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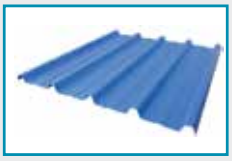

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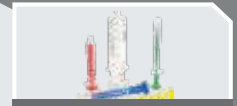
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Dear Friends,

Happy Spring and as we welcome the new season, it provides an opportunity to reflect on past 12 months with mixed feelings of lockdowns as well as turning a full circle as we stand today. There have been a lot of learnings in our professional and personal life which we would not have experienced in regular circumstances. This has led to lot of innovations which we have been sharing through our Journal & Webinar's and hope you benefitted from the same.

IPI along with Ocean Recovery Alliance, Goa Institute of Management & The Commitments Accelerator for Plastic Pollution ("CAPP") had organized a competition on Plastics Sustainability & Recycling with final presentation in the month of March. This issue of Journal has top 6 presentations by the finalists highlighting waste management, recycling & applications. We have been fortunate to interview Doug Woodring, Founder of Ocean Recovery Alliance, where he speaks about his motivation and challenges facing the ocean and marine life with reference to plastics.

As we end the fiscal year, it also marks end of the publication committee's 2 years tenure, we would like to thank the GC & committee members for all their support and a special thanks to the advertisers.

Wish you all a warm summer, take care and be safe.

Regards,

Sriman Banerjee

Chairman, Publication Committee

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Inside

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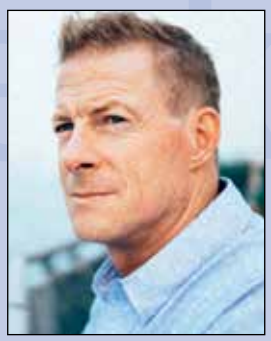
Leader's Speak

Doug Woodring

Founder and Managing Director,
Ocean Recovery Alliance



1. **Can you elaborate on Ocean Recovery and what inspired you to start the initiative?**

   Coming from California, and competitive in all types of water sports, I quickly realized the comparison between clean environments, and polluted ones, when I moved to Asia where I have lived and worked for over 25 years. My first job in Japan showed me both the extent of air pollution but also trash and litter in public places, even in Japan. When there, I worked for one of the largest Japanese fishing companies, and the knowledge I gained from that experience, about the large extent of overfishing by the global community, is what got me inspired to help the ocean in the future.

   I started working for the ocean full time in 2009, when we created the first expedition to the North Pacific Gyre which had "real" science involved, in it, as we co-funded Scripps Oceanography from San Diego to join us to incorporate all types of scientific testing and analysis in the middle of the Pacific Ocean. This received a lot of international publicity, and in fact, it was our expedition which started the idea for the film Plastic Ocean, as two of their camera crew came on our trip to get some of their first footage. In seeing the global interest on this topic, we then announced two projects at the Clinton Global Initiative on plastic pollution reduction, which were probably eight years ahead of their time, but which are highly relevant and useful today, as the world has now woken to some of the complexities of plastic pollution. They are the Plastic Disclosure Project (PDP), which is like that of carbon and water reporting, but with a focus on plastic, and our Global Alert app, which lets anyone in the world report on trash hotspots in or near waterways and coastlines with their smartphone. We have continued our work since then, with a wide variety of programs, stakeholders and countries involved.

2. **While there is a lot of awareness now about Ocean plastics, what are some of the challenges you have?**

   Well the challenges used to be to get companies and governments to be truly interested and aware of this topic. Now we don't have to waste time with that part of discussion when in meetings, as everyone is very aware of the global challenges we face. Now companies call us for solutions, ideas and help, so that's nice to see. But, all of those working in this space need more funding and participation by all types of stakeholders, from companies, to governments and the general public. For too long, as with almost all environmental negative externalities, the price of polluting has been "zero" to those making the impact, and that is still roughly the case today. So, without a "fee" to do business, which is allocated to remediation of some of these problems, there is not enough infrastructure and capacity to handle the world's waste stream in the form of plastic. Even the allocation of funds and resources by the Alliance to End Plastic Waste (AEPW), which has earmarked the equivalent of US$1.5bn in grants and internal projects within their global industry partners, is a mere drop in the bucket, and tiny fraction of what is needed today to handle all of the costs associated with this issue.

   So, it would help immensely if companies engage in thorough, thoughtful programs which help to decrease their waste outputs, while increasing both their recovery rates, and their use of recycled content. Governments usually do not "lead" in attempting to create wide scale changes, nor are they fast enough, but they will follow with regulations if they see that some of the companies who have been early adopters on changes are doing well with it, and having success. So, we need more of that leadership from the corporate sector, as they have the resources, R&D budgets, marketing teams, and products, which can change the world – if they try.

3. **We see applications on ocean plastics, can you share some of the innovative ones?**

   Ocean Plastics are a messy topic, as usually there is never enough consistent volume, anywhere, of the right quality, to do anything with it. So, when you hear the term "ocean

plastics," usually it means "ocean bound plastics," meaning that it was not recovered from the ocean when it has bio fouling, salt and sun degradation, it is from the city, town or community's waste stream, and is captured before it makes its way to the waters. There is nothing wrong with this, and it needs to be done, but there is a lot of myth around the hopes to make widespread uses of the volumes of plastic in our waters today.

One area where people are working, however, is with old fishing nets, and the use of Nylon 6, which is what many nets are made from, to be used in carpets, fiber products, and also molded for rigid products like skateboards. The challenge, however, is being able to determine which nets are Nylon 6, as there are many types, and of course, to clean and purify them after being exposed to the ocean for a long time.

Two of the most exciting areas for "mixed dirty" plastic from our waterways, which will never make it to normal recycling, is the use of this material in aggregate for concrete, or asphalt. These technologies and opportunities are starting to expand, and the world uses much more of these two heavy products, than it does of plastic, meaning that literally all of the world's plastic could be absorbed, and reincarnated, into these types of products, bringing strength, durability, lighter weight, and even carbon sequestration. Watch this space.

4. You are organizing several competitions globally including India, what are some of the trends you are observing?

It seems in most countries, the desire to develop new programs to reduce or eliminate plastic waste is extremely strong, even with the pandemic. In fact, we see an increasing number of entrepreneurs, NGOs, companies and local governments engaged and interested in implementing solutions. From our UN-funded report "Crafting High-Impact Voluntary Commitments to Reduce or Eliminate Marine Litter," we concluded that stakeholders around the world mostly operate in their own local vacuum, and, for the most part, do not share best practices. As a result, outside of beach cleanups, the world always seems to be reinventing the wheel, so to speak, and not optimizing the resources, time and effort of hundreds and thousands of people and organizations engaged in reducing plastic waste.

In our India "Make the Case" Competition, we see that there are some great innovative initiatives being organized and business models being proven out, especially those initiatives which engage communities. These initiatives need to be replicated and scaled, which is exactly why we hosted the "Make The Case" Competition. We are highlighting initiatives which are underway to reduce plastic pollution, but which often don't get the visibility and exposure that they need to grow. It is our belief that these programs that are succeeding in India are truly the "trends," in and of themselves. Thus, the goal of the "Make the Case" Competition is for others in India, and around the world, to be able to learn from these successful "trends" (initiatives) to create them in their local areas.

5. What do you see the future of Plastics Waste management, Recycling, Sustainability & Circular economy?

I see huge opportunities in this space, as there has to be enormous amounts of new investment in infrastructures and capacities, social change in the way that we recover materials in "the first mile" (from the hands of the public and companies when they are thrown away), product design and valuable remediation, for some type of reincarnation. Plastic has to have a 2nd life, somehow, whether for fuel, building materials or being recycled, because if not, it then becomes waste, and that is not circular. I don't believe there is a perfect circular system for most plastics, but there are many 2nd, 3rd and 4th lives for all polymers, none of which are being hatched today, and this needs to change. All of the material we create can be reincarnated, usually at least once, so for those offering these innovations and solutions, the opportunities are great.

Mr. Woodring is the Founder and Managing Director of Ocean Recovery Alliance, a non-profit organization which is focused on bringing together innovative solutions, technology, collaborations and policy to create positive improvements for the health of the ocean. Two of its global programs were launched at the Clinton Global Initiative. He is the winner of the 2018 Prince's Prize for Innovative Philanthropy in Monaco, a UN Climate Hero, a Google Earth Hero, the founder of the Plasticity Forum, and the co-founder of their new CAPP Program (Commitments Accelerator for Plastic Pollution).

Rob Steir, *Co-Founder of Commitments Accelerator for Plastic Pollution*

The Commitments Accelerator for Plastic Pollution ("CAPP") was created in early 2020, and operates under the auspices of Doug Woodring's Ocean Recovery Alliance. It was formed as a result of its UN Environment's funded 98-page report published in early 2020 titled "Crafting High-Impact Voluntary Commitments to Prevent or Reduce Marine Litter." CAPP's mission is to help support, facilitate and incubate initiatives that reduce or prevent plastic pollution from entering our ocean. Its four co-founders hail from the U.S, Europe and Hong Kong. In 2020, it secured the active engagement of two flagship nations, the governments of Curacao and Fiji, both island states who have serious proactive efforts to prevent plastic waste, and where the threats of climate change and plastic waste is considerable.

Beyond working with its flagship nations, CAPP also found itself launching its first external program in India. This came in the form of the "Make the Case" Competition, for MBA and technical students nationwide, to find top initiatives in India preventing plastic waste (http://cappindia.in)

How? The butterfly, for those involved in chaos theory, was a 3-minute virtual networking session at a UN Compact conference in late September, 2020 between myself and Professor Divya Singhal, the chairperson of the Center for Social Sensitivity and Action of the Goa Institute of Management, Goa, India.

What? Our competition concept was to call upon the brightest youth in India, students at the top business and technical graduate institutions, to research, select, and, ultimately showcase proven plastic waste reducing initiatives they deem worth replicating throughout the country.

The competition was jointly hosted by CAPP, the GOA Institute of Management and the Indian Plastics Institute. A working group met regularly from each organization, including IPI's Mr. Atul Kanuga, Mr. Sameer Joshi and Mr. Sriman Banerjee. The Chellaram Foundation signed on as our main sponsor, to provide $5000 as prize money to the winning teams.

Why? To highlight a large number of plastic waste initiatives that are making a difference in India; to bring attention to the very best ones; to showcase any and all innovations that generate plastic waste reduction results; and to provide a number of high-impact initiatives that other stakeholders in India (or globally), can replicate.

The results 5 months later (www.cappindia.in/awards):

- 165 registered teams; 16 teams qualified for the final round and submitted Case Studies
- Two judging rounds of student submissions
- Over 25 reviewers from within India and around the world including academicians and practitioners; and 5 IPI members as Final Round mentors
- 6 final teams had 7-minute presentations to win the top 3 prizes during a 2.5 hour final online event, which included a panel discussion with the "doers" of the initiatives these teams selected.

CAPP would like to issue the following invitations to IPI Members and all readers:

1. Sign-up at CAPP.Global for a free CAPP membership and join our India Plastic Waste Sub-Group
2. Reach out to get involved in next year's "Make the Case" Competition as a mentor/reviewer
3. Recommend an initiative that the students should select for next year's annual competition.

Please reach out to Rob@CAPP.Global for all of the above invites. We look forward to your participation.

