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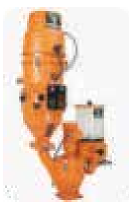			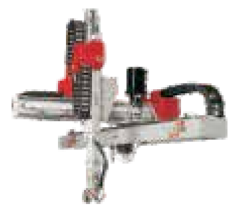

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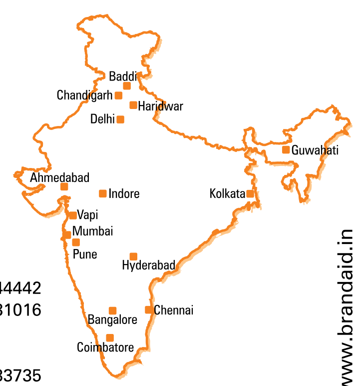

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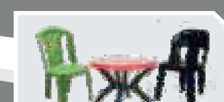
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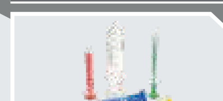
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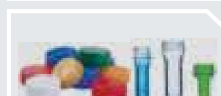
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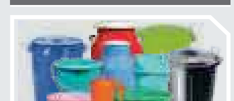
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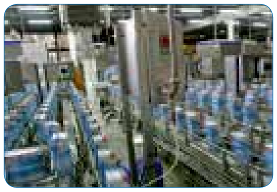

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Dear Friends,

Hope you all have being doing well. It has been a challenging time across the globe and as I write, we all hope things normalize soon.

The June – July is an special issue of IPI Journal covering Sustainability & Recycling in recognition of world environmental day. We have interview from Andrew Almack, CEO of Plastics for Change, where he speaks on scenario of recycling, applications and opportunities. This issue has also articles from students & professors of MIT University, Pune and Amritha University on the work they have been doing on recycled materials. While a lot has been said about Plastics, it also promotes sustainability of an important resource i.e. water and there is an interesting article on how plastics helps in sustainability and conservation of water.

We are also happy to share with you IPI is the first and only Indian entity to be a signatory to Ellen MacArthur Foundation : New Plastic Economy Global Commitment. Take this opportunity to thank Dr. Sameer Joshi, Secretary IPI for driving this initiative and his relentless passion on sustainability & recycling.

Happy Reading, take care and be safe.

Sriman

Sriman Banerjee
Chairman, Publication Committee

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Inside

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IPI partners THR Global Commitment to End Plastic Waste and Ocean Recovery Alliance – First organization from India to do so

The Global Commitment is led by the Ellen MacArthur Foundation, in collaboration with the UN Environment Program- UNEP. The Ellen MacArthur Foundation leads the engagement with the private sector (the business signatories and endorsers), and UNEP leads the engagement with the governments

The problem with plastic starts long before it reaches our oceans, rivers, and beaches, and so must the solutions. Through the Global Commitment, businesses and governments commit to change how we produce, use, and reuse plastic. They will work to eliminate the plastic items we don't need; innovate so all plastic we do need is designed to be safely reused, recycled, or composted; and circulate everything we use to keep it in the economy and out of the environment.

The Global Commitment has already mobilized over 450 signatories that are determined to start building a circular economy for plastic. These include companies representing 20% of all plastic packaging produced globally, some of which are well-known consumer businesses such as L'Oreal; MARS; Nestlé; PepsiCo; The Coca-Cola Company; and Unilever; the world's largest retailer - Wal-Mart; major packaging producers such as Amcor and Berry Global; and two of the largest resource management specialists - Veolia and Suez.

The Global Commitment and its vision for a circular economy for plastic are supported by the World Wide Fund for Nature (WWF), and have been endorsed by the World Economic Forum, The Consumer Goods Forum (a CEO-led organization representing some 450 retailers and manufacturers from 70 countries), and 40 universities, institutions and academics. More than 15 financial institutions with in excess of $2.5 trillion in assets under management have also endorsed the Global Commitment, and over $200 million has been pledged by five venture capital funds to create a circular economy for plastic.

The mission of Ocean Recovery Alliance is to reduce plastic pollution on land and water by creating strategic solutions for governments, industry and communities which lead to long-term, hands-on engaging business practices. The mission is achieved through purposefully designed programs to educate, build awareness and provide solutions which inspire positive societal change at the community, national and international levels.

This organization beings together new ways of thinking, technologies, creativity and collaborations in order to introduce innovative projects and initiatives that will help improve our ocean environment. This includes creating business opportunities for local communities when applicable, in order to address some of the pressing issues that our ocean faces today. Ocean Recovery Alliance is a registered non-profit organization in California, USA and is a registered charitable organization in Hong Kong.

Ocean Recovery Alliance takes a lead with a variety of existing stakeholders, leveraging each of their qualities and institutional capacities when needed, while combining forces with the business and technology sectors in ways that have not been done before. This includes the Plastic Disclosure Project, and the Global Alert platform. It has since written reports for the United Nations Environment (UNEP), "Valuing Plastic", and also the World Bank, and will publish another with UNEP ion global plastic pollution commitments.

This organization has partnered IPI to do work in India

https://www.oceanrecov.org/about/collaborating-partners/duplicate-of-how-can-you-help.html

Leader's Speak

Andrew Almack

CEO, Plastic for Change.

Andrew is passionate about supporting sustainable livelihoods and reducing plastic pollution. Andrew has co-founded three award winning social enterprises in the field of waste management. He has worked in slums of South America, India and Indonesia to strengthen the informal recycling economy.

As the CEO of Plastics for Change his current work is focused on applying mobile technology to create ethical recycling supply chains for the urban poor in developing regions, while catalyzing the industry to make a profitable transition towards to use of recycled plastic.

How did the initiative Plastics for change come into being and motivation for the same?

(Andrew Almack) My journey started with a trip to Cambodia in 2011. I was overwhelmed by the extreme poverty in the region and the audacious levels of plastic pollution. This experience inspired me to understand the economics of an "eco label" which could represent ethically sourced recycled plastic, ultimately helping to reduce plastic pollution and poverty. I started Plastics for Change in 2015 with the goal of bringing recycling infrastructure to developing regions and creating sustainable livelihoods.

My entire career has been focused on reducing plastic pollution and creating livelihoods for marginalised communities through plastic collection/segregation. I've worked in the slums of South America, India and Indonesia to strengthen the informal recycling economy. Over the last few years, at Plastics for Change we have been able to successfully find high value markets for recycled plastic and are currently contracted to provide consistent supply of various recycled resin streams for global billion dollar brands.

Hear Andrew's story:
https://www.youtube.com/watch?v=ftigc4uyImI

What is the market size for recycled polymer material and future growth opportunities?

The recycled polymer industry has the potential to transform a 500 billion dollar global plastics industry while improving the lives of millions of waste pickers.

Currently only 5% of the formal manufacturers in India source recycled plastic. It is difficult for them to obtain recycled plastic because of the following factors: 1) quality standards 2) consistent supply 3) the competitive price of virgin plastic. The Plastics for Change platform is designed to break down these barriers and help companies source recycled plastic ethically.

The global recycled plastics market was valued at USD 34,804.1 million in 2016 and is projected to reach USD 50,356.1 million by 2022, at a CAGR of 6.4% during the forecast period.

The market is witnessing growth due to a growing preference for recycled plastics over virgin plastics as a result of severe pollution caused by the disposal of used plastics in oceans and the scarcity of landfill areas in many countries. Factors such as increasing use of recycled plastics in many new applications in the packaging, automotive and the electrical & electronics industry and many favorable initiatives promoting the use of recycled plastics worldwide offer lucrative opportunities for the growth of the recycled plastics market. The ban on import of certain waste plastic scraps to China and irregular collection of the waste plastics for its reprocessing are some of the factors challenging the growth of the global recycled plastics market globally.

How difficult or easy it is to get plastic waste for recycling in India and globally?

The recycled plastics market is highly dependent on the proper collection of its raw materials, i.e. the plastic wastes or scraps. Globally, only 14% of the plastic packaging are recycled. The rest of it ends up in the oceans each year, indirectly causing harm to the aquatic biodiversity. Recycling of the remaining 86% of used plastics could create a huge revenue of around USD 80-120 billion as per Ellen MacArthur Foundation. But realization of this revenue cannot be expected without designing new methods. It is necessary to devise new ways as breakdown and reuse of the plastic packaging that are not recycled is extremely difficult, because the material is either contaminated with multiple materials with very little scope for separation, too small for collection, or has very low economic value. Thus, this industry which could have a huge growth, is sometimes limited as collection of the raw materials is not very easy.

Some of the challenges of sourcing from emerging economies like India firstly, is that the waste management sector is highly informal. These economies are also highly dysfunctional with inefficient supply chains and typically use crude technology that down-cycles the recycled material. This makes it difficult for the brands to source supplies of high quality recycled plastic.

Secondly, as the system is informal, the existing supply chain is not able to meet consistent volume and consistency quality as per requirement of global brands.

Thirdly, the informal recycling supply chain in developing countries is a very exploitative system. The waste pickers at the base of the supply chain face numerous challenges when trying to access fair market prices for the discarded plastics they collect. They have multiple barriers to formal employment so when they are unable to make a living from recycling as there is often no other safety net to sustain their families.

Plastics For Change has FOUR main value propositions that make it easy for brands and manufacturers to use recycled plastic by breaking down all of the above barriers.

- Price: Plastics For Change prices the material to be cost-competitive as per industry standards and stacks on additional value for brands by providing go-to-market strategies in engaging with their customers.
- Consistency: Plastics For Change develops a unique SOP for each plastic stream as per the desired spec of the brand. This is then deployed to various collection partners in our portfolio across the country to ensure the partner is following the same SOP's. This ensures that the material is segregated consistently.
- Quality - Plastics For Change has full transparency in the supply chain to ensure the correct QA and QC processes have been adhered to. PFC field workers are deployed to each collection centre to complete lot-by-lot inspection.
- Responsible Supply Chains - Plastics For Change's supply chains are verified by the WFTO (World Fair Trade Organisation). We are the first supplier of fair trade plastic globally.

Can you shed light on some of the applications and innovations using recycled materials?

Some of the key innovations that Plastics for Change has been involved in -

- We have developed virgin equivalent recycled material for the majority of the waste stream, including food-grade PET, recycled LDPE, recycled HDPE bottles, Reach + Rohs compliant rPP, Polyester filament and other types of recycled plastics. Currently these are being used for applications in the Cosmetic, Homecare and Food & Beverage industries.
- Alternate construction material by creating plastic lumbar bricks and panels through single use and multi use packets. The application for this has been to create low cost homes for waste-pickers.

Given the Covid 19 crisis do you see any changes in waste management and recycling?

Versatile and affordable, plastics have been essential to keeping hospitals running and protecting our frontline workers during the COVID-19 pandemic. They're the bedrock of medical equipment and protective gear. They're even at the heart of innovative cross-industry collaborations to combat the virus; the luxury auto brand Ferrari, for instance, announced it will produce the thermoplastic components needed for respiratory valves, while Apple designed plastic face shields for medical professionals and is shipping millions of them across the United States every week. As demand skyrockets for masks, gloves, gowns and disposable bags, one thing is clear: plastics are indispensable, especially during a pandemic.

The devastating impact of COVID-19 and the extraordinary measures taken around the world have led to some tough questions for those working to combat plastic pollution. How do we support those in our community hit hardest by the outbreak? Can the recycling industry survive COVID-19?

Informal sector waste pickers have long worked on the frontlines of efforts to keep cities and villages free from waste and litter. In India, for instance, the informal sector is the backbone of plastic waste management, collecting 1 million tonnes of plastic waste per year. Yet with a general lack of job security or health benefits, waste pickers are also facing unprecedented threats to their safety and their livelihoods. Governments and businesses must explicitly and thoughtfully build support for waste pickers into their COVID-19 responses, by supplying them with personal protective equipment, connecting them with food and community resources and ensuring access to formal healthcare systems.

Plummeting oil prices globally have led to a dramatic decrease in the value of plastics, and companies are making tough decisions about whether recycling is still an economically viable option. This means many consumer brands, such as beverage companies, could have difficulty meeting previous commitments to adopt more sustainable practices and replace all or portions of their products with recycled plastic. As a result, we could see companies increasingly return to producing virgin, or new, plastic – adding to the unsustainable levels of plastic production and mismanaged waste we were already seeing before the pandemic.

What can we do better in terms of recycling and sustainability?

We stand at the junction of two diverging paths. One is a stop-gap solution that puts us solidly on track toward a not-so-distant future in which there is more plastic in the ocean than fish. The other is a sustainable model of living and working that will benefit us long into the future – one that will create a healthier, more equitable and more livable future for all.

- As consumers we need to embrace and help popularize the concept of the circular economy for plastics – which keeps plastic waste out of our waterways, our oceans and our environment through the principle of Reduce, Reuse and Recycle. Responsibly discard disposable products like masks and gloves through formal waste collection systems, rather than littering or leaving them in public places.
- As brands and businesses, we need to uphold commitments to reduce plastic waste, and not to lose sight of longer-term sustainability targets.
- Continue to invest in new technology, R&D and innovative financial models in the recycling sector to make it cost-competitive for brands to transition to use of recycled material.

The influence of COVID-19 on Recycling

Monique Maissan

Founder and CEO of Waste2wear, a company focused on making textile products from Recycled Plastics.

The COVID-19 virus has changed the way we are working, studying, sporting, eating, and all kinds of other things we were previously doing. In short; it has changed the way we are living. Habits have changed, many for good but some unfortunately for worse.

The path of reducing waste, that a large part of the world was on, has been put on hold, and its course has been altered. The question is though: what are we going to do moving forward?

COVID has been a challenging time for the environment. How do we minimize the use of packaging in a world where we are ordering more and more online? How do we comply with mask-wearing obligations without harming our environment? How do we reduce waste in a world where medical waste has increased 5-fold compared to similar periods pre-COVID?

