Nations goals for waste management and address the challenges we have analysed above.

REFERENCES

1. Global Waste Management Outlook 2015 [Online]. Available: https://www.uncclearn.org/sites/default/files/inventory/unep23092015.pdf
2. Solid Waste Rules 2016 [Online]. Available: http://pib.nic.in/newsite/PrintRelease.aspx?relid=138591
3. Sandip Chakraborty, Praveen Jayachandran. “Blockchain - Architecture, Design and Use cases”, NPTEL Course Lecture (2018).
4. Satoshi Nakamoto: Bitcoin: A Peer-to-Peer Electronic Cash System. www.bitcoin.org (2008)
5. Swachh Coin White Paper [Online]. Available: https://swachhcoin.com/whitepaper.pdf
6. Ethereum Blockchain [Online]. Available: https://www.ethereum.org/
7. Swachh Tokens [Online]. Available: https://icobench.com/ico/swachhcoin
8. Recereum Whitepaper [Online]. Available http://recereum.com/files/WhitePaper-Recereum.pdf
9. Recereum Coins [Online]. Available: https://icobench.com/ico/recereum
10. Plastic Bank [Online]. Available: https://www.plasticbank.com/
11. Salimitari, Mehrdad & Chatterjee, Mainak. (2018). A Survey on Consensus Protocols in Blockchain for IoT Networks.
12. Siva Sankar, Lakshmi & Sindhu, M & Sethumadhavan, M. (2017). Survey of consensus protocols on blockchain applications. 1-5. 10.1109/ICACCS.2017.8014672.

AUTHORS PROFILE

Preethi Gopalakrishnan is an Assistant Professor in the Department of Civil Engineering in Sri Krishna College of Engineering and Technology, Coimbatore. She has done her post-graduation in Environmental Engineering from Government College of Technology, Coimbatore after her graduation in Civil Engineering. Her areas of specialization for research include waste management, indoor air quality.

Ramaguru R has completed Master's in Cyber security from TIFAC-CORE in Cyber Security, Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Coimbatore. He completed his Bachelor's degree in Information Technology from Kumaraguru College of Technology, Coimbatore. He has around 5 years of work experience in the areas of automotive infotainment, test automation, framework development and current areas of research include blockchain, waste management and connected cars.