The Author: Rob Steir: Based in Florida, United States, Rob is a co-founder of CAPP. He is also a consultant for Ocean Recovery Alliance where he was the main author of a January 2020 United Nations-funded report "Crafting High-Impact Voluntary Commitments to Prevent and Reduce Marine Litter." Rob is also the co-founder of Frontline Waste, a waste-to-energy company, focused on developing countries and islands, featuring a 20-100 tons/day slow-pyrolysis solution.

The Finals Invitation

The Make the Case Team

The Working Group

From Commitments Accelerator for Plastic Pollution: (CAPP)
Rob Steir

From Indian Plastics Institute:
Atul H. Kanuga
Sameer Joshi
Sriman Banerjee

From Goa Institute of Management (GIM)
Professor Divya Singhal
Professor Sreerupa Sengupta

Final Judges
Doug Woodring, Ocean Recovery Alliance
Professor Ajit Parulekar, GIM
Vijay Merchant, Past President of IPI and AIPMA
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Team Polytopes
Initiative: Bharat Petroleum's Plastic Waste to Road

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Anmol Malhotra
Ankush Koundal
Pritish Jain

Bhaskracharya College of Applied Sciences, University of Delhi

3rd Place

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Initiative: Rudra Environment Solution
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Student Team:
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Sagar Mukherjee
Namit Chhatbar
Abinaya Santhakumar

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Kabadiwalla Connect: An Anthropocentric approach to Circular Economy

Team: Nature Nurturers

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Abstract:

Kabadiwalla Connect specializes in integrating the informal sector into the formal waste management system in developing nations. They have worked in 5 cities across India, Indonesia and the Ivory Coast with commercial contracts from Veolia, Unilever and Danone for specific engagements around plastic collection, recycling and informal chain integration. Through a revolutionary waste management model and a SAAS-based technology they integrated the informal ecosystem into the reverse-logistics supply chain; helping municipalities, brands and waste management companies to recover post-consumer waste cheaply, efficiently and more inclusively in the developing world. The Award-winning start up is revolutionizing urban waste management, relying in particular on mapping technologies. Based in Chennai, India's fourth-largest urban hub, it offers a social and environmental model that holds an appeal beyond the country's borders.

Keywords: Informal Sector, Reverse Logistics, Waste Supply Chain, Waste Pickers

Introduction:

Kabadiwalla Connect(KC), founded in 2014, is a technology-based social enterprise. The technology developed is set in such a way that it can adjust to various waste management ecosystems. It has determined that leveraging the informal ecosystem of urban waste recyclers has the potential to decrease the amount of waste sent to landfills in Indian cities by 70 percent. In other words, 48.16 million metric tons of material recovered. The founders believe that with little survey and research the 'hyperlokal' service used by KC can be used elsewhere, Indonesia is one such example. Siddharth Hande, the founder of KC started cleaning up the waste polluting his city's beaches since his teenage years. He then saw the potential of recovering this waste and began to take a closer interest in the informal economy, which allows the most destitute to earn a living by selling the waste collected all over the city. To increase this system's performance, they came up with the idea of mapping the districts of Chennai down to the meter to draw up a list of all the stakeholders in the informal recycling value chain. Then, once identified, providing them with a whole logistical framework to guarantee outlets for them. KWC worked under the motto that Rather than approaching the informality as a problem and developing a new system for waste management, Kabadiwalla Connect uses its technology platform to leverage the already existing informal infrastructure toward a more efficient waste management system.

Mapping and Survey:

With the initial grant received from World Economic Forum, Kabadiwalla Connect started mapping and enumerating small scrap-shops (called kabadiwallas in India) that waste pickers sold to, as well as larger informal traders and middle-men in Chennai. Using an initial 50-question survey, the KC team set out to map the areas of Guindy, Velachery, Adyar and Besant Nagar. What emerged from these surveys is an amazing landscape of information on the informal sector ecosystem – largely invisible yet intrinsically interwoven into the urban environment. The data painted an enlightening picture of frugal yet efficient adaptation, juxtaposed against the stark image of low-income urban livelihoods. The key findings were as following,

- Kabadiwallas were ubiquitous throughout the city. There were close to 2,000 in Chennai.
- They sourced more than 24 % of the total recyclable waste in Chennai, which includes paper, plastic, glass and metal.
- They were making between 20,000 and 30,000 rupees a

month and had been in the business for quite a long time (13 years on average).

- 52 % of kabadiwallas owned and operated a smartphone.
- They were hindered by a lack of visibility

From the initial research, they won another grant from the Global Partnership For Sustainable Development Data, a global network bringing together organizations dedicated to using the data revolution to achieve the Sustainable Development Goals. With this grant, they completed the first census-style data collection of the informal sector in Chennai. The main findings were,

- The informal sector represents an extremely robust and decentralized supply chain with significant volumes, especially when it comes to paper and metal.
- When it comes to plastic, the informal sector understands that there is a market but the maturity is yet to come. Therefore, there is a very interesting opportunity here to organize the ecosystem more systematically.

KC realized that there was a business opportunity in the interface between the informal scrap shops and the formal processing of plastics. A small material recycling facility was set to procure PET from the informal ecosystem. The main objective behind this was to prove that it was possible to procure consistent volumes from the informal sector and provide certain benefits (better price, better pick up time, clearer signal on the market dynamic of plastics recycling). Soon after a technology-based process was developed that allowed them to track the quality and volume of material that we are getting from the informal sector.

The Informal Waste Supply Chain:

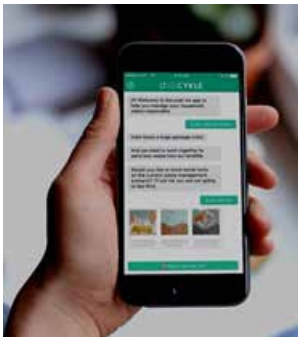
Kabadiwalla Connect defines the informal waste supply chain in three levels:

- **Level 0 aggregators :** Consist of waste pickers who collect waste material from dustbins or landfills and have no input cost. Sometimes L0 aggregators have a method of transportation like a tricycle which they use to cover a larger area and collect more waste. At times, L0 aggregators also collect directly from the households. They have no shop/storage space of their own.
- **Level 1 aggregators :** Known colloquially as kabadiwallas, they are small scrap aggregators who own a shop where they collect, store waste material collected from L0 aggregators, households, apartments and small businesses. They typically like to set up shop where they can be guaranteed a constant supply of post-consumer waste – either in residential areas, near industries, or near a landfill. In urban India, they typically buy many types of paper, glass, metal and plastic. They generally sell all the material they collect to an L2 or a larger L1 aggregator in weekly or biweekly cycles.
- **Level 2 aggregators:** they primarily buy material from L1 aggregators and bulk generators of recyclable waste. To be viable, they have to be able to store much larger volumes of recyclables, and so favour setting up shop on the periphery of the city. Greater specialization with regards to material is typically found at the L2 aggregator level, in terms of segregation and/or processing.

Services and products offered by KC:

1) **Mapping:** A Spatially-enabled, industry compliant data-collection service of informal and formal waste infrastructure in cities in the developing world
2) **Digitalization:** KYC and transaction-based material tracking and traceability across stakeholders in the formal/informal supply-chain
3) **Sourcing:** Secondary raw material guarantees for processors/PROs in cities in the developing world through informal sector procurement
4) **Hyperlokal :** Reverse logistics solutions for post-consumer waste collection — powered by local informal scrap-shops and their waste-pickers under which it has deployed 'Urbins' which are fitted with built-in field sensors which will send a text message to the neighborhood kabadiwalla once the bin is full.
5) **Recykle:** The Recykle app works on a map-based interface which has pinned the drop-off points of the Urbins and also the contact details of the kabadiwallas nearby. It provides users simple information on how to segregate and compost at home, make it easy to connect to their closest kabadiwalla, as well as allow them to sign up for local events like composting and rooftop gardening workshops. Another important function of the app is that it recommends prices that different types of recyclable material should be sold at to help residents get good prices for their materials. The app has been temporarily closed.

Urbins



Recykle

Conclusion

To solve this major plastic waste management issue, no silver bullet has been discovered yet. Cross-industrial and value chain collaborations is something that will help the root cause. To replicate such initiatives, partnerships from a brand and processor's perspective keeping in loop with the EPR guidelines, are to prioritized, because what EPR says is that the brands have to take the responsibility, irrespective of where they have littered, so this is where initiatives like ours have to be funded and work closely with the brand owners and develop this entire supply chain across different cities. Educating the consumers should also be the top priority, especially in a developing economy like India, collaborations at an academic level should be the driving force. The future lies in the hands of youth, sowing the right seeds of sustainability from a very young age will surely help us build a strong foundation for the circular economy.

These initiatives like that of Kabadiwalla connect are startup organizations led by a team of diverse and visionary professionals. Their focus lies on the unsung heroes of the circular economy, all the efforts of the initiative are directed to revolutionize and discover the true potential of this closely guarded and clandestine economy who form the backbone of the waste management sector in India.

To conclude, there are entrepreneurs, who can communicate to the audience and there are entrepreneurs who just want to bring bread on the table for their families, and the kabadiwallas and Lapaks of the world do that, so they deserve to be recognized as the central part of the circular economy.

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A sustainable method of using plastic waste for construction of roads

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ABSTRACT

Plastic can be a boon or a bane depending upon the way it is used, disposed and handled. Being a versatile material with numerous applications in various industries, plastic truly is an irreplaceable material. But every good material has its own set of disadvantages and humans being on the top of the food chain, are accustomed to over-exploit each and every thing that comes into their hands without thinking about the future consequences. Consequently, one of the major disadvantages of plastic is large waste generation due to its persistence in environment. In accordance to its long biodegradation cycle, a lot of plastic waste has been accumulated since the invention of plastic as there is no cost effective and environmentally sound way to deal with plastic waste, especially with our present waste disposal, management and treatment system. Fortunately, an entirely new concept has been introduced to overcome this problem. It uses mixed plastic waste from different origins and of varying proportions to manufacture modules. These modules can then be used to construct roads or footpaths giving bitumen roads additional durability and decreasing their thickness. Since this process uses plastic waste, total cost of manufacturing the roads will be lower than that of conventional techniques and this process will also ensure environmental conservation.

Key words: plastic waste, plastic roads, bitumen

Abbreviations:

UTM: Universal Testing Machine, LLDPE: Linear Low Density Polyethylene, LDPE: Low Density Polyethylene, HDPE: High Density Polyethylene, PVC: Poly (vinyl chloride), PP: Polypropylene, PET: Polyethylene terephthalate, PLA: Poly (lactic acid), PS: Polystyrene, EVA: Ethylene-vinyl acetate, EBA: Ethylene Butyl acetate

INTRODUCTION

The demand for plastics has increased from around 1.5 million metric tonnes to more than 350 million metric tonnes worldwide in the past 50 years. This also has increased the amount of plastic waste generated per year. Plastic is a versatile material that is used almost in every product, ranging from commodity materials to high-performance materials like in automobile bumpers, aerospace industries, etc. Plastics are non-biodegradable materials that may remain on earth for up to 4000-5000 years without showing any degradation signs. Since it is a cheap to manufacture material, it is used on a very large scale. Moreover, they show extreme chemical resistance which is the reason behind their slow degradation. Due to improper disposal practices and mismanagement of waste, sometimes litter and micro plastic is generated, for example due to flash floods waste plastics can get into river bodies and then make their way into the oceans. This waste is broken down into smaller parts (micro plastics), and then consumed by fish and then the fish is consumed by humans again (this is more prominent in cities near coastal areas). Also, due to increased plastic consumption, many countries are facing difficulties in landfill spaces which leads to littering causing air, water, and land pollution as a result of which it also enters the food chain. Recent studies show that almost 13 million metric tonnes of plastic waste end up in the ocean causing billions of dollars in the cleaning process. The most common plastics found in generated waste are HDPE, LDPE, LLDPE, PP, PET, and PVC. According to various surveys conducted around the world, it was found that the packaging sector contributed most towards waste generation from all 3 major sources of waste generation i.e. industries, agriculture and households out of which food packaging contributed around 31%, bottle caps around 15.5%, plastic bags around 11%, the remaining amount of waste was generated from other packaging materials not used in the food packaging sector.