Increasing the amount of single-use plastic and reducing the operating hours of waste management organizations, is counter-intuitive. On top of it, the incentive for using recycled materials has become even more challenging with record low oil prices to compete with.

We have to be aware of the impact some of our changed habits are having on our environment. It has never been more vital to be increasingly mindful about the environment and the need to improve our ways.

What exactly happened that created this situation?

Due to the pandemic, the concerns about safety and cross-contamination has caused a sizeable global increase in single-use plastics. In the last few months, The US has withdrawn the single-use plastic ban which has resulted in a heightened demand for bottled water, plastic bags, packaging, and PPE. Several governments around the globe have been reconsidering the overall plastic waste regulations/management amid the COVID-19 pandemic.

In India, Tamil Nadu has revoked bans of single-use plastic bottles and bags in retail trade. The UK has suspended the plastic bag charge for online deliveries and Scotland is delaying the introduction of a packaging deposit-return scheme.

Some fast-food chains, including Starbucks and Tim Horton's, have banned the use of reusable cups and food containers. A few states in the United States presently have "bottle bills", or mandatory container buyback programs. Currently, eight out of ten US states have temporarily terminated enforcements that require retailers to participate in these container redemption programs. Some states have banned reusable bags during the outbreak and ordered retail stores to use single-use paper or plastic bags. Many grocery stores across Canada are now not allowing reusable bags into their stores. Since March 2020, shops are not charging for bags used in online grocery deliveries in England, which is expected to continue until September 2020 and The European Plastics Converters, a trade association, has even called for the EU legislation on the reduction of single-use plastic to be put back a year because of COVID-19.

The pandemic has seen exponential growth in the amount of infectious, medical, and household waste, generated by hospitals, health centers as well as care homes, and medicalized facilities; i-e;- homes & hotels.

Online ordering has increased worldwide and has gravely contributed to the deteriorating waste situation in the world. In Hong Kong, people have used 2.2 times more throw-away plastics related to takeout packages since the outbreak, compared with the same time period last year, China has not released detailed data on plastic waste caused by more home deliveries but the deliveries were up by a quarter in March, April, and May. In Thailand, the volume of household waste (particularly plastic waste), has risen 15 percent due to 3 times as many food deliveries a day nationwide (TEI).

Waste among residential homes has spiked by as much as 40 percent in some parts of the USA, as Americans have been staying home and generating more trash and recyclables. In as many as 80 communities nationwide temporary suspensions in curbside recycling or yard waste collections have been reported. Extended city lockdowns in many of the main recycling countries in Asia (such as Malaysia, Vietnam, and India), in combination with the social distancing restrictions, have resulted in only 30 percent of recyclers continuing operations.

The increase of waste due to new items such as disposable masks and gloves are causing enormous amounts of damage to the environment. Face masks are generally made from a few layers of different types of polypropylene (PP). This makes the total product more difficult to recycle. PP in thin form has the tendency to deteriorate into very small pieces quickly when wrongly disposed of and exposed to the elements. However, apart from very thin pieces, it does not deteriorate until or unless exposed to high temperature, or intensive UV rays.

Before the pandemic, only 15 percent of hospital waste material around the world was considered dangerous: 10 percent was contagious, and 5 percent was harmful because of its chemical or radioactive properties, according to World Health Organization (WHO) figures from 2018.

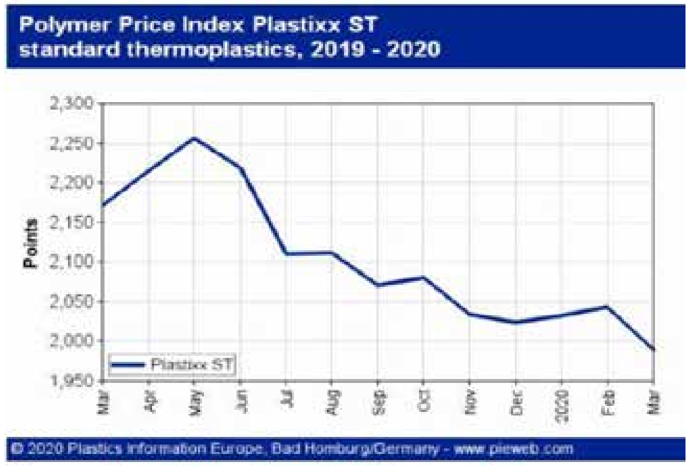
Due to the fact that COVID-19 is a new disease. There are deficient standard operating procedures, insufficient resources, and employee training on how to handle, manage, and dispose of the virus. Coupled with the complexities around balancing patient safety, cost, and sustainability has resulted in more materials being managed through traditional waste processes (incineration and landfill) than being recycled.

In an industry that was already overwhelmed with challenges, materials that would normally find its way to recyclers were being channeled directly as solid waste to landfills and incinerators out of an abundance of caution. In many countries, the dumping into landfills has increased significantly as there was no manual sorting of the mixed waste, and even in countries with great recovery capabilities such as Italy (83 percent), they prioritized burning waste as health authorities banned opening plastic bags and any kind of non-mechanical filtering.

In Madrid and Catalonia, Spain's two most-affected regions, healthcare waste has increased by 300-350 percent, respectively. Hospitals in Wuhan, China, were generating six times as much medical waste at the peak of the outbreak as they did before the crisis began.

Waste management experts warned that "If waste is incinerated inadequately, this can cause the release of pollutants into the air, such as human carcinogens that have been associated with a range of adverse health effects".

According to a WWF report, "if just 1 percent of the masks were disposed of incorrectly and dispersed in nature, this would result in as many as 10 million masks per month polluting the environment. A disposable mask has life span of roughly 450 years. Considering that the weight of each mask is about 4 grams, this results in the dispersion of more than 40 thousand kg of plastic in nature."



(Source: https://plasticker.de/index_en.php)

Besides the reduction of recycling due to medical and managerial reasons, another factor influencing the reduction is the enormous drop in the oil prices. This subsequently depleted the value of recycled commodities relative to new materials, and without government mandates that require minimum recycled content in products, producing virgin plastic in processes using oil as a feedstock has now became far cheaper.

It has to be mentioned that as residential waste has risen, commercial waste has been falling enormously, tumbling because of closures of non-essential businesses and stay-at-home guidelines. Filco Carting, a big US waste Management Company, has seen commercial waste drop by 50% since the pandemic hit. There is however not enough data available to establish if this can significantly offset the increase of household and medical waste.

Even as countries are about to open, and infection rates have dropped in most parts of the world, the need for masks and other PPE due to the virus will stay. There are many actions to be taken from lessons learnt so far, and there will be many more to come, but what we do now will define the future of our environment.

Will governments work on increasing recycling of these products by improving the collection of the PPE materials?

Many of these items are packaging for food and drink and most were designed to be used only once ("single-use plastics"). That's a waste of valuable resources.

In Wuhan, China, they have put out special bins for mask collection and were collecting about 200-300kg of discarded face masks per day from an specific area which is the home of more than 400,000 people alone in Wuhan city. This is a step in the right direction. Will governments return back on the path of bans of single-use plastic, on encouraging the use of reusable bags and drink-containers?

Will we, ourselves, as individuals, contribute to a reduction by using washable and reusable facemasks? Will we even buy them made from a mix of recycled materials if we have a chance? (thus, reducing more waste in the process)

Waste2wear collection of solid and printed face masks made from a mix of recycled polyester and cotton. (Waste2Wear, 2020)

Are we as individuals going to become more mindful in reducing the online ordering of goods we came accustomed to?

Are companies going to allow us to use our own drink containers and reusable bags again soon? Will companies increase the use of green and recycled materials? Are we going to be seeing more recycled content in worker uniforms, garments, and bag collections? Are we going to be seeing, more recycled content in upholstery and curtain collections? And are we, as individuals going to choose those options over the virgin ones, even though the current price is a bit higher due to the low oil prices? Are we going to consume less, but more conscious and mindful? Are we actively going to flatten this curve of increased waste due to COVID-19?

The answer to all of this can and should only be YES!

The environment was already in a very dire situation before COVID, with ocean plastic and marine litter challenging our oceans. If we do not do it for ourselves, we have to do it for our children and for our children's children. Our environment does not differentiate by choice of politics, religion, and beliefs, it does not discriminate by the color of skin or country of origin. It is there for every living creature on this planet, and we should all be doing our part to protect it.

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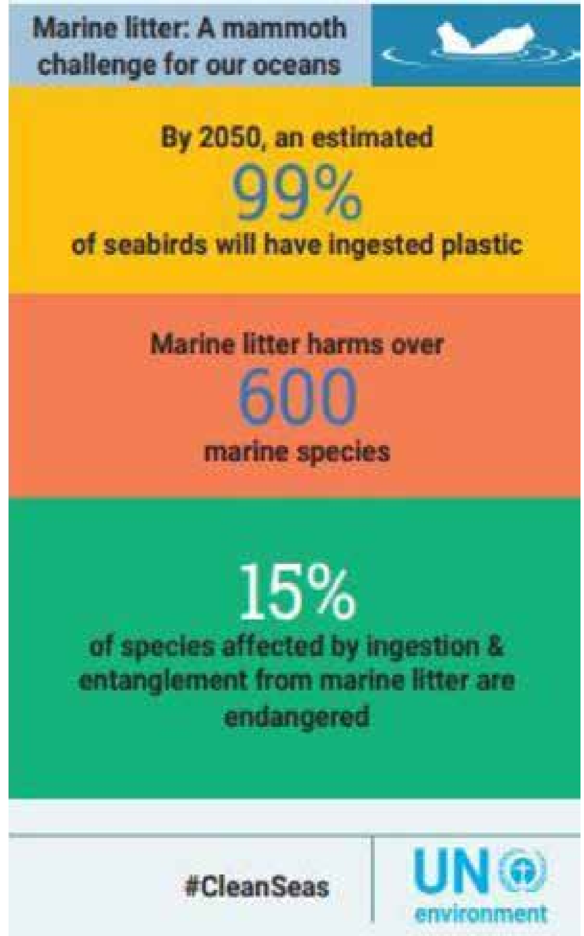

References

https://www.planetcustodian.com/plastic-waste-increasing-amid-coronavirus/14232/

https://blogs.platts.com/2020/04/01/coronavirus-us-plastics-recycling-collections/

https://www.euronews.com/2020/05/12/will-plastic-pollution-get-worse-after-the-covid-19-pandemic

https://www.scmp.com/news/china/society/article/3065049/coronavirus-china-struggling-deal-mountain-medical-waste-created

https://www.forbes.com/sites/thebakersinstitute/2020/04/14/pandemic-plastics-and-the-continuing-quest-for-sustainability/#5da7499477b4

https://www.euractiv.com/section/coronavirus/news/coronavirus-waste-burn-it-or-dump-it/

https://www.cnbc.com/2020/05/16/coronavirus-sanitation-workers-battle-higher-waste-levels.html

https://plasticker.de/preise/marktbericht3_en.php?id=203wwwww

https://resource-recycling.com/plastics/2020/05/06/low-virgin-plastics-pricing-pinches-recycling-market-further/

https://www.nytimes.com/2020/03/26/climate/plastic-bag-ban-virus.html

https://www.weforum.org/agenda/2020/04/plastic-packaging-coronavirus-crisis

https://blogs.platts.com/2020/04/01/coronavirus-us-plastics-recycling-collections/

https://www.azom.com/article.aspx?ArticleID=7899#:~:text=PP%20products%20degrade%20very%20slowly,toxins%20including%20cadmium%20and%20lead.

Paper using Polymer Adhesive to Provide Sustainable Solution

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Abstract

This discussion paper aims at discussing the concept of sustainability and the potential possible methods to implement the same in various industries. With increasing demands from the consumer base coupled with global reforms imposing compulsory sustainability regulations, various alternatives are being proposed and considered, that work with the concept of circular economy or aim at gradually eradicating potentially harmful substances altogether. One of the sustainability topics we want to cover in this discussion paper focuses on single use plastics and the reasons behind its dominance, the economic implications of manufacturing, utilizing or replacing single use plastics, their physical properties, potential sustainable alternatives (Plastic to Paper) and their feasibility. To make use of paper in the manner of plastic, polymer coating is done on the paper to increase water resistance, oil resistance and can act as a potential replacement for plastic. Also, polymer adhesive is used to bond paper to make paper straws, cups pouches etc. which can give good water resistance. Polymer coating and adhesive makes paper as an alternative, compostable and recyclable hence a sustainable solution.

1. Introduction

With industries growing at an exponential rate, the resources being depleted, usage of substances that are detrimental to the environment and the subsequent consequences are also being reflected exponentially. With reference to the present context, plastics are made from a range of molecular chains called polymers, which accommodate a wide variety of properties and can be highly customised to meet each manufacturer's specific requirements. However, most plastic models like straws and cups are manufactured from multiple materials, adhesives and coatings that cannot be easily separated and recycled.

Single use plastics, as the name suggests, is a disposable plastic that is to be discarded after being used once. These variety of plastics are primarily employed for the manufacture of cups, straws, food pouches etc. among many others.

To overcome this, organizations globally have invested in technical teams and procedures that strive towards developing robust design guidelines for polymer alternates, adhesives manufacturing, adjacencies, application procedures and sustainability factors, green plastic alternatives and the efficient construction of environmentally sensitive infrastructure to collect, sort and recycle.

2. Logical deductions from analysis of Case Studies

2.1 Plastics Dilemma

Plastics are unique. Due to its low cost, versatility, durability and high strength-weight ratio, plastic is most used in packaging. Plastic protects vulnerable products and preserves our food, but packaging which are largely single-use, and after its intended useful life of typically less than a year, it is discarded. Around 95% of the value of plastic is lost into the environment, with estimates of around 8 million tons leaking into oceans every year.