In the past few years, more focus has been driven towards reusing and recycling of plastic waste. Plastic roads are the most advantageous way of reusing plastic waste; the use of plastic waste in bituminous roads is gaining popularity nowadays. Initially, Plastic waste is collected from various sources, since the material used for construction comes from waste the raw material cost is almost negligible, the most commonly used method for the construction of roads is the dry process. In the dry process, the collected waste is first shredded into small pieces and is then melted, molten plastic is then poured onto aggregates which are then poured onto hot

bitumen (160°C) resulting in the formation of plastic-coated aggregate bitumen mixture, which is then used for road laying at around 120°C. The most commonly used plastics in plastic-modified bitumen road construction are HDPE, LDPE, LLDPE, PP, EBA, EVA, and PVC. When compared to normal bitumen roads plastic modified roads tend to show improved road strength (almost twice), almost no potholes formation, reduced bleeding in summer without any extra machinery for road construction.

In this article, we will be discussing about this patented process of making plastic modified bitumen roads and how these plastic roads differ from normal bitumen roads in terms of properties and cost. We will also talk about the environmental and social benefits of constructing these plastic roads.

EXPERIMENTAL

LLDPE, LDPE, HDPE, PVC, PP, EBA, EVA, PET, PLA, PS, Multi layer Plastics (were redeemed in various forms from plastic waste), bitumen, gravel, stones chips, sand, concrete and water.

Initially, the collected plastic waste is segregated to collect required plastics through various segregation techniques. The first step was to dry and shred the plastic waste. There was no desired particle size of the shredded waste; the plastic was shredded into bits small enough to be manageable. Then a concrete mould was made in which the shredded plastic waste was heat and pressure treated to get the modules of desired dimensions. The modules can be of different shapes and sizes depending upon the requirements but the height of the modules was fixed to be uniformly maintained at 2.5" and 1.5" and zero inches. It was found that zero inches modules were ideal during commercial preparation of roads since they were economical and easy to handle and could be easily laid down on the base by the help of the paver machine. Several small scale tests were conducted to find out the desired dimensions of modules. In the first test conducted modules with a small height were used so as to test the difference and because it was easier this way when construction of roads were done manually. Also when more tests were conducted and more small scale roads were built, the dimensions of the modules were normalised to be 20 x 20 inches due to easy production of modules with these dimensions.

The initial step in construction of roads was to dig down around 500 mm of the area on which the road was to be constructed. Then the area was flattened and made even by the help of a roller, water was sprinkled and the area was allowed to dry for three days. Then a layer stone of size ranging from 2-3 inches were laid over the flattened area and evenly distributed with the help of a roller. Water was sprinkled and was allowed to dry. The top layer was cleaned and then stone chips of size ranging from 0.50 to 0.75 inches and later sand and clay was spread to fill the minor gaps. The surface was rolled and cleaned again.

This was the sub-base, on which base was prepared by spraying hot bitumen, then applying one inches of concrete on which plastic modules were placed. This was done so that they don't move from their place. Then the modules were covered with any even layer of bitumen (aka coal tar) and the surface was worked upon by a roller.

The latest advancement in the procedure of plastic road construction is the development of new type of modules with five punch holes. In the new process the old road is not destroyed and a layer of hot tar is spread over its surface, on this topcoat the new modules with punch holes are placed and then a layer of bitumen is added on the top of this layer. Also note that there is always some space(around 2m) left on the right and left side of the plastic roads so that if a new water, sewage or optical fibre line, etc. have to be placed underground/below the road or an already existing pipe has to be repaired, it can be repaired or set up easily.

CHARACTERIZATION

Simultaneous thermal analysis (STA) of modules was carried out using a Simultaneous thermal analyser; this method was used to analyse decomposition temperature/stability of modules.

Maximum stress, maximum strain and compression modulus of modules at different temperature values and pressure rates were evaluated using an Instron UTM. The samples were prepared by cutting modules in to disk form of diameter 50 mm. The samples were subjected to the temperatures range of 28°C to 150°C along with pressure at a rate of 10 mm/min and 20 mm/min. The stress and strain data were collected by conducting 5 experiments at each condition. The samples prepared were mounted in sample chamber and the temperature of the chamber was maintained at 28°C, 50°C, 75°C, 100°C, 125°C, and 150°C during individual runs. At each temperature the experiment was conducted by varying the load rate i.e. 10 mm/min and 20 mm/min. The data obtained was used in the estimation of stress, strain and compression modulus

Density measurement of road was also carried out to estimate the compaction of road with respect to standard roads as it is seen that more is the compactness of the material used to make roads; more is the strength of the road. The compactness of the roads is directly related to the density of the roads, hence more dense the packing of the material in the roads is better is the strength of the road. The density of the roads can be calculated using the sand replacement method. The sand replacement test is used to measure density. The apparatus for sand replacement method of contains a sand-pouring cylinder, cylindrical calibrating container, tray with a central circular hole, and a chisel. Standard method was carried out for Determination of field density using the sand replacement method. The density was estimated by taking the core at different depth so as to estimate the compaction.

It is known that roads get deflected when vehicles pass over its surface. The deformation or elastic deflection under a given load depends upon sub grades soil type, its moisture content and compaction, the thickness and quality of the pavement courses, drainage conditions, pavement surface temperature etc. The Benkelman Beam Deflection Method is thus widely used for evaluation of structural capacity of flexible pavements and also for estimation and design of overlays for strengthening of any weak pavement for the stretch., the extent of deflection can be measured by the help of the Benkelman Beam Deflection Method. This method measures the vertical deflection of the surface of roads with the help of a measuring beam under a constant load of 5 tonnes of a rolling tyre or object.

RESULTS AND DISCUSSION

1) Thermal stability - Since the plastic waste is mixture of many plastics, glass transition temperature (Tg) was not observed moreover multiple melting points were also observed. The STA of modules showed that the modules were stable up to 250°C with 10% mass loss at 400°C and almost 90% mass loss at 500°C.

   This analyses is extremely important for understanding the behaviour of prepared modules under temperature variations, moreover it was also observed that the composition of plastic in modules varied from place to place since it not possible to control the composition of particular plastic type. The STA results indicated that the modules showed stability and can withstand road preparation conditions despite of vast variation in composition

2) Maximum stress, Maximum strain and Compression modulus- from obtained data it was observed that, as testing temperature increased from Room Temperature (about 28°C) to around 150°C, the samples displayed slight increase in values of maximum % strain as the samples became more pliable at high temperatures. Also it was observed that, the maximum stress of the sample did not undergo drastic decrease with increasing temperature. Correspondingly, the compression modulus also did not undergo much reduction till about 15°C where for a lower speed of testing the modulus decreased by about half as compared to Room Temperature samples at same speed of testing. At higher speed of testing of 20 mm/min, the modulus was equivalent to the rest of samples. There was not much change in compressive values at different rates of testing except at highest test temperature of 150°C. Five samples were tested at each speed and temperature of testing so data is statistically sound. Sample to sample variation was quite less and samples were completely distorted after testing at highest temperature of 125°C; rest tested samples were thinned down to flattened disk size. This indicates that the modules can very well be used in road application as it can withstand pressure and temperature.

3) Density - It was observed that the stretch with waste plastic and without plastic (road prepared with conventional standard process), showed the similar compaction i.e. it was found that both road with and without plastic modules had almost the same density value which suggests that the strength of the road is not affected by addition of modules.

4) Average deflection- It was observed that average deflection of conventional roads and plastic roads were almost similar which suggest that there is not much strength difference in both the types of road

CONCLUSION

Though there was not much of major difference in strength/ load bearing capacity of plastic modified road when compared with conventional bitumen roads, the plastic roads have a significant social and environmental impact.

Construction of plastic roads can indirectly reduce the amount of unintended litter produced. This happens because the mixed plastic waste that is used to make the modules is collected from waste suppliers which involves less transportation of the plastic

As mentioned earlier the process proposed utilizes a large amount of plastic waste and the amount of waste utilized is very high are compared to other plastic waste treatment methods proposed internationally. This will surely decreases the amount of waste going into landfills and incinerators, which will decrease the carbon footprint of the products as on incineration of the product allot of greenhouse gases are evolved which is responsible for climate change. Also the open dry plastic waste present in unsanitary landfill can catch fire during the summers due to intense heat and high temperatures, this also contribute to GHG emissions which can be reduced by making plastic roads. Also if less waste is being sent to landfills, less land will be used for land filling, hence decreasing the land pollution/wastage and that area can be used for more important purposes.

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because he never misses an opportunity to learn new stuff especially when it's related to research and development. He has been a part of some inter-college workshops based on polymers. He has also been involved with certain research-based events and has presented his project at U21 Rise Awards (a highly reputed international competition).

Pritish Jain currently studying polymer science from Bhaskaracharya College of Applied Sciences is one of those students who are interested in each and every topic that they come across. He is passionate about learning various things in

different fields of science and technology. He is most interested in performing experimental research. He has participated in numerous international and national workshops, events and competitions. Few of his achievements include being selected as a finalist in Google code-in 2018 and representing a project in U21 rise awards.

Anmol Malhotra is a student pursuing B.Sc.(Hons.) Polymer Science from Bhaskaracharya College of Applied Sciences. He has always been academically bright and focused. He has always shown his interest when it comes to taking part in a challenging competition or some workshop. He's been a part

of a few inter-college workshops on topics related to polymers (one being held in IIT Delhi). He is very determined and totally displays this characteristic when it's his turn to deliver. He has been working on an extraordinary research project under the guidance of his department's teacher in-charge.

Ankush Koundal is a student currently studying polymer science from Bhaskaracharya College of Applied Sciences. He

has always been keen to master his practical skills. He not only gathers knowledge about a topic, he tries to develop a deep insight about all the aspects involved. He has been able to showcase excellent leadership skills when working in a team and is able to coordinate in a very friendly manner. Hence, he makes his team shine out from the rest.

IIM Visakhapatnam

Rudra Environmental Solutions Pvt. Ltd. – Towards A Plastic Free World

Team Terra

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ABSTRACT:

Rudra Environment Solutions India Ltd. is an initiative that converts plastic waste into oil & fuel that is used in various other processes. The process adopted is TCD (Thermo Catalytic De-Polymerization). Based out of Pune, the plant processes plastic wastes that are recyclable such as thin plastics, residual plastics, etc. The fuel generated from the process is energy efficient & creates zero emissions (Sulphur content produced in the process < 18ppm). The company has achieved success in its past due to which various corporate institutions & local government bodies have started collaborating with the company. It is an ISO 9001-2008 certified company. The company has been able to create a positive impact with this initiative. They started from a point where they initiated as a backyard model, and they can recycle up to 750 tons of plastics. The entire process is Zero-emission, and each ton of plastic waste produces approx. 500-600 litters of poly fuel, 20% of synthetic gas produced is used up in the TCD process & others are sold. 10% residual Char produced is used as road filler with bitumen. Poly fuel produced is sold to local area farmers at a cheap cost. They strongly believe in Social transformation through Innovation.

INTRODUCTION

"We at Rudra Environmental Solutions very strongly believe in Social transformation through Innovation. We believe invention can solve many of the biggest social, environmental, and economic challenges of our time."

In recent years, the plastic industry in India has seen tremendous growth. From 8.33 MMTPA in FY10 to 20MMTPA in FY20 & is growing at a CAGR of 10% annually. The amount of Plastic that India generates is almost equal to 5%-6% of overall global waste generation. One of the primal assertions supporting this is 50% of prevailing plastic generated is discarded as waste after a single use. We observe that Maharashtra, Tamil Nadu, Gujrat, Karnataka, UP & Telangana are the top contributors to the cumulative plastic waste dumped. As per a Bangalore City survey, food packaging, personal care, and household products contribute heavily to the plastic problem. This gives us an indication regarding the immensely and exponentially growing plastic problem in our country.

In 2009, the founders of Rudra Environmental Solutions (Mr. Shirish Phadtare & Dr. Medha Tadpatrikar) visited a sanctuary & were capturing the wildlife through their lenses. Suddenly, they saw a dead deer. After a primary investigation, it was found out that the cause of death was the consumption of plastic waste materials. The incident moved them in such a way that they decided to work for plastic waste reduction. They began experimenting on plastic waste to save this planet & make something good out of it to make it sustainable. Finally, on 29th July 2009, Rudra Environment solution private limited was established with a goal in mind to reduce & convert plastic waste into consumable fuel & other products. The two decided to move ahead with their vision of making the environment plastic-free. Soon, the first working plant was set up in March 2010. Under the leadership of co-founders, the company has progressed well in the past & has reached new heights.

EXPERIMENTAL / DATA COLLECTION TECHNIQUES

The overall data collection process involved both primary and secondary methods. We carried out extensive discussions on the presiding Plastic Problem in our country, the current solutions in place, and how Rudra can redefine the way we look at this issue with Mr. Shirish Phadtare, Chairman, Rudra Environmental Solutions Ltd. From a Pune city perspective, we understood the quantum of waste generated per day, the degree of waste segregation, and the current waste management practices.

Rudra, in association with the Keshav Sita Trust, aims at reducing and eliminating the plastics in our daily lives. Their aim has been to involve the community in generating awareness about the environment and building a sustainable

Awareness Drives

Session at Dhankawdi Pune

Awareness Drive at Phoenix Mall, Pune

Awareness Drives among Students

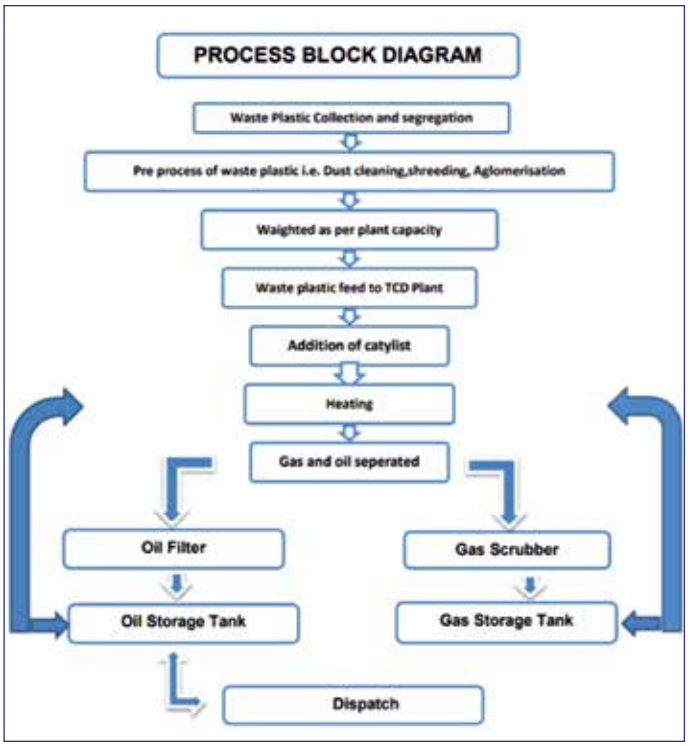
future. They have been involved in creating awareness in and around the city of Pune for more than half a decade now. They encourage people to carry out segregation at the source, collect garbage, and collaborate with Rudra Environmental Solutions to recover the poly-fuel from the waste. The Trust firmly believes that for any waste management program to succeed, it is essential to create awareness at the source and create a system of segregation. Currently, they collect waste from Pune, PCMC, and nearby locations.

They have expanded the waste collection to regions of Dombivali, Kalyan & Thane. They connect with the societies, conduct meetings with flat owners, make people aware of the importance of segregation at source and how harmful Plastic bears are to the environment. This personal connection has enabled the Trust to create awareness and formulate a willing army of people who have started segregation and giving the plastic to trust as well as spreading the word in their respective areas. Rudra Environmental solutions and Keshav Sita Trust are committed to creating a circular economy.

We also gathered information regarding the Poly-fuel, the initiative, its scalability, and implications from various secondary resources listed in the References section.

RESULTS AND DISCUSSION

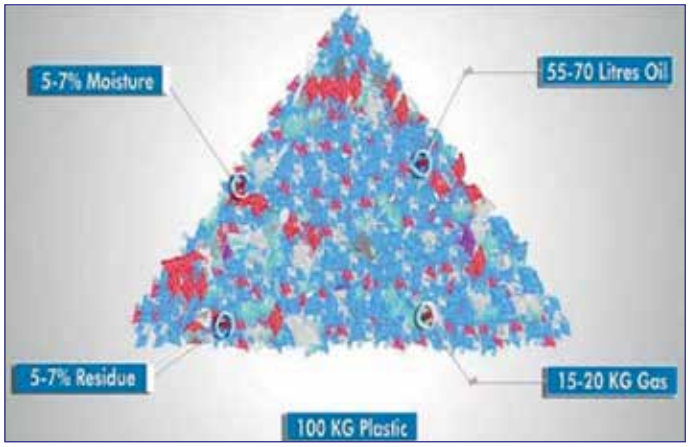
After its inception in 2009, Rudra was involved in the research & development of the proposed TCD process. Their major goal in the formative years was to understand the most efficient way to recycle the waste plastic. They spent a huge amount of time figuring out the quality of the oil generated and its suitability in the day-to-day activities as a fuel. Plastic that they use in their process is majorly those which is thrown away, and either eventually, they are burnt or used in landfills.



They started off with a backyard model, where they experimented on what could be done of the waste plastic. Their initial experiment was in a pressure cooker, fitted with a tube nozzle, with which they cooled off and found the poly-fuel so produced. Post extensive research and development activities, they formulated and patented a standard process for extracting oil from the waste process. The entire process is environmentally friendly. Even the gas so generated was scrubbed and compressed and re-used in the process again. By 2013, they established the entire process, which generated 55-60% of oil as output, 15-20% of Gas output, 5-7% moisture, and 5-7% residue. They involved BOP household for operation majorly and sold it to farmers and marginalized society to sell the produced output at a cheaper cost.

In 2009-10 as a 50Kg plant, the initiative took off to scaling up to 2X the capacity by 2013. They started off in negotiations with the Pune Municipal Corporation for a collaboration. They would help collect the desired plastic, and Rudra, in turn, would convert it into poly-fuel. This would solve the waste accumulation for PMC as well as the material sourcing problem for Rudra. By 2015 Rudra received the ISO 9001:2008 certification. In 2016, they were again able to scale up the plant capacity, and a 3rd generation plant of 500 Kg was set up.

The initiative has led to an impact on every dimension, be it towards the society, create employment, or create value for the market. Rudra works with a motive of community improvement, aiming at making it plastic-free. They provide employment opportunities to the BOP and marginalized community. They



employ 12-13 people for every ton of plastic that is recycled. Also, serving the community, Rudra sells the generated fuel at a much lesser price than the conventional prices in the market.

The Trust gives preference to involving rural women in primary segregation and sorting work to separate metal, paper, or other types of waste from the plastic. The band of women who are employed is given a yearly medical check-up, which includes a blood test, eye, gynecological test, and blood pressure and sugar levels. At BOP Level, they involve ragpickers and small-scale plastic vendors to collect waste materials from malls & supermarkets. They have collected 15,00,000 kgs of plastic, leading to a reduction in 90,00,000 Kg of CO2 emission.

Trust feels it is a duty to help women living in rural areas. In many low-income areas and villages, wood and plastic are used for cooking or heating the water for bathing. This problem was presented during the collection process. The Trust has tied up with more than FIFTY villages and areas where the Trust and Rudra sell the poly-fuel to these marginalized women at a subsidized rate provided they.

Rudra strongly believes that changes in people's habits profoundly impact the success of waste management. Even then, cosmetical cleanliness drives help to create awareness and feel-good factors. With this aim, Trust undertakes cleanliness drives of popular or historical places. Such drives are specially arranged for various offices, colleges, clubs, and organizations.

CONCLUSIONS

Rudra's Value proposition was to create a circular economy by reducing and recovering the waste plastic and converting them to Poly fuel, creating a positive environmental impact. They achieved this by having the technical capability to convert waste plastic into poly-fuel and their ability to scale the plant's capacity with their patented technology gradually. The process involved mobilizing the community to engage them in Waste collection, converting plastic into poly-fuel using their TCD process, and finally selling the output to the customers and other industries. Their Profit formula involved the sale of Converted Poly-fuel at a price lower than conventional fuel, providing waste management solution to Municipal Corp., sale of by-products, segregated plastics to plastic recyclers.

For any business enterprise to be truly successful, it must be Environmentally sustainable, Socially Inclusive, and at the same time, Economically viable. With the entire process being energy efficient and with zero-emission, Rudra has created a new equilibrium that helps companies & govt bodies to carry out circular economy practices. The poly fuel generated has Sulphur content, less than 18 ppm, which makes it a safe fuel for usage. The availability of cheaper fuel to the BOP people helps the rural women break free from burning wood and plastic as a fuel substitute. Reverse engineering & converting back to Poly fuel, which has high calorific value, can be used by industries for running equipment, which in turn, reduces dependency on conventional fuel.

Thus, Rudra is truly a sustainable solution that we feel can accelerate India's Mission to eradicate plastic waste and improve life on land and in the ocean.


Factory Building at Jejuri, Pune


First Trial Plant of 50 Kg.


Second Trial Plant of 100 Kg.

Acknowledgments

We would like to express my special thanks of gratitude to Mr. Shirish Phadtare, Chairman, Rudra Environmental Solutions, as well as Dr. Medha Tadpatrikar, Director, Rudra Environmental Solutions, who gave us the opportunity and the guidance to do this wonderful project. Their insights about the plastic problem in India were strikingly immense, and we, as students, underwent a huge learning curve.