Awareness has tremendously increased due to Digital technology and with high profile campaigns on environment impacts having far reaching engagements and solutions. One example to share is, a video of a sea turtle having a plastic straw removed from its nostril - which has clocked up 33 million views on YouTube hit public consciousness. From a yearly production of approximately 311 million tons in 2014, plastic packaging production is projected to reach about 1,124 million tons by 2050[1].

Now, majority of the Countries have introduced bans and levies to curb single-use plastic waste.

India is taking many responsible steps working closely between Government, Industry and across the End to End Value chain stakeholders, influencers to develop solutions ensuring a paradigm shift in thinking and execution. Indeed, big credit to all partners working on this agenda. In addition, in EU, France made an aim, commitment to work recycle 100% of all plastics by 2025; Kenya imposed a major fine, penalty for producing, selling or using plastic bags; and the EU has proposed a ban on single-use plastics including straws and plastic-stemmed cotton buds. Major Corporations are committed to reduce their use of plastic packaging.

2.2 Creating a circular economy for plastics

Plastics seem to possess opinions spread across a spectrum ranging from a material of the gods to a material that must be eradicated off the face of this planet. Primarily, due to increased awareness and evolving environmental regulations, the view these days tends to be shifting towards the negative side. Circular economy is restorative and regenerative by design. This means materials constantly flow around a 'closed loop' system, rather than being used once and then discarded. Building on the above, this means simultaneously keeping the value of plastics in the economy, without leakage into the natural environment.[2] But this is easier said than done as we know.

- 14% of the plastic packaging used globally is recycled.
- 40% ends up in landfill and
- 32% in ecosystems.
- Remaining 14% used for incineration or energy recovery

Improved functioning infrastructure for recycled plastics is one of the biggest barriers facing a circular plastics economy, presenting a challenge to improving global recycling rates. Producers of plastics and packaging are getting now highly focused when they design products keeping end-of-life needs in mind throughout product development processes.[2]

2.3 Minimize the lifestyle impacts of plastic

Innovative alternatives, when used appropriately, can play a significant role in reducing our need for plastics. The present scenario has seen various alternatives being proposed and tested which are either 'bio-based' (made from plant material), 'biodegradable' (broken down by biological organisms) or 'compostable' (broken down by home composting.) This also significantly reduces our dependence on fossil fuels.[3]

It is important however, to note the need to thoroughly evaluate potential alternatives on the basis of many factors including durability, practicality, suitability to the industry, and compliance with safety regulations, environmental footprint and overall net benefits.

2.4 Collaboration and Consumer efforts

After distribution and sales, the handling and streamlined disposal of plastic waste primarily lies in the hands of the consumer. Products with plastic components range from a variety of industries from healthcare to food and beverage, each catering to varying demographic trends. Industries in charge of disposal of plastic are putting good plans to efficiently collect plastic waste from the consumers. However, a lot of factors needs to be considered to effectively devise a collection strategy.

Also, due to social media and technological advances, a good percentage of the society is aware of the environmental implications and are acting responsibly using plastic. The rewards can be tailored according to societal, cultural or other factors. Convenient drop points for waste can be devised thus making it easier for people to contribute towards the cause. Collection and distribution can also be handled by local industries.

3. PLASTICS TO PAPER: Potential option to explore for discussion

While circular economy is certainly a balanced solution, various alternatives to plastics are also being explored. This is where research, industry collaboration, consumer involvement and experimentation come in. While a wide array of options is being studied, the scope of this paper covers a popular alternative material being considered in the place of plastic - paper as potential option to be explored where realistically possible.

3.1 General overview

This discussion paper for inputs is going to be covering the general benefits of transitioning to paper from plastic. Paper starting advantage is having a considerably short decomposition time. Plastic packaging can have a lifespan up to 500 years, depending on type of plastic, before it is fully decomposed. During that time, the plastic packaging product will break down into smaller pieces that cause problems for its surrounding environment[4] in the form of littering (land and ocean), greenhouse gas emissions and danger to the health and safety of animal and plant life.

On the other hand, products made from virgin kraft paper or recycled fiber (85%), for the purpose of testing fully dissolved in roughly 6 months[5]. The dissolved paper is microscopic in nature subsequently becoming a part of sediment or being ingested by animals. Furthermore, paper is not known to have any harmful impacts on animal life or the ecosystem. Paper products also have added benefits post their lifespan as paper and pulp industries primarily use renewable feedstock.

3.2 Straws

Straws provide a simple solution for drinking beverages conveniently. While straws may seem like a recent addition to society, they have, in fact existed for centuries. While not just a mere object of convenience, straws also help people with special needs get along with their life with relative comfort. The earliest evidence of straw use was found in a Sumerian tomb dating back to 3000 B.C. The tomb seal showed two men drinking a beer from a jar using a tube made of gold [6]. Fast forward to the 1800, straws were more part of the beverage themselves than a convenient drinking aid, with the straw being made of ryegrass, a biodegradable material which tended to alter the flavour and disintegrate into the drink.

As time passed, straws began to be viewed as convenient drinking aids and became a staple in most countries with regards to beverage distribution. Due to exposure to liquid, industries sought out a durable material that withstood the effects of a variety of beverages while not being harmful to the consumer. Plastic is still a wonderful solution due to its cost, mouldable nature, durability and inert properties.

In present day, the world produces more than 400 million tons of plastics every year, and 36% is destined for single-use materials, such as packaging, which in turn generates 300 million tons of waste (UNEP 2018). Of that amount, only 9% is recycled, 12% is incinerated, and the remaining 79% accumulates in landfills and dumps or is littered in the environment, with half of this amount coming from packaging waste[7].

Various alternatives such as select metals were considered but as with anything, they come with their set of disadvantages. Metal straws proved to be dangerous due to them being rather sharp presenting more chances of injury and in some cases, fatalities if not handled with care.

3.3 Paper Straws

Heads are once again turning towards paper as an alternative, with great research on how and if paper brings anything new to the game.

The components that go into the assembly of paper products, such as adhesive coatings etc. can themselves be more environmentally friendly when compared to their plastic counterparts. A great research initiative can serve as an example for the same, which uses a paper straw with a developed adhesive solution, although a plastic, but is more sustainable in nature.

Waterborne adhesives are very popular and are conceived as an environmentally friendly and economically viable alternative to solvent-based adhesives. For this class of adhesives a wide variety of polymers are used (usually thermoplastics and/or elastomers), which are either dispersed or dissolved in the continuous aqueous phase. Waterborne adhesives are usually wet bonding and, therefore, at least one of the substrates has to be water permeable to allow water to escape from the bondline. This explains why these adhesive are widely used for bonding wood, paper, textiles, leather and other porous substrates[8].

Typically, different types of Ethylene Vinyl Acetate (EVA) polymer and polyvinyl alcohol (PVOH) at different hydrolysis constants and viscosities are used to prepare the adhesive. Ethylene-vinyl acetate copolymers (EVA), containing from 25 to 50% vinyl acetate, are used in adhesives. The vinyl acetate contributes tack, solubility, improved adhesion to polar surfaces and low temperature flexibility [9]. Poly vinyl alcohol on the other hand is readily biodegradable and water soluble. Its main degradation method is disintegration in water which is influenced by its crystallinity and molecular weight.

Strictly restricted to straws, the application calls for good bonding and water resistance. Research on a suitable formulation is in place and widely progressed based on many factors such as solid, viscosity, drying time, wet tack.

All the material suggested are as per FDA guideline. Hence this is safe option to replace existing straw. By this we can provide compostable and recyclable solution which can prevent environment pollution.

4. Analysis and conclusion

Paper straws using water based polymer adhesive come with obvious environmental benefits. They break down in the ocean in 30-60 days unlike plastic, so they won't harm the environment or wildlife. They are also compostable and take a matter of months to break down into microscopic particles subsequently forming sediment. They are also rather affordable making them more accessible to a larger fraction of the society. Businesses can now buy paper straws in bulk for a competitive price.

Paper alternatives also come with their own share of downsides. For one, the primary factor of durability comes into question. Paper straws experience weight gain almost immediately after exposure to liquids and gain weights of 30% to 50% within 60 min. Plastic straws are generally stronger than paper straws in the dry state and do not gain weight when immersed in fluids. Plastic straws also do not display any decrease in mechanical properties upon immersion in liquids[10]. Plastic are made of petroleum by-products, meaning they are made from materials that have already been extracted and processed for other purposes. In contrast, paper bags must be made from fresh raw materials which can translate if not being careful to potential deforestation and habitat damage[11].

This is a rather broad topic with multiple variables that need to be considered. If paper as an alternative is truly to be considered, various grades and forms of paper are to be tested against traditionally opted forms of plastics being commercially used. Furthermore, indirect factors such as transportation, manufacturing facilities, net costs among various others are to be considered.

Research of a binary nature is impossible, and a multitude of combinations need to be tested followed by a collective analysis to ascertain the feasibility of this potential transition.

References

[1] World Economic Forum, Ellen Macarthur Foundation & Mckinsey & Company 2016. The New Plastics Economy - Rethinking the future of plastics.

[2] Nicola Ledsham, 12 Nov 2018, 'Creating a Circular Economy for Plastics', accessed 13th May 2020, < https://sustainability.com/our-work/insights/creating-a-circular-economy-for-plastics/>

[3] Nicola Ledsham, 26 Nov 2018, 'Innovating to Minimise the Lifecycle Impacts of Plastic', accessed 13th May 2020, < https://sustainability.com/our-work/insights/innovating-to-minimise-the-lifecycle-impacts-of-plastic/>

[4] MCILGORM, A., CAMPBELL, H. F. & RULE, M. J. 2008.

Understanding the economic benefits and costs of controlling marine debris in the APEC region. APEC and UNEP

[5] DAHLGREN, L., STRIPPLE, H. & OLIVEIRA, F. 2015. Life cycle assessment - Comparative study of virgin fibre based packaging products with competing plastic materials. Stockholm, Sweden: IVL Swedish Environmental Research Institute Ltd

[6] Thompson, D. (2011). 'The amazing history and the strange invention of the bendy straw,' The Atlantic, accessed 14th May 2020, <https://www.theatlantic.com/business/archive/2011/11/the- amazing-history-and-the-strange-invention-of-the-bendy-straw/248923/>

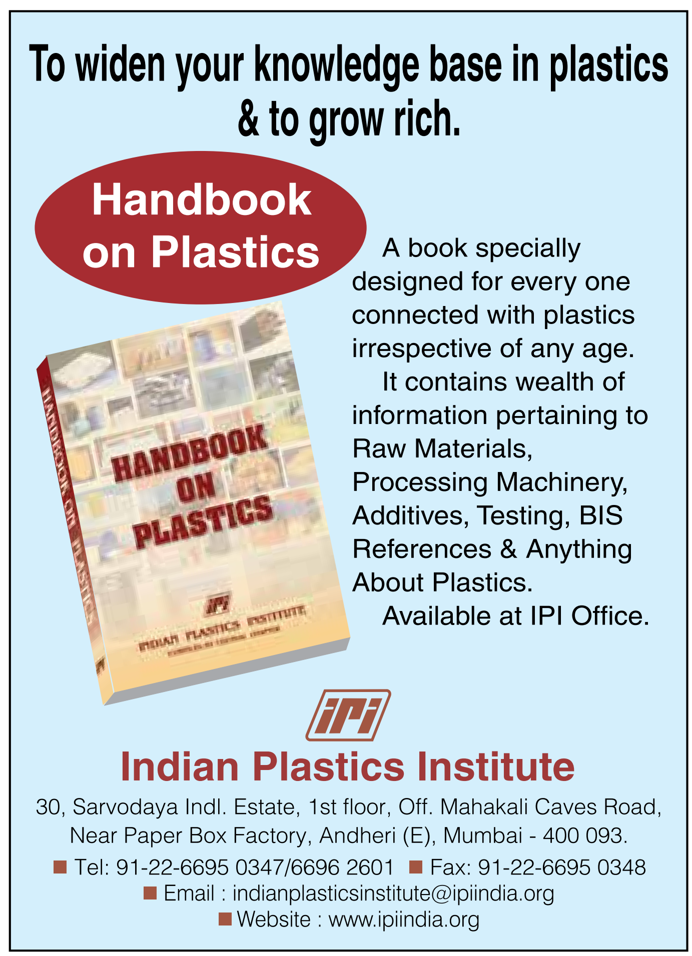
[7] Geyer, R., Jambeck, J. R., and Law, K. L. (2017). "Production, use, and fate of all plastics ever made," Science Advances 3(7), 25-29. DOI: 10.1126/sciadv.1700782

[8] WATERBORNE ADHESIVES AND SEALANTS, accessed 21st May 2020, <https://polymerdatabase.com/Adhesives/WB%20Adhesives.html>

[9] Hubert J. Fabris, Wolfgang G. Knauss, in Comprehensive Polymer Science and Supplements, 1989

[10] Joseph Gutierrez, Aidan W. Royals, Hasan Jameel, Richard Venditti, September 2019, 'Evaluation of Paper Straws versus Plastic Straws: Development of a Methodology for Testing and Understanding Challenges for Paper Straws', accessed 14th May 2020, <https://www.researchgate.net/publication/335611652_Evaluation_of_Paper_Straws_versus_Plastic_Straws_Development_of_a_Methodology_for_Testing_and_Understanding_Challenges_for_Paper_Straws>

[11] Allie Molinaro, June 25 2018, 'Paper or Plastic? Why the Answer Should be "Neither', accessed 14th May 2020, <https://www.cleanwateraction.org/2018/06/25/paper-or-plastic-why-answer-should-be-%E2%80%9Cneither%E2%80%9D>



Journey of Plastics from "Wonder Material" to "Hazardous Waste" A Conceptual Business Model to Address the Challenges

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Graphical Abstract

Disposal of waste plastic is one of the critical challenges being faced globally. Several attempts have been made till date to address the issue. However, looking at the complexity of mixed waste plastic, a sustainable and economical pathway still eludes the scientific community. Therefore, it is imperative that there is an urgent need to address this issue. Present work demonstrates a novel approach for effective handling of waste plastic economically and in an environment friendly manner.