We would also like to extend our sincere thanks to Commitment Accelerator for Plastic Pollution, Indian Plastic Institute, Ocean Recovery Alliance, Chellaram Foundation, and Goa Institute of Management for relaying this opportunity in the form of 'MAKE THE CASE COMPETITION' to the students. This was in a true sense, 'More than a Competition' which pushed us to understand the grievous situation of Plastic Pollution across the globe and how eminent it is to address the same.

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Brief Biography of the authors

1. **Kanchan Krishan (LinkedIn ID: https://www.linkedin.com/in/kanchan-krishan-892b76187/):**

   A Marine Engineer by graduation, Kanchan has sailed onboard 4 ships for over two years of time span. During these two years he has observed the abysmal condition of the World ocean, created by the human intervention, and moved by the current lagging system. Currently pursuing his MBA in IIM Visakhapatnam, in the specialization areas of Strategy, Operations and Marketing, he has interned with Jio Creative Labs in field of Advertising and marketing. He has also worked as a volunteer for Smart Village Movement, with UC Berkley, for making the Indian villages sustainable and self-sufficient.

2. **Abinaya S (LinkedIn Id: https://www.linkedin.com/in/abinayasanthakumar/)**

   A chemical engineer, with entrepreneurship at heart, she is currently pursuing her MBA in fields of Sales & marketing. She has undertaken several projects such as Impact of Online Product recommendation on Impulse buying behavior of consumer, Kinetic Study on the formation and dissociation of gas hydrates system & assessment of Anti-Microbial Efficacy of Oil for its Potential Application in Cutting Fluid. He loves to contribute to nature at individual as well as at NGO level as much as possible by taking part in various awareness and collection drives.

3. **Sagar Mukherjee (LinkedIn Id: https://www.linkedin.com/in/sagar-mukherjee-489281152/)**

   A Computer Science B.Tech. graduate from RCC IIT, Kolkata. Post his engineering he worked with ZS Associates for a period of 11 months. He is pursuing a major is Strategy and Marketing in his MBA and his areas of interest to work mostly includes solving the problem of the society. Out of all this, waste management is the most interesting area to him and would like to make a huge impact to the Earth by saving it from the menace of plastic through his own venture.

4. **Namit Chhatbar (LinkedIn Id: https://www.linkedin.com/in/namit-chhatbar-81103775/)**

   Namit has a strong analytical mindset which helps to create insight and rationale for decision-making. An open-minded approach and curiosity to learn something new is what drives him ahead. He comes with 2+ years of enriching customer-facing experience in B2B industry with Berkshire Hathaway owned Lubrizol Corporation. His previous degree includes B. Tech in Chemical Technology from India's premier chemical technology institute - Institute of Chemical Technology (formerly known as UDCT)

Indian Institute of Management (IIM), INDORE

Combating Plastic Waste via Education : Case study of the Akshar Model

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ABSTRACT

This paper discusses Akshar Foundation's unique initiative of battling two very urgent issues- illiteracy and increasing plastic-waste by using an integrated model- combining educational and environmental reform. Students of this school pay plastic as school fees in exchange for quality education. Motivated to get rid of harmful practices amongst the locals such as burning of plastics to keep oneself warm and unsanitary waste collection practices, this initiative provides targeted education for children who are ragpickers. Besides this students undergo basic vocational education and skill development, and work in a Recycle Centre where eco-bricks are made out of the plastic fee collected, which are further used for construction of walls, buildings, pavements and other structures within the school. The school currently boasts 130 students, many of whom are school dropouts. The school follows a self-education system as well where older students teach younger students to earn credit points which can be used to buy food and other products available only in the school premises. This helps students enhance their financial planning and literacy. The initiative sets up an entire ecosystem for change, trade and education that helps inculcate safe habits, confidence and skills in students, whilst fighting against plastic.

INTRODUCTION

Why did Akshar come into being?

Ms Parmita Sarma, the co-founder of the initiative came across a group of slum-dwellers huddled around a fire made out of plastic wastes on one winter evening in Guwahati. As she recalls, seeing them inhale the toxic fumes out of burning plastic made her see the problem as it is, leaving her with the desire to make Guwahati a better place to live.

On a different frontier, she had just started her school in Guwahati, which was attended by children of ragpickers. The attendance was skimpy on most days, as often poverty forced them to take up daily-labouring tasks to aid their parents. Hence, the choice of introducing this initiative was Guwahati- a city where they had already established the base of education.

Where is Akshar ?

Akshar Foundation conducts its operation in its school in Guwahati, Assam. With a population density of 2695.43 per sq. Km, and a total population of 11.2lakhs, Guwahati is characterized by major instances of displacement and migration- due to floods/ natural calamities caused by the hilly terrain of the city. The multidimensional poverty index (MPI) of poor households in Guwahati city is primarily related to their work status, social status and literacy status. In fact, slum areas are a major source and habitat of all forms of plastic waste . Hence, education (and its derivatives: occupation, awareness etc.) and environment (i.e. Sanitation, pollution etc.) are the major deprivations of the slum-dwellers in Guwahati. But, on a positive note, Guwahati is much less prone to caste-based inequalities than the majority of Indian states.

According to a report by a Guwahati Based NGO Environ, the city generated about 1110000 kgs of plastic waste every month (As of 2018). To put this in perspective, this is equivalent to around 1 kg per person per month, which is 11 percent higher than the national average. Estimates say around 60,000 children reside in slums, often which are characterized by harmful practices such as burning plastics and unsanitary collection of waste. Adding to these problematic numbers are the poor recycling and disposing facilities that currently exist in North-East India, highlighting how important and common this issue is in the city of Guwahati.

Based out of Guwahati, Sarma and Mukhtar witnessed the plastic problem in Guwahati, first hand. Akshar primarily impacts the students of Guwahati, teaching them how to responsibly use plastics, and make value out of them. Furthermore, Akshar acts as an institution of rehabilitation. Many school dropouts were integrated into the school and were guided into transforming themselves into confident and educated students. Looking at the bigger picture, Akshar helped transform the entire locality. Through children, the values taught at school could be taken back home to parents and other members of the community. Furthermore, an informal network of plastic collection was formed with local businesses, who were witnessing and constraining students to creating value out of plastic. This

changes the way the locality perceives plastic, at a grass root level.

How does Akshar work?

The school runs on the "plastic waste as fees" model where each student has to "pay" 25 plastic items (samagris) to the school per week as the fee. These plastics are recycled into Eco-Bricks, made by students, at the Recycling Center. The Centre is located inside the school's premises, and the eco-bricks produced are used to make various basic structures including fountains, gardens and small walls. In the process of eco-brick creation students are taught about safe ways of dealing with and recycling plastics.

Sarma and Mukhtar formulated the curriculum to adhere to the resources and requirements of the students. The curriculum did not follow a traditional formal education system, but was heavily interspersed with vocational training in carpentry, sculpting and gardening. This was done in light of equipping students with skills that ensure a source of income for them. Since the area (and the country at large) faces a shortage of good quality teachers, Sarma and Muktar established a peer-to-peer learning system in which older students taught the younger students, besides having sessions with professional teachers.

The country-wide issue of student-retention in schools, was tackled by paying students for various activities. Students were paid an approximate amount of Rs10-15 for each eco-brick they made. Older students were paid to teach younger students as well, by the hour.

EXPERIMENTAL / DATA COLLECTION TECHNIQUES

Data was collected through three interviews with the co-founder of Akshar, Paromita Sarma. The interview followed a conversation-style guided by a pre-made questionnaire consisting of open ended questions.

RESULTS AND DISCUSSION

PART A: MORE ON THE ORGANIZATION

- **Organizational Structure:** Akshar Foundation currently has around 130 students enrolled in classes from 1 to 10th and employs 6 teachers and 1 caretaker. The two co-founders head the entire team. The organization is quite flat and students contribute as per their capability through peer-to-peer learning: senior students teach junior-students, earning money and gaining agency in the process.
- **Working:** The school runs on the principle of "plastic waste as fees" where each student has to carry 25-30 plastic items (samagris) to the school per week, which they then recycle into Eco-Bricks in the Recycling Centre attached to the school. With plastic as fees instead of money for school and monetary incentives for recycling, burning plastic would not exist any longer and students would now be motivated to come learn and attend classes. It works towards incentivizing a student's education by involving monetary incentives: for example: In the process of making Eco-Bricks, the students also earn money: between 10 and 15 rupees per Eco-brick. The motto is to fight child labour with child labour, to skill the deprived children, most of who come from a family of ragpickers. By incentivizing a child's attendance in a school, it ensures they do not engage in hazardous or other detrimental forms of child labour.

PART B: Impact

Output:

The initiative, as of now collects around 13,000 plastic samagris per month from its 130 students. Each eco-brick takes around 25-30 plastic samagris, hence, makes the students end up making around 500 eco-bricks per month from the plastic collected, which are later used for improving infrastructure around the school premises: eg. building pavements, fountains and gardens, therefore, not just reducing plastic waste but also generating value out of the plastic wastes. Overall, it makes the general environment cleaner and reduces air pollution.

On the qualitative front, it helps children of rag pickers to change their lives: by providing them opportunities for a better livelihood and also making them aware, educated and giving them agency. It also creates a multiplier effect: not only are the children learning, but they are also simultaneously taking back the values and teachings to home and making their parents conscious, as well as carving a better path for the next generations.

The impact has been divided into 3 parts: that on society, environment and economy respectively.

Societal impact:

Akshar Foundation School is a high-impact initiative that creates value in both the short & long term by leveraging one of the most powerful & potent tools: Education. By accepting plastic litter as fees for their school, the foundation has been able to increase the class strength from 80 to 130 students in just over 2 years, which is a 62.5 percent growth. The initiative has also garnered social recognition in the form of symbiotic relationships that exist with local business and shop owners. Often, many students of these schools go and collect plastic from local shops who are happy to give it to them because it saves them both money and time. A significant majority of the school population are children of rag pickers who cannot afford to attend a conventional school. As part of their curriculum, these children learn to make eco-bricks: an economically viable and environment-friendly way of disposing of plastic.

Overall, this initiative is able to create a net value in society and is able to influence and improve the plastic use habits

of all its stakeholders. For instance, the local shop owners and parents now recognize that there are social, economic & environmental costs associated with each piece of plastic, and this realization directly leads to more responsible consumption habits.

Environmental impact:

Numerically speaking there has been a substantial decrease in the plastic on the roads, directly caused by the plastic-fees students are expected to pay to the school. Akshar takes 25 plastic things, called samagris, per week for approximately 130 students. This, in itself, reduces around 3900 plastic pieces of litter, each week. These pieces are used to make around 120-140 bricks every week, with each brick consisting of 30 samagris. Thus, not only is litter taken off the street, it is disposed of and used constructively. A major trigger for the initiative itself is the burning of plastic that locals took to, to keep themselves warm during winters. Not only is this terrible for their lungs and overall health, but it was also very detrimental to the environment. The reduction of plastic on the streets, and increased awareness had brought down this practice drastically thereby directly reducing air pollution, and bettering health conditions in the locality

Economic Impact:

From an economic perspective, the initiative has been able to create a local market for plastic, and thus by virtue of eco-bricks. Although currently very small, this unrealized market has the potential to explode in the future. Infact, the school is in talks with the local government to provide plastic for road-construction purposes.