The work reported has been carried out at experimental level and it is shown that the novel process is capability of accommodating almost all kinds of non-segregated mixed waste plastics, except non plastic materials. Depending on the size and thickness of the modules, up to 60 tons of waste plastic/km may be utilized (for 6 meter road). This has been shown by conducting a trial at one of the BPCL Location. Most important aspect of this innovation is, once the product is utilized, no waste is being generated again. To prove the feasibility of this innovative concept, mixed waste plastic generated and collected from various sources has been used. Modules were prepared from such plastic and used in demonstration trials. Till date seven such road stretches were prepared wherein about 72 metric tons of plastic has been utilized. One of the stretches prepared being operated successfully since last three years. The field demonstration proves that there is great potential to implement this novel approach, which not only address the disposal issue but also can result in to an economical business model, while protecting the environment.

Most important part of this process is, there is no change of alteration required in any of the material or process used in conventional approved process of road making. The product can be directly used in sub-base or base of the road. The product can be stored under open environment and can be used need based. If implemented, the process will not only address the issue of plastic waste but may be a source of revenue generation and control plastic waste accumulation.

Introduction:

Once held a "Wonder Material", plastic is now seen as a threat to society. The issues related to it is mainly due to lack in economic feasibility of recycling mixed litter plastic.

Troublesome collection, segregation and cleaning process make it un-economical and such materials are resulted in creating pollution. Plastic was introduced to the society as a grate invention and soon capture the market due to its lucrative nature in terms of cost, ease in handling and to certain extent easy to use and easy to throw approach. For any new product, the commercialization pathway practiced is to introduce new invention, incremental innovation and capture market, capitalize on it for enhancing the profit margin, without paying any attention towards possible short term or long term socio-economics and environment impacts post use. Therefore, due to stringent need of protecting environment, a time has come to put thoughts in blueprint itself for eco-friendly disposal or recycling of post use product prior to its manufacturing and introducing it in the market. It is equally important to fix the responsibility or the ownership, on either manufacturer or consumer, for green disposal of post use material. Developing a product and commercializing the same, without looking into its short/long term effects needs to be a part of future business expansions or new business licensing in view of protecting environment. The appropriate authority should be empowered to force implement the environmental norms strictly or else impose penalty and, if required, may also be empowered to stop the production of such unit till the time such unit met necessary compliances.

This should be the responsibility of investors, prior to initiating new business, more clarity about the green disposal of product needs to be insured before developing infrastructure for new products. Therefore, a policy needs to be cautiously drafted for the new production unit with a condition that it will be permitted to produce finished product only on accepting the responsibility and putting plan forward a green disposal of waste generated out of production and post-used product/s. The modalities may be defined by competent authorities in discussion with the experts in the area, as the case may be.

Post used mixed plastic litter materials are leading a serious environmental and health issues not only on soil but in water also. United Nations Environment Program (UNEP) already given a stern warning that unless we take action, our oceans will contain more plastic than fish by 2050. More than 280 million tons of plastic are produced globally each year, and only a small percentage is recycled. About 13 million tons of the rest ends up in the world's oceans, costing several billion dollars per year in environmental damage to marine ecosystems[1].

Plastic is a truly versatile and valuable material and hence it's not surprising that its production and use is growing exponentially. On the other hand the waste is also getting generated at same rate. Most of the waste plastic is getting generated by different sources such as Municipal Solid Waste (MSW), paper mills and various other industries. The nature of such waste is generally mixed waste plastic, hence; recycling of such plastic waste is a tough task. However, in cases where MSW segregation takes place, the segregated mix waste plastic often remains contaminated and its further segregation according to type of plastic and recycling becomes cumbersome and uneconomical. These contaminated material further needs to be cleaned prior to its use for making recycled product. Cleaning and subsequent drying of such plastic with waste is also economically unviable; as large amount of water, space, power and manpower are required for such operations. There are several options discussed in the literature including land filling, incineration and energy recovery, down gauging, in road surfacing, re-use of plastic packaging recycling etc. (2-25). Use of waste plastic, as an alternative fuel in Cement Kilns was proposed to be better option compared to burning the waste in incinerators for energy recovery. However, this solution is creating huge environmental issues across the country due to pollution, hence, there is an urgent need to address this issue. On the other side, some of the significant challenges still exist from both, technological factors and social issues relating to the collection of recyclable wastes from the dirty and unhygienic places. However, hardly any solution has resulted to the extent needed till date (26- 41). Hence, the acute problem of plastic waste is forcing us to practice the existing methods ignoring the health and environmental impacts. There are a number of research gaps that need to be addressed to provide a stronger evidence-base on which the policy can be developed. Some of these are at the exhaustive level of impact, such as the actual levels of chemical exposure caused by plastic waste. Others are more action-orientated, for example, identifying potential hotspots where plastic waste is problematic, identifying high-risk products that use plastic or identifying wildlife and human groups that are more vulnerable to the impacts of plastic waste. However, the very nature of plastic waste as a fluctuating and mobile issue means that science is unlikely to be able to answer all the questions. It may be preferable to take policy action before waiting for a completely clear picture to emerge so as to avoid the risk of impacts worsening and becoming more difficult to manage in the future. Figure 1, below depicts scenario resulted out of waste plastic across the world.

The present paper discusses the problems arises due to extensive use of plastic materials in numerous applications and consequences due to non-management of post used garbage accumulated. A novel solution in the form of concept has been researched, developed, demonstrated and implemented, to address the issue of waste plastic including litter plastic waste. A novel product developed from waste plastic and novel process demonstrated to use the same in road construction has been discussed and presented in the form of demo stretches. However, it is important to note that the application of this product is not limited to road but can be used in other construction application as well.

It is shown that, to address this vexing issue of plastic waste, only those technologies are capable which can bridge the gap between waste generation and consumption and generate revenue and generate employment locally. As the rate of waste plastic utilization increases the generation of waste can be controlled, however, this may only happen if an entrepreneur implementing technology can find value in the waste and able to generate revenue. Present process of waste plastic utilization can handle such issues effectively. This is proven by demonstrating the process with real life examples and business model has been proposed for commercialization of the same.

The article presents a novel concept that has been proposed and demonstrated for its use in road construction in economically sustainable and environmentally friendly manner. The demonstration proves feasibility of the new approach to solve this vexing problem. It presents evidence of the capability of the novel process to accommodate almost all kinds of non-segregated mixed waste plastics, except non-plastic materials. Depending on the size and thickness of the modules, up to 55 to 60 tons of waste plastic/km shown to be utilized (for 6 meter width and 1000 meter length road). Most important aspect of this innovation is, once the product is utilized, no waste is generated. The application also arrest the formation of "Micro Plastic" as the modules are placed in the sub-base or base of the road. The field demonstration proves that there is great potential to implement this novel approach, which not only address the disposal issue but also can result in to an economical business model, while protecting the environment.

The Concept of Module

Recycling is an attractive option practiced so far due to the potential environmental and economic benefits; however, the demand depends on the price of virgin material as well as the quality of the recycled material itself. Use of recycled plastics is marginal compared to virgin plastics across all plastic types due to a range of technological and market factors. Another constraint on the use of recycled plastics is that the plastic processors require large quantities of recycled plastics, strictly controlled specifications at a competitive price in comparison to virgin plastic. Such constraints are challenging, in particular because of the diversity sources and types of plastic waste and the high potential for contamination. Hence, a challenging task was to develop a product which will overcome all above barriers. A concept of using waste plastic in modular form in road construction thought to be promising idea. In view of above a demonstration project is planned and completed. On the basis of results obtained, it is observed that the innovation will help in reduction of plastic waste. However, Research & Development (R&D) efforts needs to facilitate best practices and should lead to the introduction of novel methodologies/ technologies that can contribute to reducing the amount of plastic waste produced. Efforts made in this direction for utilization of waste plastic using novel method and implemented at R&D Centre of Bharat Petroleum Corporation Ltd.

The work done resulted in positive outcomes, particularly in terms of increasing levels of utilization of waste plastic in environment friendly way there by reducing the overall quantities of plastic waste. The approach would offer flexibility in terms of its implementation and potentially lead to a better environmental reputation. In view of above it is necessary to explore an innovative approach for utilization of waste plastic at pilot scale. The present process covers following points:

- Simple to implement and economical localized production and suitable for all geographical location and climatic conditions
- Accommodate almost all types of waste plastic without any segregation amongst plastic
- No or very limited preprocessing, waste etc. (low opex)
- No risk of reappearance in atmosphere once the product is utilized
- Off site preparation and can be stored and transported based on requirement.
- No additional utilities needed at site for module laying
- Fast and voluminous consumption with environmentally friendly process

Research report published earlier discussed using of waste plastic in such constructions and few research groups were experimented as well, however, the issue of waste plastic still surface largely. This may be due to lack in effectiveness of the processes practiced. One of the reasons may be the process complexity in existing methods in utilizing the waste plastic materials and limitations thereof. In current approach, a ready to use solution has been provided and such solution will be effective to implement at both centralized and localized locations as well. The facility for product preparation can also be fabricated such that that it can be of mobile in nature. The waste plastic used in current process is based on mixed waste plastic originated from paper mill, and however, current process can accommodate all kind of waste plastic originated from any source. However, the non-plastic materials such as metal, wood etc needs to be separated prior to use.

Designing of Modules

The concept implementation initiated with product design from mixed waste plastic. The product preparation process is IP protected process. As mentioned, It is important to note that the raw material for product development varies batch to batch or even product to product, hence preparation of product with varying raw material composition is challenging task. Moreover, there may be other impurities other than plastics such as paper, aluminum foils etc. Considering this variations it is proposed to design and make a product that can be used in road construction. Figure 2, shows the design for proposed module from waste plastic. Fig 2a, shows the illustrative design of module proposed to be prepared, by shaping a waste plastic, with appropriate dimensions. Fig. 2b, is illustrated figure of module filled with bituminous concrete. The module can be used in both open top and closed top mode with cover. Fig. 2c, depicts the cover for the module. In case of module needs to be used with cover the provision of the same can also be made. Fig. 2d, shows the module ready to be used on the road. Such modules can be tailored with different shape and sizes. The need dependent shaping of modules can also be made. It may be noted that the modules used in current trial are prepared in different rectangular sizes. However, for a continuous production of such modules, an automated system needs to be designed which can directly prepared the modules with desired shape, size and thickness in one single piece. The facility of filling of bituminous concrete can also be made a part of such facility and ready to use modules can be prepared. As mentioned above the shaping of such modules can be done with the help of manual or automated device. The various possible shapes that can be designed are depicted in figure 3. Such modules can also be tailored with variation in dimensions to suit the need of the road or site. Current report chosen a square and rectangle shape for demonstrating the feasibility of the concept. The modules so developed are used with various length, width and height.

However, in all the modules the height maintained uniformly at 2.5" and 1.5" and zero inches also to cater the need of low thickness road and to suit the base course and sub base course thickness. It is important to note that the final and optimized module implements for semi commercial trials are with zero height i.e flat module with provision of holes, four to five numbers, to hold on. This design perform successfully in terms of economic, ease in transportation, laying and most importantly this can used with paver machine as well. Once the module are laid the bituminous concrete can be spread evenly and set by paver and followed roiling. On completion of base course, a coat of bituminous concrete can be applied prior to lay other set of modules on the sub-base course. On completion of the both the layers, road can be completed by using the conventional process.

Concept of Road Preparation:

Introduction of any new concept, process or modification in existing set practices is relatively difficult in first stage. This may be primarily due to two major reasons, a process is set and proven and adopted in the given frame of pros and cons and second, which is probable strong, is the comfort zone. Therefore, chances of embedding new process or technology in existing practice are very high, if it can be implemented without doing much changes in either technical specification or parameters of the current process practices. Keeping this in mind the product has been developed such a way that is can be used during the construction of existing road without changing any approved parameter such as road specifications (depth, width, thickness) or basic road preparation and laying process. The design of module is such that that is can be used either in the sub-base (or even base also) of the road. In view of this we have performed the trials by using modules in both in sub-base and base of the road. It is preferred to be used in the sub-base as the modules may protect the road base from the deterioration due to water.

Physico-Chemical Characterization:

In view of demonstrating the feasibility of the concept, the sample product in the form of modules has been developed from mixed plastic waste sourced from the paper recycling industry. It may be noted that the modules means a shape of structure with certain length, depth and height tailored to suit the need of road dimensions. It is also important to note that the raw material comprises of mix of variety of plastic types such as polyethylene terephthalate (PET), polylactic acid (PLA), polypropylene (PP), high-density polyethylene (HDPE), polyvinyl chloride (PVC), low-density polyethylene/linear low-density polyethylene (LDPE/LLDPE), polystyrene (PS), multi-layer plastics (MLP) and other resins as well, including impurities of other materials used for preparation of packaging material. Since the objective was to address the issue of those plastic which otherwise don't have any value of not feasible for recycling. Needless to say that the composition of such raw materials varies batch to batch. It is also important to note that, the raw material may also include impurities such as pieces of aluminum foils, paper and pieces of cloths etc. As the prime objective is to utilize the plastic waste on as received and unsegregated basis, the characterization was based on the strength of the final product prepared from mixture of such raw material. The finals product is being utilized in construction, it should withstand desired pressure and temperature till it gets utilized. Once application is over, the local conditions helps to keep the structure study.