By educating the children of rag pickers who were otherwise destined to be ragpickers themselves, the initiative is able to break the vicious cycle of caste-based jobs and poverty. Further, even if they still want to work in the waste industry, these children will now be able to contribute much more than simply collecting plastic litter by virtue of their training, signaling a grass root level change.

Sustainable Development Goals impacted via the initiative:

ENVIRONMENTAL

As mentioned before, there are various environmental changes the initiative has brought about with promote SDG 15 (Life on Land) indirectly:

1. Visible reduction in plastic on the streets, which can indirectly contribute to reduction of plastic in water channels thereby impacting SDG 6 (Clean water and sanitation) positively.
2. Smarter disposal of plastics : Eco brick production and plastic collection rather than burning
3. Betterment in air quality and overall health

SOCIAL

- The initiative tackles not only plastic collection and disposal, but also education on a grass root level.

- SDG 4 (Provision of Quality Education)- - This initiative gives students the most relevant skills sets, besides elementary school education. This vocational education enables them to avail better educational opportunities .
- SDG 8 (Decent work and Economic Growth)- The initiative employs older students to teach younger ones, which is a lucrative employment opportunity, besides helping them have employable skillsets as mentioned before
- SDG 3 (Good health and well-being)- Besides educating the children, the initiative propagates a lot of awareness about plastic and the dangers of burning and other inefficient disposal techniques. The initiative has seen a noticeable change in the litter in the locality, betterment in air quality and overall health.
- SDG 12 (Responsible Production and Consumption)- The initiative enables the creation of environment friendly eco-bricks which are employed for construction- this is a method of responsible production Further, the educating children enables responsible consumption as well

ECONOMIC

- SDG 9 (Industry, Innovation and Infrastructure)- This is accomplished by the MOU signed with the Assam Government, for supplying innovative eco-bricks for new-generation construction. Furthermore, the initiative provides good infrastructure for the students' education as well. Tabs and computers are often utilized for teaching purposes, bettering the country's educational infrastructure.
- SDG 11 (Sustainable cities and communities) - The initiative provides safer alternatives for plastic disposal, which helps makes the community sustainable at large. The waste-picker community is now better aware and safer. Besides, informal networks are made with local business for collecting their disposed plastic, thereby making the sustainablity expand on itself.

PART C: Replicability and scalability

The results of the initiative, despite being concentrated in one city with limited resources have been phenomenal. It has changed the way people view plastic- from a liability to an asset. Given the amount of social welfare- by the dual act of educating and environmental betterment is huge, it makes economic sense to replicate the scale as well the scope of the initiative. If properly replicated, it has potential to perpetually raise the standard of living for rag-pickers. Apart from it, this initiative also holds intertemporal benefits-educating as well as incentivizing environmental awareness helps break the poverty trap for all generations.

The initiative is highly scalable and replicable across India. For instance, the plastic incentive scheme can be easily introduced in government schools near ragpicker communities. This is feasible because the school already has a pool of teachers, staff and the infrastructure. Further, their affiliation with the general governmental system makes them suitable candidates for coordination with the municipality. Establishing this system in these working structures is easier than starting from scratch.

Further, access to industry essential for creation of partnerships. Given various relevant corporates have a presence in many cities in India (and have the capital to penetrate into rural parts as well) tying up with these bodies will be easily done with a good team. The positive impact the brand of the MNC would have after association stands as a major attraction for creation of such partnerships.

Having a motivated, well-networked and convincing team is crucial to the initiative. The team needs to work in tandem with the locals, understanding their needs to gauge what training is appropriate, what products need to be created and how individuals can be recruited into the initiative; amongst other duties. We have prioritized cities because a higher population enhances the chances of finding motivated individuals. Creation of a cross-city structure enables exchange of work force and personnel to ensure that all branches of the initiative are working in tandem and as efficiently as possible.

To summarize, the following resources will be needed for successful replication of the initiative:-

Short Term:

- Capital: Setting up ecobrick production centers and buying precious plastic machines
- People:
  - A large ragpicker population is crucial for the initiative to replicate itself in order to socially impact the largest number of people and foster more large scale projects.
  - The general population must be cooperative with the initiatives, in case any differential disposal (such as returning used plastic bottles) techniques are required.
- Municipality: Coordination with the municipality for getting plastic inflow specifically, and for general ease in operations is crucial since they are closely connected to the plastic waste collection system.
- Networking: Contacting and drafting appropriate deals with big names is crucial to execute CSR-linked expansion.

Long Term:

- The aim is to provide different sources of livelihood and a more dignified lifestyle through
- **Training:** Vocational and manufacturing training for production of locally popular goods using disposed plastics (Example: production of plastic tiffin-baskets for school children, popular in Bangalore).
- **Learning:** Waste pickers are well versed in their field and their expertise can be used to enhance segregation techniques. Setting up structures to learn from their experiences require funding.
- **Policy Changes:** An ideal way of involving local citizens in the fight against plastics would be to tax people depending on their involvement in waste segregation. This would motivate people to be more aware and constructive.

Apart from requiring these resources, there are also some challenges that need to be overcome for replication. These are:

- Formation of a robust local team that coordinates with stakeholders and localizes the initiative in terms of production and resource allocation.
- Cooperative municipalities are important to establishing large plastic inflow streams to enable mass production and revenue generation.
- Incentive of availing education in exchange for plastic payment is not successful in a lot of populations that are willing to pay a nominal fee rather than burden themselves with waste collection to attain education.

Another aspect to consider is to decide the cities that the initiative needs to be first expanded into. The success and the impact of the initiative depends on three main factors:

- A population of underprivileged children who would benefit from the plastic payment incentive based-scheme,
- Support from the municipality
- A motivated local team.

For shortlisting purposes, we have taken the population of rag pickers and Municipal revenue per capita as a proxy for the first and second factors respectively. The third criteria is harder to judge quantitatively, but a well-networked city should imply greater chances of such a team. As such, the shortlisted cities are:

City	Population of Ragpickers	Municipal Revenue Per Capita(2017-18)** (Statewise, in Rs.)
Mumbai	More than 3 Lakhs	8772 (highest in the country)
Kolkata	More than 1.1 Lakhs	5143
Indore	More than 8000 families	5782
Bengaluru	As of 2012, the city had more than 12,000 waste pickers	5212

Traditionally, the initiative's model consisted of virtually no partnerships, since the only coordination was done for funds received rather than forming long term contract-bound deals. However, the MOU signed with the Assam government is indicative of further potential in this arena. The stakeholders were primarily the students and the initiative founders, and extends to the students' parents and community at large.

As per the ideas proposed, the stakeholders will now consist primarily of students, waste-pickers, trainers (who impact vocational skills to the waste-pickers and other students), consumers (who buy the products that waste-pickers manufacture from plastics) and society at large (not only in terms of cleaner environment but greater involvement in the fight against plastic).Partnerships will consist of partnering with Precious Plastic Bazaar (to sell products), the municipality and the subject MNC and we believe that establishing such partnerships will opens doors to more of the same.

PART D: Road ahead

While it is possible for Akshar foundation to sustain as they are, expansion and innovation possibilities are limited since their sustenance is based on external funding primarily. Source of plastics is only the plastic fee given by students, hence mass production of eco bricks and subsequent project acquisition is difficult. The following can be implemented:

The two-pronged approach:

- Establishment of consistent and large plastic inflow for mass production of eco bricks and other locally and commercially relevant products made using Precious Plastic Machines.
- Training of rag-pickers to employ them in these production units and utilize their expertise in the field.

Plastic inflow can be established through:

1. Coordination with Municipality.
2. CSR Ties with relevant corporates (E.g.: The Coca Cola Company) :

- Collection structure either through deposit booths for customers to dispose bottles in, enhancing consumers' social sensitivity or direct collection from company
- Added benefit of possible funds for buying capital from MNC.
- Greater likelihood of successful deal creation because initiative adds very positively to the brand image of the company

Where can additional money be invested?

[The following sheet has been made with one school of Guwahati as primary reference]

Item	Amount	Rationale
Precious Plastic Machine	2 lakhs	Helps in creation of diverse sellable products as per local and commercial needs.
Training Purposes	1 lakh	Engage the ragpickers in a 4-week training session in order to enable employment in manufacture of plastic-composed products
Hiring specialized teacher	2 lakhs/ month	To establish higher secondary education (11th and 12th)
Publicity (Digital)	50,000	Aiming to make relations with big corporate names requires the company to become moderately well-known. Can be done through hiring interns to expand on social media presence.

INCREMENTAL RESULTS/BENEFITS

- More employment generation and revenue: Precious Plastic Machines will create more employment (*mostly of current ragpickers) and also lead to higher revenues via the diverse products created.
- Self sustainability of the initiative: If executed properly, the initiative can self-sustain itself- i.e. it would not need to rely on outside funds to run its operations, because of the increased revenue extracted from the economies of scale and scope.
- Better quality of education/training: Higher quantity as well as quality of teachers will ensure better learning process of the students.

CONCLUSIONS

The Akshar Foundation is a unique and revolutionary model, worthy of replication across the country. It causes a paradigm shift in the way an entire community of people think. The initiative ties the isolated issue of plastics to the basic functioning of the community via education, thereby creating behavioral impacts - students, parents and other community members learn from the value-creation in plastic. The way people demand and use plastic changes.

The initiative changes the way plastic is supplied as well. Plastic is not dismantled into more biodegradable or less-harmful substances- it is put back into the market as something that can create more value.

Furthermore, it does not isolate the issue of plastics into a one-dimensional industry. The initiative acknowledged the impact

of plastic in other spheres of lives and actively tries to tackle it through another fundamental cause of education.

Acknowledgements

We would like to thank Ms. Parmita Sarma for her time and patience. This journey would have been impossible without her interviews and insights. We would also like to thank Assistant Professor Sneha Thapliyal, for her insightful guidance, throughout the journey. Lastly we would like to thank CAPP India, for providing us with this wonderful opportunity.

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Scrap Plastic to Paver Blocks

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ABSTRACT:

The main aim of our initiative is to utilize the Ocean plastic waste into decorative HDCP (High-Density Composites Polymer) tiles and Paver Blocks, and other construction materials for public benches, public dustbins, moving toilets, etc. The selected initiative is the best development of the products and through which we can get the more useful products out of it. The increase in the popularity of using environmentally friendly, low cost and lightweight construction materials has brought lots of research to be done for Paver Blocks. The alarming surge in usage of non-biodegradable plastic products has impacted the ecosystem at hazardous levels leaving the planet choked every single day. Our initiative has been incorporated with the intent to reduce the dumping of plastics in the environment to save the planet, creating affordable structural materials from plastic waste and thus creating a better tomorrow for the generations to come. Using plastic waste materials, we are able to turn waste plastics into high-performance materials in the form of High-Density Composite polymer (HDCP) tiles and blocks. These materials are weather-resistant, chip-resistant, acid-proof, durable and offer better structural stability at a lower cost as compared to conventional materials in addition to protecting the environment from plastic dumping.

Key words:

- HDCP (High Density Composite Polymer)
- Tonnes (A unit of measurement, 1 tonne =1000 kg)

INTRODUCTION:

Shayna EcoUnified is an ISO 9001 : 2015 certified company incorporated with the intent to reduce the dumping of plastics in the environment, by creating affordable materials and structural products by recycling the plastic waste and thus creating a cleaner tomorrow for the generations to come.

This has been made possible by collaborating with 'The Council of Scientific & Industrial Research' (CSIR), National Physical Laboratory (NPL) with whom this technology was developed, tested and certified for usage in multiple applications. Using waste plastic, we recycle and produce high performance materials in the form of tiles, furniture, panels, modules and units.

PROCESS:

1. **Collection**

   Plastics scrap is available in a number of forms for example containers, jars, bottles, bags, packaging film, big industrial plastics just to mention a few. Due to their nature and availability, there are plastic collection centres and some business people have ventured into plastic collecting business as a source of income. Tons and tons of scrap plastic is collected and sent to collecting yard where they are then packed and then transported to plastic processing plants. Unfortunately, not all countries have the capacity to recycle plastic. Very few developing countries can actually recycle plastic. This means that, plastic waste is still a major problem to some countries in the world.

2. **Sorting**

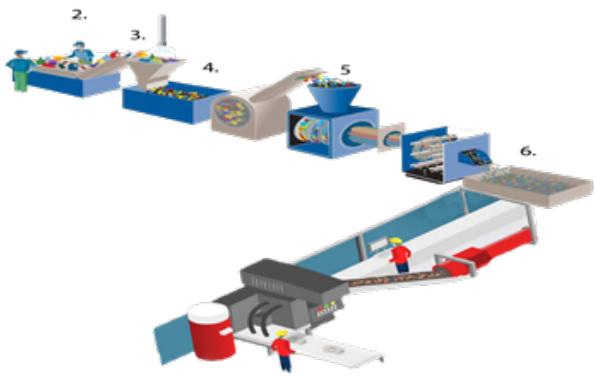
   The actual plastic recycling process starts with sorting of the different plastic items by their resin content and color. This process is also done to ensure all contaminates are eliminated. There are specially designed machines that help in sorting of the plastics according to their resin content.

3. **Shredding**

   After sorting the plastics, the next step is to cut the plastics into tiny chunks or pieces.

4. **Cleaning**

   After a complete separation, the flakes or chunks are then washed with detergents to remove the remaining contamination



5. **Melting**

   The dry flakes are melted down. They can be melted down and moulded into a new shape or they are melted down and processed into granules. The melting process is done under regulated temperatures.

6. **Making of pellets and Injection Moulding**

   After the melting process, the plastic pieces are then compressed into tiny pellets known as nurdles. In this state, the plastic pellets are ready for reuse or be redesigned into new plastic products and finally injection moulded into Paver Blocks.

India's mission to reduce plastic waste:

It is every individual's duty to bring a positive change in this concern but with certain regulations provided by our government has to be considered.

Safe substitute – As the product has excellent bond ability as compared to currently employed materials so it can successfully substitute the ongoing materials also it comes with attractive quality and cost.

Growth impact – Considering economic growth is very important as it is an element of success for initiative. And will leads to increased growth scale.

New start up – This initiative we consider as an ideal for fresh and fruitful minds to enhance their potential in this concern.

Multiple Opportunities – Every single start up comes with bulk of opportunities to work and experience the real situation of market and industry and intensify the skills and experience

Sustainable development goals:

Economic growth - As the product has good market potential due to acceptable cost one can see economic growth in sector

Innovation in infrastructure - This initiative innovates a unique product which is one of its kind

Sustainable communities - as people are affording and accepting this product it can sustain in communities and market.

Responsible consumption - as the initiative is using existing scraps of plastics instead of virgin. It's a consuming in a responsible manner with all proper research.

Aqua life - recovered Plastic from ocean can also be employed in this product and product can be made.

Life on land - The dumped Plastics are collected from ecosystem and employed as material to create wellbeing of life on land.

Replication: Time is crucial and it's important to contribute and devote socially, economically and environmentally to plastic waste solutions. This initiative is based on waste plastic recycling into Paver Blocks. So the basic requirement for the replication will be the availability of a scrap plastic products in plenty and he types of machinery for further processing along with basic amenities. We need to do a better job collecting the waste, sorting it. The industry response was a little more combative. so that we can solve plastic pollution at an alarming rate and to secure future generations by replicating this initiative in major cities. This initiative can be replicated by Government Approvals and support. We have to create a network for collecting scrap plastic from the nearby areas. After collection, the next step will be segregation, grinding and finally scrap plastic is converted into flakes. These flakes are fed along with additives into an extrusion machine to obtain HDCP beads. The beads are then fed in an injection moulding machine to form paver blocks.

Thus to replicate this initiative, the basic requirements are: - Government approvals, Waste plastic collection network, additives, other inputs and types of machinery along with the land, electricity and other basic amenities. Awareness should be spread to encourage more usage of recycled paver blocks as this will remain intact for a longer period than the ordinary cement paver blocks. Government approvals is needed along with the support for spreading more awareness.

Uniqueness: There are certain influential uniqueness of this initiative.

Energy saving - As we all know majority of polymers are petroleum products so recovering existing ones is recovering energy.

Zero scrap generation - In this initiative there is zero scrap generation. In fact, the scrap is immediately employed in product.

Competitive in market - As this product has huge market potential, it is one of the key reasons for its success. Prevent carbon Emission- Carbon emission is also now-a-days a global challenge. It is a unique feature of the product.

Flexible product - This initiative is not limited to only tiles or some shape, the focus is on acceptable and potential quality so customisation is there as per needs.

Multiple time recyclability - the continuous evolution of research and improvements adds on value to the product and

its further recyclable. So it still has a potential to recover from the same.

Benefits:

Efficient Machinery will lead to energy saving and Energy saving is there as plastic is a petroleum product and we are recovering the value of plastic through this product. Research enables our initiative 3-4 times recyclable product with immense life cycle of 20-25 years. The Land or rental shed will lead to proper expansion in capacity as per the growth and budget. No virgin-plastics are used. Only existing scrap is recycled into affordable materials that lead to zero waste generation. Products manufactured has potential to replace existing ones due to low cost of production and affordable price. 575 tonnes of plastic is already recycled in 3 years so it comes up with greater start up and can create a Global impact. Once breakeven point is crossed this start up can create wealth as there's plenty of scrap-plastic available to recycle.

RESULTS AND DISCUSSION

To successfully run these initiative in a methodical manner and to make commitments, stakeholders and partnership will be required for financial and managerial support. Nowadays, the most municipal corporations are responsible for the Road construction, footpath, developing common plots, playgrounds and other public places. So for the replication, partnership or collaboration with Municipal Corporation will be required to market the product and grow the start up well. By accepting to recycling industrial waste, this initiative provides end-to-end and hassle-free industrial plastic waste management solutions. The bigger goal is to dispose and recycle plastic waste safely and be a part of Swatch Bharat Adhyayan in India. Other than government, collaboration can be done with bigger companies that promote plastic recycling such as Nestle, TATA motors, L'Oréal, Bisleri international, U flex ltd, etc. Helping the corporate sector by amplifying Corporate Social Responsibility activities, and adding eco-friendly value-added products like (HDCP) Paver Blocks

CONCLUSIONS

The plastic recycling industry is an unexplored market that has the potential to grow a lot in the coming years. This initiative is competing to expand cost effective architectural tiles and plastic free environments further redirecting the recycling dimension globally towards a different green revolution with the economical management option. As the used plastics are only utilised with some other fillers, they can safely substitute the concrete and hence impart great help in the economy. Also, increased life cycle of product at a cheaper cost is much competing in market and opportunity for new innovative startups to create a business is huge.

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Sadiya Zaveri

I am a student of Plastic engineering. I am looking forward to recycle plastic and to make something valuable from it. My goal is to recycle plastic waste which is on land and in the ocean. I am interested in an internship in the companies that promote such tasks along with the core fields like Production, Adhesive, Raw-materials of Polymer stream so I can learn and explore the possibilities of Polymer Science and composite field.

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Conversion of Non-Recyclable Plastic Waste into Synthetic Fuel: A Case Study

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ABSTRACT:

Disposal of non-recyclable plastic waste has become a challenge for cities. India generated more than 25000 tonnes of plastic waste daily, among other cities Delhi top the list with around 700 tonnes of plastic waste generation. In this case study, Rudra Environmental Solution (India) LTD is chosen for their innovative idea of disposing of non-recyclable plastic waste by converting it into useable fuel (synthetic oil) by thermo catalytic depolymerization (TCD) process, where the by-products produced as gas and char are also utilized to make the whole process environmentally friendly and energy-efficient. Synthetic oil showed closer physiochemical properties to petroleum products; thus, it may be used directly in kerosene stoves, boilers, furnaces, and certain types of gensets. However, gas produced during the conversion process is utilized within the process. Other by-products, char is collected and used for road construction giving more strength and longer life to roads. Further, the burning of synthetic oil generates very few emissions making it a cleaner source of fuel. The case study gives a successful idea for the disposal of non-recyclable plastic waste, and, such initiatives should also be practiced in other cities of India.

Keywords : Non-recyclable plastic, Thermo Catalytic Depolymerization, Synthetic oil, Residue char.

INTRODUCTION

India generates a huge amount of waste daily, among which most of the part belongs to plastics both recyclable and non-recyclable. Recyclable plastic may be collected and send back to the processing plant for recycling or reusing, while non-recyclable plastic is either burnt or used in landfills. Both the burning as well as landfilling process of disposing of non-recyclable plastic waste degrades the environment [1]. The burning of plastic pollutes the air by emitting toxic gases into the environment, whereas landfilling reduces the fertility of the soil, and the chemicals from plastic spill out to degrade groundwater reservoirs [2,3]. This way, plastic create serious health hazards to humans and animals as well (figure 1).

Figure 1: Examples of plastic entering the animal food chain

However, the crops planted in landfill sites require more chemical fertilizers due to reduced fertility of the soil, this, worsens the situation. To tackle this problem of non-recyclable plastic waste disposal, Rudra Environmental Solution (India) LTD has come up with a solution where non-recyclable plastic waste is used to produce synthetic oil, while by-products gases and char are also utilized to further minimize the waste disposal problem[1]. The estimated plastic generation by the top 10 cities of India is shown in figure 2.

Rudra Environmental Solution (India) LTD is an ISO 9001-2008 certified company established in 2009. Within one year of establishment, in 2010, the company has developed the first trial plant of 50 kg capacity, where conversion of 50 kg of non-recyclable plastic waste is done successfully. While second trial plant of 100 kg capacity is established in 2013. The plant converts non-recyclable plastic waste into synthetic oil and gases, where gases are consumed within the plant operation. While the solid residue, char is mixed with asphalt, and in road construction which provides more strength and improves the life of the roads. Other operational plants consist of plants with a daily capacity of 300 kg, and 500 kg in the Jejuri M.I.D.C.