Prior to preparation of module, as received mixed plastic waste raw material from various sources was dried. The mixture then transferred to the shredder line. The most important thing to be noticed is there is no restriction on particle size of the shredded particles. The pieces received from shredding has been used as such without any sieving treatment. The material received post shredding was directly subject to the product line without further shredding. The shredded material received converted in to the module there by applying a desired temperature and pressure. The product prepared was further tested for its physic-chemical properties. It may be noted that prior to optimizing the production process, the samples prepared were subjected to testing at reputed institute, Polymer Chemistry Division of National Chemical Laboratory (NCL), Pune, equipped with advanced instrumentation and expertise. The present process developed utilizes the plastic which is mixed in nature as a result of post used plastics generated by various Industry. The waste generated by industries is in the form of different shape & sizes and of different qualities. In this waste other impurities such as paper, aluminum follies, and pieces of cartons which are poly coated, other plastic laminated materials or plastic coated are always present. In view of this, a study was carried out to understand the nature of such material when used in modular form. Mixed waste plastic was converted in modular form and randomly selected modules were subjected to sample collection from waste plastic modules for analysis. It may be noted that, as samples are mixture of different waste streams and composition can very sample to sample. In order have as accurate date as possible, samples collected from various modules were subjected to different techniques and analyzed and should be viewed in a broad spectrum of characteristics. The characterization was carried out in Polymer Division of National Chemical Laboratory, Pune and results are discussed limited to its utilization in current context. The major and important test is thermal stability of waste plastic modules and there is variation in composition of raw material. Therefore, the modules prepare using such raw materials needs to be tested for its thermal stability. It should also be noted that, since samples prepared out of raw material that is mixture in nature, it is difficult to compare with any standard methodology due to its heterogeneity. The bituminous macadam which is used in road laying at a temperature ranging between 100 OC to 120 OC. Therefore, the module structure should withstand the above temperature. Another important parameter is structure stability of module. The modules used will experience a heavy weight of bituminous macadam and pressure exerted due to press rolling to set the road. The modules also should also have strength enough to bear this loads during road preparation. The detailed study of thermal properties of modules prepared out of varying raw material has been carried out, mainly the thermal stability and the result obtained are described below.

As mentioned above, thermal analysis is an important tool used in wide variety of industries, this includes polymers, composites, pharmaceuticals, foods, petroleum, inorganic and organic chemicals, and many others. Thermal analysis study typically measure heat flow, weight loss, dimension change, or mechanical properties as a function of temperature for the material under test. Properties characterized include melting, crystallization, glass transitions, cross-linking, oxidation, decomposition, volatilization, coefficient of thermal expansion, and modulus. These experiments help to examine end-use performance, composition, processing, stability, and molecular structure and mobility. There are several techniques are available for thermal characterization of material. These techniques can be applied depends on the nature of material and the properties desired to be studied. There are various thermal analysis techniques available and can be implemented based on properties required to be investigated.

Another technique, Simultaneous Thermal Analysis (STA) generally refers to the simultaneous application of Thermogravimetry (TGA) and Differential Scanning Calorimetry (DSC) to one and the same sample in a single instrument. Thermoplastic polymers are commonly found in everyday packaging and household items, but for the analysis of the raw materials, effects of the many additive used (including stabilizers and colors) and fine-tuning of the molding or extrusion processing used can be achieved by using DSC. An example is oxidation induction time (OIT) by DSC which can determine the amount of oxidation stabilizer present in a thermoplastic (usually a polyolefin) polymer material. Compositional analysis is often made using TGA, which can separate fillers, polymer resin and other additives. TGA can also give an indication of thermal stability and the effects of additives. Thermal analysis of composite materials, such as carbon fiber composites or glass epoxy composites are often carried out using DMA or DMTA, which can measure the stiffness of materials by determining the modulus and damping (energy absorbing) properties of the material. Aerospace companies often employ these analyzers in routine quality control to ensure that products being manufactured meet the required strength specifications. DSC is used to determine the curing properties of the resins used in composite materials, and can also confirm whether a resin can be cured and how much heat is evolved during that process. Application of predictive kinetics analysis can help to fine-tune manufacturing processes.

Another example is that TGA can be used to measure the fiber content of composites by heating a sample to remove the resin by application of heat and then determining the mass remaining. When the martial/s subject to examination in its pure form, it is easy to achieve the accuracy in analysis and interpret the results with reference to the appropriate standards, however, when it comes to mixture of uncertain components in varying proportion, several experiments needs to be conducted. In spite of this, the data generated can give

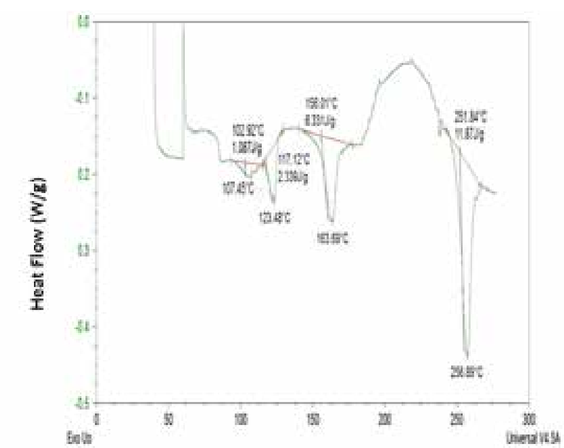

Figure 4
Differential scanning calorimetry of the sample was done on TA Instruments Q100, for estimation of glass transition temperature waste plastic module sample

an overall idea of the materials behavior over a broad range. However, a broad guideline can be obtained from the analysis of uncertain or mixed types of plastic. Looking at application of such mixed waste plastic material in present application, the modules samples were subjected to the thermal analysis.

The objective to carry out such analysis is to identify the thermal stability of module over a temperature range from ambient to 500 OC. In present work the modules are filled with hot bituminous macadam, (temp. range 100 OC to 120 OC), hence, it is necessary to ascertain the stability of modules at above temperature. In view of this DSC (for glass transition temperature) and STA was employed to analyze to evaluate the mixed waste plastic samples drawn from modules. The results obtained from GT, are shown in Figure 4 below. Since the sample is a mixture of many polymers, there is no glass transition temperature Tg as such. We can also see multiple melting which could be of PE, PP, PET etc. However, the presence of one polymer affects the melting of other. In order to establish the module stability, a Simultaneous Thermal Analysts (STA), figure 5, study was also carried out on waste plastic samples and it is observed that it is stable up to a temperature of about 250 OC. About 10% weight loss happens at a temperature of 400 OC. However, 90% weight loss happens at around a temperature of 500 OC. This study is very important in understanding the behavior of product under variation in temperature. As mentioned above the input raw material composition various place to place and there is no control on composition of a particular type of plastic type. In view of this it is utmost important to understand the performance of the product. The results obtained through thermal analysis indicated that, though there is a vast variation in composition, when the product exposed to thermal variation the overall range of stability is well beyond the material temperature range. Therefore, stability wise module can withstand the road preparation conditions. This has also been practically observed while preparation of stretches.

Due to versatile in nature, the plastics molding processes allow parts designers more freedom than working with metals. However, the mechanical properties of plastics are very sensitive to the type, rate, duration, and frequency of loading, the change in operating temperature etc. The physical properties, such as stress-strain behavior, determine the material contribution to part strength (or stiffness), the relationship between load and deflection in a plastic part. Other factors that affect part strength include part geometry, loading, constraint conditions on the part, and the residual stresses and orientations that result from the molding process. There are various types of strength, such as tensile, compressive, torsional, flexural, and shear, depending on the load and restraint conditions the part is subjected to. These types also correspond to the primary load state present in the part. The stress-strain behavior of the material in the same mode as the primary load state in the part is most relevant in determining part strength. It is important to note that the loading rate (or the strain rate) and temperature can significantly affect the stress-strain behavior of plastics. In general, at higher loading rates or lower temperatures, plastics materials appear to be more rigid and brittle. On the other hand, at lower loading rates or higher temperatures, materials appear to be more flexible or ductile because of their viscous characteristics. In view of the mix type of waste plastic it is important and challenging task to investigate the rheological properties of this multi-phase system. Moreover, as the waste plastic is being used in road construction in modular form, it is Important of evaluate Stress, Strain of a material Sample in a rheological investigation.

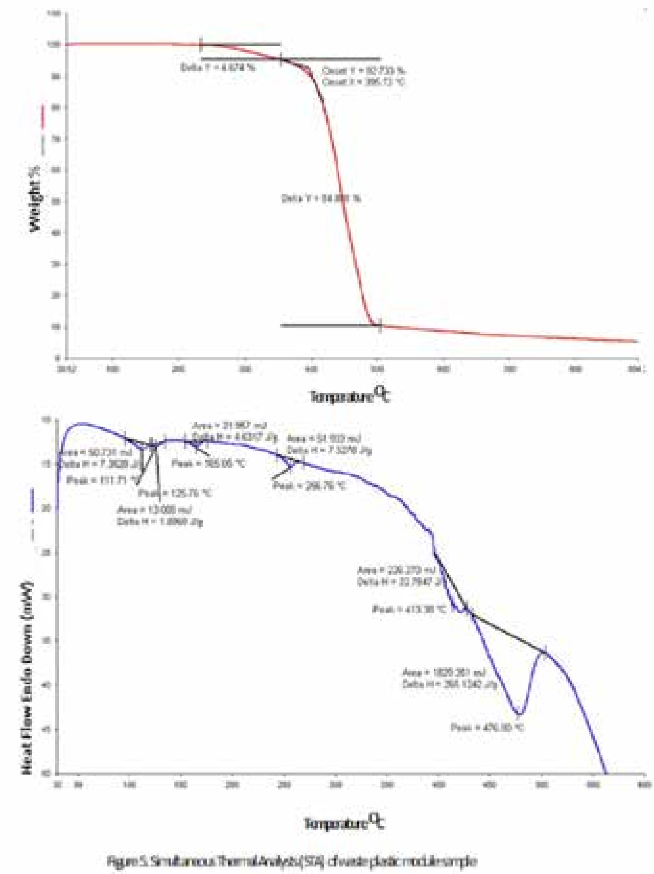

Figure 5. Simultaneous Thermal Analysts (STA) of waste plastic module sample

In order to measure a material's rheology, following five criteria must be taken in to consideration: geometric boundary conditions, stress, train, strain rate and mode of deformation. To achieve good comprehension of the rheological properties of materials, it is essential to either measure the deformation resulting from a given force or measure the force required to produce a given deformation. As a measure of force, one can use the stress which is defined as the ratio of applied force to the cross sectional area on which the force acts. Deformation can be described in term of strain or rate of strain. Owing to its sensitive response to changes of microstructures for heterogeneous polymers, rheological measurement has been a preferred approach in the characterization of the formation and evolution of microstructures for multi-component or multi- phase polymeric material systems. As the application in road base the temperature-dependence of the study of stress observed at different temperatures provide an insight into the mechanism of structure breakdown, induced by the applied force. Stress relaxation, upon cessation of flow, reveals complex behavior, depending on temperature. Strain, stress data have also been obtained, indicating strong dependence on the composition of the copolymers with respect to variation in temperature and pressure. The samples were prepared by cutting in to disk form of 50 mm dia and evaluated the properties on Instron UTM instrument. The disks were subjected to the temperatures ranging from 28 OC to 150 OC. The disks were subjected to 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 so prepared were mounted in sample chamber and the temperature of the chamber maintained at 28 OC, 50 OC, 75 OC, 100 OC, 125 OC, and 150 OC during individual runs. At each temperature the experiment were conducted by varying the load rate i.e 10 mm/min and 20 mm/min. On the basis of data obtained the estimation for stress, strain and compression modulus were carried out. On the basis of data obtained it is observed that, in general, as temperature of testing increased from RT (from 28 OC) to about 150 OC, the samples displayed slightly increasing values of maximum % strain as the samples became more pliable at high temperatures. Beneficially, the max. stress of the sample did not undergo drastic decrease in temperature. Correspondingly, the compression modulus also did not undergo much reduction till about 15 OC where for a lower speed of testing the modulus decreased by about half as compared to RT 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 OC. Five no. of 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 OC; 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 withstands press and temperature. Table 1, depicts the data obtained.

Valorization of Modules Performance:

On characterization and generating data the desired properties were optimized. Based on the data the desired product properties were tuned thereby controlling the temperature and pressure in product line accordingly. The product modules has been prepared with the thickness of 10 to 12 mm. These modules were prepared with various sizes in length and width to evaluate the feasibility of laying and handling, figure 6.

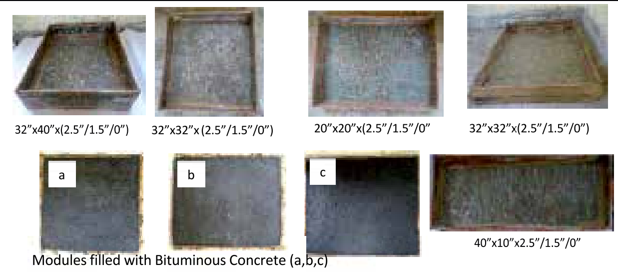

Figure 6. Modules prepared with varying sizes to establish the stability and feasibility.
*The dimensions shown are (length X width X height) zero indicates

Table 1. Rheological properties of waste plastic samples Compression Test on Instron UTM, Load Cell: 10KN Five samples tested at each condition

Condi-tion	Temp. (°C)	Rate (mm/min)	Max. Stress (MPa)	Max. Strain (%)	Compression Modulus (Automatic) (MPa)
1	28	10	4.07457	72.68712	14.58756
2	28	20	4.07529	83.0256	14.16988
3	50	10	4.07489	92.4055	13.61103
4	50	20	4.07523	74.11408	13.82447
5	75	10	4.07453	81.55874	13.46949
6	75	20	4.07483	95.43298	13.10579
7	100	10	4.07478	77.23193	15.30517
8	100	20	4.07491	82.55761	13.15089
9	125	10	4.0745	85.92771	13.1082
10	125	20	4.07493	115.0742	12.14637

Therefore, once the process parameters are established at laboratory scale, it helps in scal-up to next intermediate level to judge potential of process. In the context the module prepared were tested with bituminous filling at about 120 OC, and feasibility of modules structure and stability has been tested over a period of time. This step helps in understanding the feasibility of utilization of waste/mixed waste plastic in road construction R&D level. The modules performance found to be good and structure was intact. After recording observations of such filled modules, it was proposed to valorize the concept by laying the first waste plastic stretch at Corporate R&D Centre of Bharat Petroleum Corporation Limited (BPCL). Such valorization is required to gather the initial data related to behavior of waste plastic road in order to extend the concept for pilot scale trials. The overall objective of valorization is to promote the project and analyze its results to foster its application for pilot, semi-commercial and commercial level with the attempt of continuously spreading and improving the utilization of waste plastic to keep the environment free and clean from dangerous waste plastic.