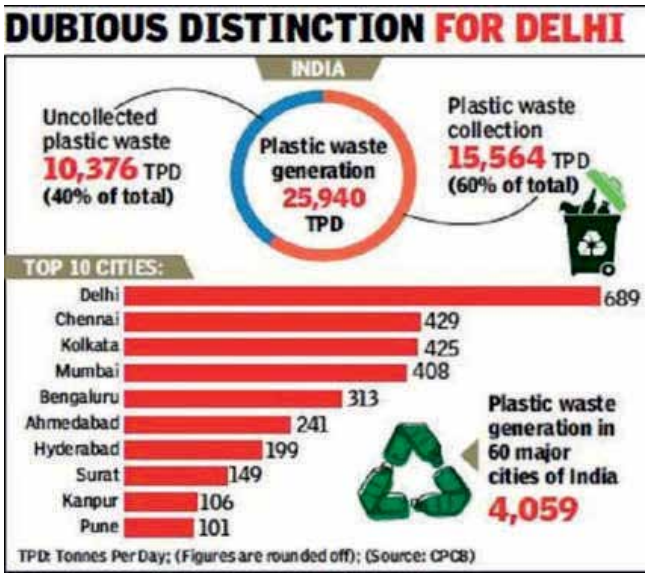

Figure 2: Plastic waste generation by top 10 cities in India[4]

area, Pune. However, the char is collected by Dow Packaging and Speciality Plastics, India and along with Pune Municipal Corporation, char is mixed with asphalt for road construction. The road with 30% of char showed drastic improvement in the road strength and road life is also enhanced. Thus, better roads may be constructed, while the asphalt usage will be reduced significantly.

EXPERIMENTAL TECHNIQUE

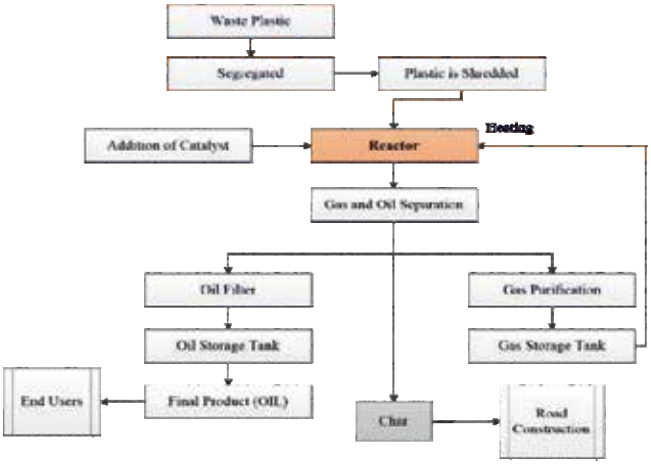

Figure 3: Process flow diagram of depolymerization process

The process flow diagram of the plant is shown in figure 3. Plastic is collected from over 30,000 households in Pune, and then segregated based upon recyclable plastic and non-recyclable plastics. Recyclable plastic is sent back to recycling plants. While, non-recyclable plastic is cleaned to remove the paper, oil, food partials, etc., and then shredded into tiny pieces to feed into the reactor. A catalyst is added into the reactor, it helps in cracking of long chains of polymers in the absence of oxygen to produce hydrocarbon vapours, and heating is done simultaneously. Initial heating is done by LPG or diesel. Plastic depolymerization requires a temperature between 380-430 , and the gases are condensed. It is a batch-type process and requires 3 to 7 hours for complete processing depending on the capacity of the reactor. Various chemical reactions are carried out inside the reactor, and the process is termed depolymerization. Since the process is thermal and catalyst is used, it is called Thermo Catalytic Depolymerization (TCD). In the TCD process, long chains of polymers are broken to convert into smaller chain compounds (useable fuel). Usable oil or synthetic oil is the desired product from the reactor, where the name synthetic oil is derived from the nature of origin. Synthetic oil is having properties closer to liquid petroleum products, and it may be used effectively as an alternative to kerosene. People in the slum have used synthetic oil as the fuel in stoves for cooking purposes, replacing kerosene. After cooking food, they found that no more black residues are deposited outside the cooking utensils by burning synthetic oil. This means that synthetic oil is a cleaner fuel. Whereas the gas produced during the process is passed through a scrubber and cleaned before using as the heating source in the depolymerization process, this significantly improved the efficiency of the plant. In contrast, the other by-product from the depolymerization of plastic is char. It has excellent properties in road construction, and currently, about 30% of the char is mixed with asphalt to construct roads by Pune Municipal Corporation.

RESULTS AND DISCUSSION

Plant Output

The depolymerization process is the reverse of the plastic production process, thus, non-recyclable plastic waste is converted into synthetic oil and gas, whereas the char left-out after extraction is used in road construction. Each ton of non-recyclable plastic produces about 55-70% synthetic oil (which is approximately 600-650 litre), 20-25% gas (which is used in the process), 5-10% moisture content, and 5-10% residue char. The properties of synthetic oil are closer to the petroleum products (as shown in table 1), and thus, it may be used directly in kerosene stoves, boilers, furnaces, and certain types of gensets.

Table 1: Properties of synthetic oil

TEST DESCRIPTION	UNIT	RESULTS	TEST METHOD
Total Acidity	mgKOH/g	7.31	IS 1448 (P 2) 2013
Ash Content	% by Wt.	Nil	IS 1448 (P 4) 2013
Cetane Index	-	51	ASTM D 4737 2016
Density at 15 °C	kg/m3	790.5	IS 1448 (P 32) 2013
Kinematic Viscosity at 40 °C	cSt	2.483	ASTM D 7042 2016
Flash Point (Abel)	deg C	< 30	IS 1448 (P 20) 2013
Total Sulphur	ppm	17	ASTM D 4294 2016 e1
Water Content	% by vol.	0.05	ASTM D 95 2013 e1

Gross Calorific Value	cal/g	10715	IS 1448 (P 6) 2013
Chlorine Content	ppm	12.72	ASTM D 4929

Thermo Catalytic Depolymerization (TCD) impacts

Following are the impacts of TCD processes:

- The plant has successfully processed plastic waste that is not easily recyclable including wrappers, other thin plastic, and residual plastic waste material from businesses and households.
- This will result in the diversion of waste plastic from the landfill and open burning to produce fuel with a lower carbon footprint.
- The fuel properties are closed to conventional petroleum products, and thus, may be used directly as a source for burning in kerosene stoves, boilers, furnaces, and certain types of gensets.
- It is an energy-efficient process with the utilization of all products from the plant and in this way harmless to the environment (or zero-emission process).
- The sulfur content in the synthetic oil is usually less than 18 ppm, and thus, may be used directly for burning without the need for further processing.
- Saves foreign exchange by adding into fuel economy
- Farmers may use synthetic fuels in pumping water from the tube well and fuel for Genset, thus help in developing the agriculture sector.
- Cost-effective compared to any petroleum fuel and does not require oil heating.
- Synthetic oil is better than furnace oil
- Helps in proper disposal of non-recyclable plastic waste, and in the process, generates employment.

CONCLUSIONS

The initiative started by Rudra Environmental Solution (India) LTD is one of the best ways of disposing of non-recyclable plastic waste. Here, the non-recyclable plastic waste is converted into usable fuel, while the by-products are either consumed into the reactor or used for some other process. This makes the whole process environmentally friendly and energy-efficient. Following are other outcomes:

- The depolymerization has a minimum environmental impact and generates very little emissions.
- The initiative helping Swachh Bharat Mission, thus, working towards a cleaner country.
- Diversion of plastic disposal helps in preserving landfill sites.
- The initiative helps in saving a considerable amount of foreign exchange, which is used for crude oil import.
- It will help in empowering rag-pickers/women for socio-economic benefits and economics & social upliftment of slum people.
- The initiative will help in a de-centralized approach to waste management.
- Long-term reduction of waste collection will help in the sustainability approach.

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Brief Biography of the authors

Mr. Neeraj Budhraja is a young and dynamic research scholar working in the field of renewable energy and IC engines. He has completed MTech in Renewable Energy Technology from Delhi Technological University, Delhi. Currently, he is pursuing a Doctoral degree in Hydrogen production techniques, and utilization in Fuel Cells and IC Engines. His interest areas are Hydrogen energy, Biofuels, IC engines, Environmental pollution reduction. He has actively participated in many workshops, seminars, and faculty development programs.

Mr. S. Lalhriatpuia is a research scholar actively indulging in the field of renewable energy and alternative fuels for IC engines. He completed his post-graduation (MTech) in Thermal Engineering from Delhi Technological University, Delhi. Currently, in his pursuance of a Ph.D., he is working on optimizing biogas production and its utilization on CI engines. His area of interest is Biofuels, alternative fuels in IC engines.

Mr. Pradeep Kumar Meena is pursuing a Ph.D. in Mechanical Engineering from Delhi Technological University. He did his MTech in Thermal Engineering from College of Engineering Pune in 2013 and completed his BE in Mechanical Engineering from Rajasthan University in 2008. He has 5 years of experience in the field of teaching and has published 7 national and international conference papers and 2 journal papers. His research area is the use of biogas in transportation applications.

PRESS RELEASE

Hyderabad, 14th April 2021.

BLEND COLOURS PVT. LTD.
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Blend Colours Launches the UHT Black Masterbatch, Redefines Milk Packaging

With product specifications validated in compliance with the proven and accepted ASTM standards, and Blend Colours being a well-accepted brand by the global markets, the UHT Masterbatch will help processors with its significant value proposition.

'Making in India' for the world! A statement well substantiated by the R&D team at Blend Colours with the successful launch of its UHT Masterbatch. This well validated product provides high grade of opacity and protection from UV degradation.

Benchmarked against the best-in-class specifications and performance globally, this product from Blend Colours is all set to make a big impact globally as well as capture a huge market locally. Saving significant foreign exchange, BLEND BLACK D441628 provides a huge advantage to the Indian dairy industry of global quality, at local price. With product specifications validated in compliance with the proven and accepted ASTM standards, and Blend Colours being a well-accepted brand by the global markets, the UHT Masterbatch will help processors with its significant value proposition.

This PE carrier resin comes with 40%±1% carbon content, no filler, excellent dispersion with heat stability at 280 - 300°C; well-suited for preservation of UHT processed milk with an unrefrigerated life of 6 - 9 months.

It is used with LLDPE, tie-layer as the second inner layer. Most suitable for 5-layer / 7-layer products, the barrier properties of this product contributes to a higher shelf-life.

No gel formation, suitability to be used on high-speed filling lines, high barrier properties and filterability, high opacity at less dosage and being recyclable are attributes that are fundamental to this product.

"With global markets to be the early adopters, we have made sure that the testing and certifications are done keeping in mind the requirements of perhaps the most stringent markets," shares Shailesh Lahoti, Director, Blend Colours Pvt. Ltd., and responsible for the company's export business.

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Remembering Shri N. Sitaram

Shri N. Sitaram, a renowned Educationalist, and Plastics Professional associated with IPI Bangalore Chapter now for several years.

Currently, he is the Chairman of the Education Committee of the Bangalore Chapter. He has played a pivotal role in launching & Establishing DIPI Course in Bangalore since 2005. He is also an elite member of the sincere initiative and relentless efforts have popularized DIPI Course in and around Bangalore City. As a professional, Shri Sitaram was associated with Kilachand and Devchand group for 36 years and retired as a General Manager (Marketing), South India.

His professional approach in completing the projects and assignments earned him recognition and accolade from his colleagues and Management as well. After his retirement, his name has become synonymous with DIPI in the academic circle. In recognition of his dedication to the educational activity of EP'I bestow upon the DI Fellowship.

We, the Indian Plastics Institute Members of Presidential Board, Members of Governing Council, and all IPI Members express our heartfelt condolences to the bereaved family members. May his noble soul rest in peace.

Pankaj Shah, *Chairman, GC, IPI*

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