Valorization study was aimed at:

- Testing and dissemination of the results of the project
- The exploitation of the results and their development in new context and environments
- Mainstreaming or addressing the decision-makers in order to convince them the value of the project outputs
- Sustainable application of the results over time in formal and informal systems, in the context of its commercial application

In any type of road construction, appropriate planning and design process and parameters are most important matters to be considered prior to road development. This is specifically applicable for changing the conventional set parameters or to implement the innovative approach to study the feasibility. Appropriate initial planning and design may lead to optimum use of material, sustainable management of resources and effective management of material generated during road laying. For example, water sensitive design, which can be managed by innovations such as permeable concrete pavements, is likely to impact on both construction and material selection and placement. Hence, one important consideration in both design and construction is ensuring quality of materials and construction processes. Control of variability (such as in the properties of materials) will contribute to improved and more predictable outcomes for the road over its life cycle. To implement the innovation in existing processes, it desirable that variation in in approved specifications should be as minimum as possible. This will help in economizing the process and develop the confidence amongst the stake holders. In present process, the waste plastic modules are tailored and arranged such that it support enhance the strength of the road stretch there by keeping the entire patch intact. Such arrangement can also be used in multilayer, alternate layer and in adjutant layer mode as well. In present process it is used in one layer, sub-base of the stretch. As the modules used under the concrete mixture this will not generate any further waste from utilized modules such as micro-plastic. The current model seems to be the best model for constructing the roads. This new idea generated and implemented can significantly address the issue of waste plastic utilization and may be a sustainable business model under "Make in India" and "Swachh Bharat Mission".

Demonstration of Construction of Road using Modules

In view of conducting the first trial, a stretch, area of 64 m2 (4 meter width and 16 meter length), at the main entrance of BPCL R&D Centre has been chosen as a sample stretch. This stretch is always subjected to traffic movement, hence the performance observation under traffic load can be assessed. Preparation of selected area of existing road stretch was carried out. The stretch was excavated up to 500 mm depth. The debris removed and leveling the surface was carried out. The sub-grade was thoroughly compacted by roller weighing 10 tons by sprinkling water till the surface levels properly. Low spots develop, if any, during rolling has been made up and brought to the grades as required. Further, on well compacted sub-grade water bound macadam (WBM) was prepared.

The stone size ranging between 2-3 inches were spread and compacted by roller weighing 10 tons till the surface leveled evenly. After spreading the material sufficient quantity water was sprinkled to set the surface properly and left till it dry. The surface was then cleaned by swiping to remove undesired material. The left over gaps were filled by 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 again rolled and a spray of water was applied during the rolling. A compacted sub base left for 3 days and ensured that it is dried properly for further process. Prior to laying, the surface was cleaned to ensure the uniformity in level. The area to be utilized for module laying was marked. A spray of hot bitumen was applied on the surface followed by 1" concrete layer and module was laid adjacent to each other. The purpose of applying the hot bitumen is to stabilize the modules on the surface and maintain the alignment till they are filled with bituminous mixture. Once the modules were laid, the alignment was done to ensure the uniformity in level of surface. Figure 7 shows the process of making the surface for laying the module. The modules were laid in both base course and sub base course.

Since this is the first trial, it was aimed to establish the feasibility of size, shape in terms of ease of preparation and handling. Therefore different sets of modules has been experimented to evaluate and establish the optimum size or sizes of modules. On completion of laying and filling the modules, the surface was rolled properly to ensure the proper compaction of material. On completion of surface coat the road was kept unused for 3 days (since this is the first time application of modules) for curing purpose and the road was open for regular transport. The final stretch open to traffic movement and being operational since July 2016.

It is important the note that when the stretch made operational and consistently monitored on daily basis. All the observations were noted carefully. The stretch was used for a period of three months and evaluated through an authorized agency who has expertise in evaluating the roads for its technical parameters as per the standard approved procedures. However, this was the trial to establish the size, shape of modules, check the feasibility of laying modules and establish the road making procedures, this has been considered as a sample. Amongst the modules used in different shape it is observed that the size 20"x20" found to be technically feasible in terms of stability, laying and handling. Based on this observation all further trials to establish the feasibility of current innovative process under different road operating conditions and climatic zones across India, the size of the module used 20"x20". The height of the module has also been evaluated in terms of suitability, both in preparation, application and suitability in road preparation. The most important think to note that the area of 64 m2 used in the trial accommodated about 1 metric tons of plastic waste. This is the first process wherein such a mammoth quantity of waste plastic utilization has been shown.

Figure 7. Process of making road using waste plastic modules (operational since 2016)

Scale-up Studies

On successful implementation and operational testing over a period of one year of waste plastic road process at BPCL R&D Centre (concept scale), it is necessary to evaluate the process at for its feasibility for higher wheel load prior to undertake the pilot scale trials. This will not only help to understand the performance of concept at little larger scale but also provide an opportunity to demonstrate its true value and discover new ways of doing things and overcome, deficiencies, if any. The data obtained from concept scale will help in optimizing the implementation of process to full scale from commercialization point of view. However, in order to speed up the project pace, the pilot project must not be either too short or too long, but represent broadly the features of pilot scale. If the pilot scale stretches for a longer monitoring period, without significant results, it would cast a shadow of doubts on the viability of the overall performance. In case of road at least one year period is required to get the initial performance data. Hence, it is always better to implement and test stretches in bits and pieces initially with gradual increase in length of road and volume of waste plastic consumption. This helps in predicting the gains and benefits of the project at commercial scale. Planning of any road construction needs to be done by considering present and future uses of the transportation system to assure maximum service with a minimum of financial and environmental cost. In view of this, initial phase of road development is to establish specific goals and prescriptions for road network development along with the more general location needs. Hence, the testing of novel technique should also be done under conditions which can be extended to other locations as well. Influences of varying climatic conditions, such as, atmospheric temperature, atmospheric rain also needs to be looked in to. Atmospheric conditions, areas such chemical industry, petroleum refinery or other industry where in chemicals are being used also needs to be taken in to consideration. The roads used for transportation in such areas may be exposed to leakage of variety of hydrocarbons or chemicals. Though the novel technique developed utilizes the waste plastic at the bottom layer, the performance data is useful for preparation of waste plastic roads in such premises. Keeping the above, a site at Mumbai has been identified for conducting the trial. The details of road preparation and its evaluation is discussed in detail in onward section. An area of about 60 meter in length and 6 meter in width was identified. It is important to note that, in view of generating the data for comparison with normal road, half of the stretch was prepared without using modules and half of the stretch was prepared using modules. About 30 meter in length and 6 meter width area was used to place the modules and identical area the road was prepared with conventional process. It is worth to note that the about 2 tons of plastic waste has been utilized in 180 m2 area of road. Further the road was subjected to traffic movement on completion. Initially, just to have an idea the traffic movement was monitored for a period of 6 months, Table 2. The purpose is to analyze the tentative load experience by the road over 6 months of time.

Table 2 Vehicular movement data for waste plastic road stretch

Month	No of trips/month			Weight on road (tons)
	Truck/Dumper (25 ton)	Jeep/Car (3 ton)	Other Vehicles 92 ton)	
1	155	350	200	5325
2	168	320	300	5760
3	200	325	400	6775
4	180	375	390	6405
5	230	400	375	7700
6	280	420	300	8860
Total weight experienced by road for a period of six months				40825

It is important to note that in Mumbai city recorded highest rain fall in 2015, the road performed well even with such a heavy rainfall and no sign of any damage on the surface recorded. This road is currently being operated successfully and completed its 3 years of operation.

Study of Effect of Climatic Conditions

In view of commercial application, the feasibility of any process should not limited to specific geography. Such limitations may act as hurdle in wide acceptance of process and limits applicability. Variations in temperature and rainfall, along with extreme weather events caused by climate change, will have effects everywhere, therefore, roads and highway safety are no exception. There will be more torrential rains or higher summer temperatures and heat waves that affect the conservation of the pavement and road mobility. People working in road construction area are aware of this, and many of them have developed strategies to mitigate the effects of climate change on the highways. Several studies have been reported which identify different methods to adapt pavements to future climate conditions (42-44).

Therefore, it is utmost important to establish the feasibility of present methodology in view of its application under various climatic conditions. To study the effect of climatic conditions on waste plastic road, four locations across India has been identified. The first stretch was already operational in northern part (Greater Noida). Three stretches were laid and being successfully operated in western part (Mumbai). Two locations, one each in East (Kolkata) and one in south (Kochi) was identified to undertake the study. All the stretches prepared were on an average operational for a period of more than two years. It means that all the stretches were passed through the cycle of all seasons two times and shown a very good performance. There are no any repair was carried since its opening to traffic. Following table 3 depicts the details of road trials that were conducted across India till date.

Table 3. Data for waste plastic consumption and stretches prepared at BPCL locations

Location	Quantity of waste plastic utilized, Ton	Road Area, m2	Operational Since
BPCL R&D Centre, G. Noida	1.0	64	July 16
Mumbai, Site 1	2.0	180	April 17
Mumbai, Site 2	2.4	288	November 17
BPCL Kochi	4.0	600	November 17
BPCL Kolkata	4.0	800	March 2019
BPCL Kochi	60.0	6000	April 2019
Mumbai, Site 3	4.5	700	October 2019

It is important to note that the process has been implemented at 1 km scale, wherein 60 metric ton of plastic has been utilized. This is the first process globally, to the best of our knowledge, which accommodate such an exorbitant quantity of plastic waste.

Laying of Waste Plastic Stretch using Paver Machine

Currently almost all the roads, may be some exception, are being laid using paver machine. Earlier the preparation of bituminous macadam and laying on road was carried by labors manually. This has limitations in terms of effective laying and speed of work. With automation the roads are being laid by paver can achieve better thickened accuracy and smooth laying. However, in case of modules the stretches prepared required to be laid manually and this may have limitations in work progress. In view of adapting the modules usage in road preparation by paver, the design has been modified and optimized. This gave an advantage in terms of less time in modules preparation, high volume of modules can be transported vis-à-vis earlier module design and very economic as well. Figure 8 shows the design optimized

Module laid on road. The bar indicates the cross section of bituminous Layer

Figure 8. Modules laying schematic and final product utilization using paver machine

Figure 8, depicts the process flow for preparation of waste plastic modules road using paver machine. It is shown that the process has been simplified and paver machine can run over modules and lay the bituminous concrete. This has avoided the major step of manually filling the bituminous concrete in module, which was inconvenient and time consuming and laborious job.

Technical Evaluation of Waste Plastic Road

Application of any new product, methodology or process in existing one needs to be evaluated for its suitability in terms of quality and performance. In case of road, as the entire transportation is depends on, the evaluation is an important stage in the development process. The other parameters is to check upon whether the designed infrastructure meets the objectives originally set for it. The comparison of performance can be made only when the sample with and without introduction of new product, methodology or process prepared in the same vicinity, same time and in identical manner. Such studies will help in generating the data which will further helpful in conducting the trials at industrial scale. The opinion of experts also act as guide in process improvement to achieve higher efficiency. In view of this, Indian Institute of Technology, Roorkee (IITR), Indian premier institution in Civil Engineering, was approached to evaluate the waste plastic road prepared for its technical parameters. Prior to preparation of road the samples of bitumen and agitates to be used to prepare both the, non-module and with modules, stretches send to IITR for evaluation of its properties. Following table 4 and table 5 shows the results of characterization done for bitumen and aggregates respectively.

Table 4: Testing Results of Bitumen Sample		
Test	Result	Specifications as per IS 73:2013 for VG-40
Penetration Test Value 1/10 of mm	46	Min 45, Test as per IS 1203
Absolute Viscosity at 60° C, Poise	3550	3200-4800, Test as per IS 1206 (Part 2)
Kinematic Viscosity at 135 C, cSt	405	Min 400, Test as per IS 1206 (Part 3)
Flash Point, (Cleveland open cup), °C	280	Min 220, Test as per 1448 (P:69)
Solubility in trichloroethylene %	99.6%	Min 99% Test as per IS 1216
Softening Point (R &B) °C	57.0°C	Min 50°C Test as per IS 1205
Specific Gravity	0.99	-
Test on Residue from Rolling Thin Film Oven Test		
Viscosity Ratio at 60 °C	3.1	Max 4.0, Test as IS 1206 (Part 2)
Ductility, cm	45	Min 25, Test as per IS 1208

Table 5 Testing Results of Aggregate samples		
Property	Test Value %	Recommended Limits (MoRTH-2013), Table 500-8/ IRC-111-2009 (%)
Combined Flakiness and Elongation Index	15.4	35 Max
Impact Value	7.5	27 Max.
Los Angeles Abrasion Value	12.0	35 Max
Water absorption Value (%)	0.40	2 Max
Stripping Value (Coating)	97 approx.	95 Min
Soundness Test (Sodium Sulphate Soln.)	2.8	12 Max

On completion of the stretch the stretch was subjected to testing for its technical parameter. While preparing the road the compaction needs to be done properly. Better the compaction better the strength of the road. Therefore the density measurement is carried to estimate the compaction with respect to standard. The sand replacement method is used to determine density.

The sand replacement method of determination of in situ density uses a sand-pouring cylinder, cylindrical calibrating container, tray with a central circular hole, and a chisel. Determination of field density using the sand replacement method was carried out by the standard method. Following table 6 shows the density values for both stretches prepared with and without plastic modules. The density was estimated by taking the core at different depth so as to estimate the compaction. It can be seen for table 4 that the stretch with waste plastic and without plastic (road prepared with conventional standard process), shows the similar compaction. Average Density in Waste Plastic Module Section = 2.128, Average Density in Normal Section = 2.132, Figure 9, shows the technical evaluation in progress

Table 6: Results of Density Measurement by Sand Replacement method		
SECTION NO.	0 TO 75 MM DEEP	75 MM TO 150 MM DEEP
1 (With Waste Plastic Module)	2.13	2.16
2 (With Waste Plastic Module)	2.11	2.14
3 (With Waste Plastic Module)	2.11	2.12
4 (Without Waste Plastic Module)	2.11	2.16
5 (Without Waste Plastic Module)	2.12	2.14

When a stretch is subjected to the load, the performance of flexible pavements is closely related to the elastic deflection of pavement under the wheel loads. The deformation or elastic deflection under a given load depends upon subgrades 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. Since the method is standard and used widely as per IRC: 81-1997. Following table 5, shows the data generated for both waste plastic and without plastic road.

Table 7: Results of Benkelman Beam Study for Structural Evaluation Deflection of Benkelman Beam in mm			
Point of Observation	50 cm from Left Edge	50 cm from Right Edge	Centre
1 (With Waste Plastic Module)	0.76	0.40	0.50
2 (With Waste Plastic Module)	0.60	0.56	0.44
3 (With Waste Plastic Module)	0.48	0.44	0.36
4 (With Waste Plastic Module)	0.48	0.40	0.36
5 (With Waste Plastic Module)	0.10	0.24	0.30
6 (Without Waste Plastic Module)	0.44	0.32	0.56
7 (Without Waste Plastic Module)	0.44	0.56	0.36
8 (Without Waste Plastic Module)	0.74	0.38	0.56
9 (Without Waste Plastic Module)	0.42	0.46	0.14
10 (Without Waste Plastic Module)	0.26	0.28	0.20

Average Deflection on Waste Plastic Module Section =0.64 mm and Average Deflection on Normal Section = 0.61 mm. Based on the results of Insitu Density by Sand Replacement Method and Structural Adequacy by Benkelman Beam Method, the Test Section having Plastic Waste Modules and Conventional Section are not having much difference. So after two months of Construction and operation for day to day transportation, the Waste Plastic Module Road seems to be having same strength as that of conventional road. It is shown that the quality of the road with plastic module is at par or better than the conventions road. Following figure 10 shows the final operational stretch.

Figure 10. One of the Operational Waste Plastic Road

Current Invention as Driver over Conventional Barriers in Utilization of Plastic Waste

Conventional Segment : Barriers	Advantage/s of Present Innovation
Industrial Segment : Pollution In industrial segment use of plastic waste in energy recovery explored to be the option. However, the pollution may be the great challenge. The uptake of material is also not certain. Plastic waste needs to be transferred to the location of industry which is again leads to handling of waste multiple times, therefore, frequent exposure may not be healthy.	In current process most of the types of waste plastic can be accommodated. There is no need to keep any specific concentration of proportion as the mixed waste can be processes and converted in to the modules at any location. However, non- plastic materials such as metal, glass needs to be separated prior to product formation.
Large Scale Processes: Transport and Economy The technologies those are dedicated to waste plastic and required large volume of waste to make the business profitable will be negatively affected due to long distance between location of waste generation and treatment.	The major advantage of current process is that it can be implemented at any scale. There is no need to transport the raw material from place to place and the unit can be designed to suit the need of the project.
Mixed Waste Plastic : Quality The volume and quantity supplied/ collected is the most critical point in post-consumer plastic recycling and recovery process. It is important to note that even the energy and feedstock recovery technologies; those are capable of handling mixed waste plastic, required to keeping the concentration of waste and other materials under acceptable limits.	There is no need to have any specific quality for input materials. The deviation in composition of shredded waste plastic may not have any problem module formation. Therefore, the issue of keeping concentration of specific type of waste in modules dose not arise.
One of the major obstacles for using recycled plastic in high quality products is stability. For a plastic producer, it is very important to have the exact same raw material every time, since the production is very sensitive to even small deviations in e.g. melting point of the raw material. Deviations in the melting point of the raw material can affect the functionality, strength or durability of the product, which is not acceptable for some applications, such as e.g. medical equipment or automobile parts (affecting safety). The use of secondary plastic for these products is therefore very limited. For less sensitive products a very common way to limit this problem is to "dilute" the secondary plastic with virgin plastic, where the composition in stable and fully documented. However, this will increase the cost of finished product, as the cost incurred in selecting the appropriate type of plastic needs to be accounted.	The modules developed out of mixed waste plastic will be utilized in road construction. There is no requirement of specific quality of product. With contaminated input raw material, the product quality does not have influence on the final application. Product with almost any quality with varying combination of mixed waste can be used. Moreover, a module prepared from waste plastic need to maintain sufficient strength for the subject application till application. Once the module is fixed in the rode its movement gets restricted there by keeping the quality of construction in good shape. However, since the modules are being used at the sub-base or base of the road the application will be very useful during preparation of new road, in current application the modules has been laid at a depth of 75 to 100 mm. We also plan to conduct the trials at level below 5 to 10 mm to prove the applicability even while surfacing the roads.
Advantages with reference to Guidelines for the use of Plastic Waste in Rural Roads Construction, Roads Development Agency Ministry of Rural Development, GoI., , (http://pmgsy.nic.in/circulars//GPW.htm)	
The waste plastic modifier should be free from dust and is to be shredded, preferably to 23 mm particle size. While CRRI specified that the shredded waste plastic should pass through 3 mm sieve	Current process, there is no restriction of size of shredding. The variation in size is acceptable for module preparation.
Method of Road Laying Dry process is recommended for isolated works. It is recommended that the percentage of shredded waste plastic will be 8% by CRRI.	There is no need to change the conventional process as the modules can be store, and used at sites as and when needed.
The stone aggregate mix (as per specification) is transferred to the mix cylinder where it is required to be heated at certain high temperature (as per the IRC specification) and then it is transferred to the mixing peddler while transferring the hot aggregate into the peddler, calculated quantity of shredded plastics is sprayed over the hot aggregate within 30 seconds. The sprayed plastic films melts and gets coated over the aggregate, thus forming an oily coating.	There is no mixing or heating in current process, energy, manpower and cost saving.
The aggregate materials will be transferred to the cylinder through the conveyer belt.	No additional utilities needed
• The shredded plastics will be sprayed over the aggregate while it is moving in the conveyer belt.	Not required
• The spraying is done by manual labors standing up on both side of the conveyer belt of the central mixing plant.	Not required
• The addition of plastics should be done quantitatively.	Not required

Manual method of using plastic, so skilled manpower, additional machine and compulsion of using the material prepared on immediate basis.	No manual intervention and additional manpower needed. The product is ready to use and existing workforce can carry out the job. No specific requirement for storage at site. A safe method of laying the module.

way we manufacture, use and manage plastics in environmentally friendly and sustainable manner, the issue remains vex. It is important to note that, this is the scenario when recyclable plastic material is already been processed and not adding to the current issue. The litter mixed waste and mostly single used and low grade plastic waste creating problem. Hence, tackling one of the biggest environmental scourges of our time will require governments to regulate, businesses to innovate and individuals to act. The current paper discussed a business model wherein such plastic waste converted in revenue generating material. Most importantly, the model has been developed such that, that it can be implemented locally and even the need based portable units for product preparation is also a possibility.

The road construction is a continuous process worldwide. Several hundred km roads are being prepared, refurbished across the world. This will keep the waste plastic module demand sustainable. Hence, this process developed, if implemented at commercial scale, will be a both revenue and employment generating model thereby keeping the waste plastic generation dramatically under control. Another important point to be noted is that the utility of module concept is not limited to roads, but is can also use in applications such as preparation of base for warehouses, foot-paths, walk ways and other similar constructions. It may also give a breathing time to small scale plastic industry to develop alternative EPR (Extended Producers Responsibility) Model. However, it is important to note that, conducting larger scale, may be 25 to 50 km initially, and establishing feasibility will open the window for commercial application of waste plastic. This may also help in addressing the issue of plastic waste there by generating the monitory value in plastic waste.

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References

1. http://web.unep.org/unepmap/un-declares-war-ocean-plastic https://pavementinteractive.org/reference-desk/design/structural-design/pavement-structure/
2. Vidula Swami, J. Abhijeet, and P. Karan, "Use of waste plastic in the construction of bituminous road",
3. International Journal of Engineering Science and Technology, vol. 4, Issue 5, 2012, pp. 1-5.
4. S. K. Sultana and K. S. B. Prasad, "Utilization of waste plastic as a strength modifier in surface course of flexible and rigid pavements", International Journal of Engineering Research and Applications, vol. 2, Issue 4, 2012, pp. 1185-1191.

A. Gawande, G. Zamare and V. C. Renge, "An overview on waste plastic utilization in asphalting of roads",

5. Journal of Engineering Research and Studies, vol. 3, Issue 2, 2012, pp. 1-5.
6. R. Vasudevan, A. Ramalinga Chandra Sekar, Sundarakannan, and R. Velkennedy, "A technique to dispose waste plastics in an eco friendly way - Application in construction of flexible pavements", Construction and Building Materials Journal, vol. 28, Issue 7, 2011, pp. 311-320
7. C. S. Bindu and K. S. Beena, "Waste plastic as a stabilizing additive in stone mastic asphalt", International
8. Journal of Engineering and Technology, vol. 2, Issue 6, 2010, pp. 379-387.
9. K. K. Babu and A. K. Raji, "Utilization of marginal materials as an ingredient in bituminous mixes", Highway Research Record No. 36, Indian Roads Congress, 2007, pp. 42-43. [7] A. K. Raji, K. K. Babu and G. Sreekala, "Use of certain industrial solid wastes in Flexible pavement construction", Proc. XXI Kerala Science Congress, Kollam, 2009, pp. 276-278.

A. K. Raji, K. K. Babu and G. Sreekala, "Utilisation of medical plastic wastes in bituminous pavement",

10. Proc. XXI Kerala Science Congress, Kollam, 2009, pp. 325-327.
11. Mahapatra, "Plastic waste time bomb ticking for India, Supreme Court says," Times ofIndia, New Delhi, Apr-2013.
12. K. Dixit, R. K. Jain, and R. M. Mathur, "Innovations & Process Development For Efficient Operation of Chemical Recovery System In Paper Industry," IPPTA, vol. 24, no. 4, pp. 119-124,2012.
13. Deloitte, "Manual on Energy Conservation Measures in Muzaffarnagar Paper Cluster," 2011.
14. Central Pollution Control Board, "Charter for Water Recycling and Pollution Prevention in Pulp & Paper Industries in Ganga River Basin.," New Delhi, 2012.
15. C. Freudenrich, "How Plastics Work," 2007. [Online]. Available: http://science.howstuffworks.com/ plastic.htm.
16. Indian Express, "Not enough landfill sites to dump plastic waste," Apr-2013.
17. F. Perugini, M. L. Mastellone, and U. Arena, "A life cycle assessment of mechanical and feedstock recycling options for management of plastic packaging wastes," Environmental Progress, vol. 24, no. 2, pp. 137-154, Jul. 2005.
18. G. P. Huffman, "Feasibility Study for a Demonstration Plant for Liquefaction and Coprocessing of Waste Plastics and Tires," Preprints of Symposia-Division ofFuelChemistry Ameican Chemical Society, vol. 42, pp. 1033-1038, 1997.
19. S. M. Al-Salem, P. Lettieri, and J. Baeyens, "Recycling and recovery routes of plastic solid waste (PSW): a review.," Waste management (New York, N.Y.), vol. 29, no. 10, pp. 2625-43, Oct. 2009.
20. J. Brandrup, M. Bittner, W. Michaeli, and G. Menges, Regcling and recovery ofplastics. New York, NY: Hanser, 1996.
21. J. Shabtai, X. Xiao, and W. Zmierczak, "Depolymerization-liquefaction of Plastics and Rubbers. 1. Polyethylene, Polypropylene and Polybutadine.," Energy Fuels, vol. 11, no. 1, pp. 76-87, 1997.
22. J. Scheirs and W. Kaminsky, Feedstock Regcling and Pyrolysis of Waste Plastics: Wiley Seriesin Polymer Science Series. John Wiley & Sons, 2006, pp. 0-470.
23. E. A. Boettner, G. L. Ball, and B. Weiss, "Combustion Products from the Incineration of Plastics," Ann Arbor, MI, 1973.
24. S. Peter, "LCA of Management Options for Mixed Waste Plastics," Banbury, Oxon, 2008.
25. V. Wollny and P. Weinem, "Comparison of Plastic Packaging Waste Management Options Feedstock Recycling versus Energy Recovery in Germany," vol. 5, no. 3, pp. 49-63, 2002.
26. E. Crawley, "System Architecture." MIT, Cambridge, MA, 2012.
27. 4R Sustainability Inc, "Conversion technologyi : A complement to plastic recycling," Portland, OR, 2011.
28. J. Aguado, D. P. Serrano, and J. M. Escola, "Fuels from Waste Plastics by Thermal and Catalytic Processes: A Review," Industrial & Engineeing Chemistry Research, vol. 47, no. 21, pp. 7982-7992, Nov. 2008.
29. F. Pinto, P. Costa, I. Gulyurtlu, and I. Cabrita, "Pyrolysis of plastic wastes. 1. Effect of plastic waste composition on product yield," Journal ofAnaytical and Applied Pyrolysis, vol. 51, no. 1-2, pp. 39-55, Jul. 1999.
30. J. M. Utterback, Mastering the dynamics ofinnovation, Boston, MA: Harvard Business School Press, 1996.
31. RTI International, "Environmental and Economic Analysis of Emerging Plastics Conversion Technologies," Research Triangle Park, NC, 2012.
32. G.-H. Zhang, J.-F. Zhu, and A. Okuwaki, "Prospect and current status of recycling waste plastics and technology for converting them into oil in China," Resources, Conservation and Recyc/ing, vol. 50, no. 3, pp. 231-239, May 2007.
33. E. Rogers, Dfusion oflnnovations, 5th Edition. The Free Press, 2003.
34. C. Herstatt and E. Hippel, "From Experience: Developing New Product Concepts Via the Lead User Method: A Case Study in a 'Low-Tech' Field," Journal ofProduct Innovation Management, vol. 9, no. 3, pp. 213-221, Sep. 1992.
35. Crang, M.; Hughes, A.; Gregson, N.; Norris, L.; Ahamed, F. (2013). Rethinking governance and value in commodity chains through global recycling networks. Transactions of the Institute of British Geographers 38, (1), 12-24. 2. Zhou, S. (2012). UK to China Flows of Waste Plastics: a Critical Evaluation. MSc, Imeprial College London, London.
36. Plastics Europe, (2013). Plastics - the facts 2013. Analysis of European plastics production, demand and waste data for 2012;

Sustainable Management of Plastic & Other Waste Generated in Households

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1. Introduction

Plastic waste has been a major cause of concern in the past 20 years or so. This concern is mainly because of its rampant littering that is taking place worldwide. This littering is happening because of the linear economy that we are practicing with take, use and throw approach. This approach is causing large amounts of plastic wastes remaining dumped across the fields causing soil, ground water and air pollution worldwide causing severe damage to the environment. Further, it is also entering oceans through various water bodies and causing major concern in the sea endangering the survival of aquatic life. It is important therefore that this plastic waste needs to be managed in a sustainable manner. This requires different interventions such as planning, technology, policy framework, Operating processes for execution, etc. These interventions need to be conceived and implemented based on the source and nature of the plastic waste. Further, their management has to be aligned as per the presence of other waste streams present along with it.

2. Sources and nature of Plastic wastes

There are three major sources from where the plastic waste gets generated; Industries, Agriculture & Households. The nature of the plastic waste generated from these sources vary considerably. Some of the plastic wastes generated by these sources are illustrated in Table 1 below.

Table 1

Industrial	Agricultural	Households
• Packaging material received along with goods; Carboys, bags, bins, drums, etc. This may be recyclable or non-recyclable. • Plastic scrap produced while producing plastic goods • Plastic waste generated from the recycled paper manufacturing activity. • Etc.	• Packaging material of seeds, fertilizers, pesticides, etc • Packaging materials of ordered equipment, machinery etc. • Etc.	• Packaging materials used for Groceries, vegetables, fruits. • Packaging materials of FMCG products • Packaging materials of packaged food & beverage items. • Packaging material for household goods. • Single use plastics. • Discarded plastic items from households. • Etc.

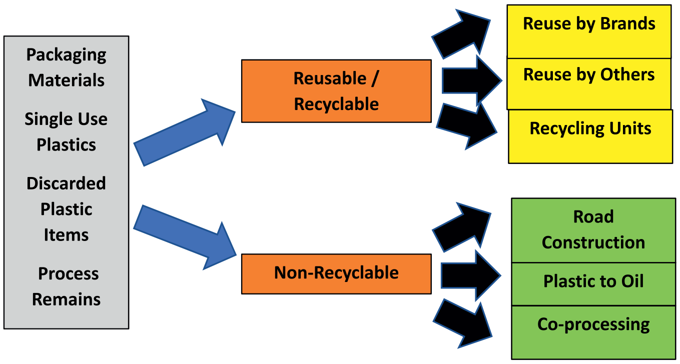
It is generally easy to manage the plastic waste from industries through reuse, recycling or recovery or disposal because the supply channels are reasonably well defined. Further, the segregation required for sustainable management of this plastic waste generally gets implemented in industries. The formal business processes are also well defined. Hence, if an option for reuse, recycling, recovery or disposal is there, it tends to get implemented. The case of the plastic waste from agricultural sector is slightly different. There is lack of existence of formal business processes and also supply chain systems in this sector. But there are informal processes that operate reasonably well in this sector through which the plastic waste generated in this sector tends to get sustainably managed. The major cause of concern of course is the MSW sector which comprises of households and commercial establishments. This problem persists in all the urban centres. The plastic waste from the household sector tends to be in soiled and in combination with other waste streams. The same waste from commercial establishments is generally present in substantially dry and segregated manner. By having a common collection system for household and commercial establishments, the properly segregated plastic waste tends to get mixed up with the household waste and becomes contaminated.

3. Options available for Sustainable Management of Plastic wastes

In the earlier days,1 the only option practiced by the stakeholders for the management of plastic waste along with other wastes was dumping it. These stakeholders included all segments from waste generators to the waste administrators. This was purely a disposal practice aligned to the concept of linear economy. Over a period of time, the recycling of recyclable plastic waste gained momentum in some countries – India in particular – but for the non-recyclable plastic waste, dumping continued to remain as the major option. This caused and continues to cause damage to the environment. For the sustainable management of plastic wastes, the practice of circular economy needs to be implemented.

Each one of the plastic constituent present in the plastic waste has its own specific features. Several technology options are available to do the sustainable management of plastic waste. These options are depicted in Fig 1 below.

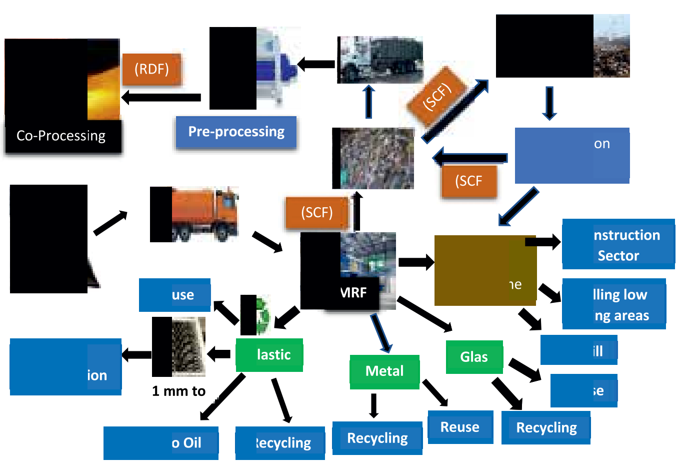
Fig 1



4. Feasible Business Processes for Management of Recyclable and non-recyclable Plastic wastes

The most important aspect in ensuring successful management of plastic wastes is its segregation into their material types. This is unlikely to happen at the household level. Hence it needs to be performed at the Material Recovery Facility (MRF). However, the same is substantially feasible and practiced at commercial establishments. Hence, it is desired that the collection of household waste and commercial establishments is organised separately. The segregation effort of the waste from commercial establishments may not be required and can be easily sent for the processing as per the options available for recyclable and non-recyclable materials. The house hold waste certainly needs to be taken to the MRF for segregation. In MRF, the recyclable materials (not only plastics but also metals and glass, non-recyclable materials (non-recyclable plastic waste, multilayer packaging materials, Rexene pieces, thermocol, rubber & leather waste, soiled paper, old / soiled clothes), and Inert material are segregated at the gross levels. Further, recyclable plastics (glass and metals too) can be further

Fig 2



segregated into different sub-types to send for reuse or recycling. This is depicted in Fig 2 below.

There is need today to design products that can be utilised for larger number of cycles so that they can be reused as such for the same or a different purpose for which they are designed. Currently, they get utilised for one cycle only and then sent for recycling back to produce new products. Reuse of these materials will facilitate achieving improvement in the resource efficiency. This reuse is feasible in many industrial applications such as FMCG, automobiles, Electrical and Electronic goods, chemical and pharma sector, some of the food and kindred products, etc. For promoting reuse, appropriate schemes can be implemented by the brands so as to get return of the recyclable materials for reuse. This will not only bring economic advantage to the brands / manufacturers but also will facilitate development of new business models.

The materials that cannot be reused can be sent across for recycling so as to bring them back to the input material stage for manufacturing new products. Currently, this is being practiced at a reasonable scale in our country and if proper systems and processes are put in place for strengthening its supply chain, much larger amount of recycling of plastics is feasible. This approach also will help build new business models. Well-designed EPR processes & its effective management by PROs with appropriate business processes and supply chain systems can add substantial value to the same. By utilising this approach, it is feasible to gainfully utilise the entire quantum of recyclable materials getting generated at the households.

After dealing with the recyclable materials, the major concern is about the non-recyclable materials. These materials are non-recyclable because of the lack of business model to recycle them. For these materials, the option of using them as bitumen replacement in road construction and converting the plastic waste into oil through pyrolytic process are the two important options. These options can be explored because the replacement value of the products manufactured in these treatments is reasonably high. In road construction the value is of that of bitumen used in road construction and diesel or furnace oil in case of plastic to oil option. When these options are not workable, then the option of co-processing in cement kilns can be utilised. In cement kiln co-processing the entire material and energy value present in waste plastics (and also all other combustible materials) get fully utilised.

The mix of waste plastics along with other similar materials as described above generated from the households is called as Segregated Combustion Fraction (SCF). SCF also gets segregated while remedying the old dump yards. For utilising it as an alternative resource, SCF needs to be converted into Refuse Derived Fuel (RDF) of desired specifications through appropriate pre-processing technology. This is depicted in Fig 3 below.

Fig 3

In this pre-processing system, SCF having substantial variation in its quality, when analysed lot to lot, is converted into a uniform quality material as required for feeding in the cement kiln for co-processing. This pre-processing is carried out through the processes of blending and shredding which provides uniform size and chemical characteristics to the SCF material. RDF having desired specifications and consistency in quality can be easily co-processed in reasonable quantities for its sustainable management.

Ministry of Housing and Urban Affairs had constituted a committee to work out appropriate specifications of this cement grade RDF and the same have been defined and documented in the "Guidelines on usage of RDF in various industries" published by MoUHA. The constituted committee has recommended three grades of RDF for use in cement industry which are provided below in Table 2.

Table 2

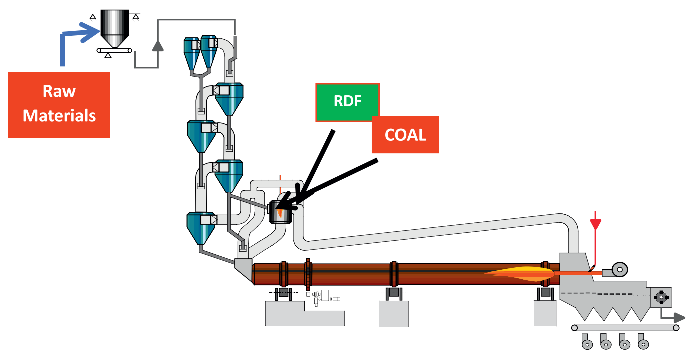
S. No	Parameters	SCF	RDF - Grade III	RDF - Grade II	RDF -Grade I
1.	Intended Use	Input material for the Waste to Energy plant or RDF pre-processing facility	For co-processing directly or after processing with other waste materials in cement plant	For direct co-processing in cement plant	For direct co-processing in cement plant
			Grade III	Grade II	Grade I
2	Size	Anything above 400mm have to be mutually agreed between Urban Local Body/ SCF Supplier and Cement Plants.	<50 mm or < 20 mm depending upon use in ILC or SLC, respectively	<50 mm or < 20 mm depending upon use in ILC or SLC, respectively	<50 mm or < 20 mm depending upon use in ILC or SLC, respectively
3	Ash	<20 %	<15 %	<10 %	<10 %
4	Moisture	<35 %	< 20%	<15 %	<10 %
5	Chlorine	< 1.0 %	< 1.0 %	< 0.7	< 0 .5
6	Sulphur	<1.5 %	<1.5 %	<1.5 %	<1.5 %
7	Net Calorific Value	> 1500 kCal/kg net	>3000 kCal/kg	>3750 kCal/kg	> 4500 kCal/kg
8	Any other parameter	Any offensive odour to be controlled.			

The required facility to convert SCF into RDF needs to be implemented and the project can be established as a business venture by a waste management entrepreneur or as a joint venture of the waste management entrepreneur and the cement plant or the same can be established by the cement plant. The techno-economic evaluation of such a facility has been evaluated as technologically workable and economically viable.

This RDF having specifications of Grade I, II & III are amenable for co-processing in cement kiln in which entire energy value and material value present in RDF gets utilised in the cement manufacture. While doing so, the energy & material utilised from RDF reduces the use of fossil fuel and raw materials utilised in the manufacture of cement. This facilitates conservation of the natural materials.

Figure 4 below depicts the process of co-processing in cement kiln.

Fig 4



When RDF is fed in the cement kiln for co-processing, the entire organic and inorganic constituents present in it get fully utilised as energy and raw material without leaving any residue subsequently. Hence, it is a highly efficient option for management of wastes sustainably. Co-processing, therefore, takes care of that waste that tends to remain littered over all places. This littered material is the one which ends up in dump yards, water bodies and then into oceans causing substantial environmental concern. Cement kiln co-processing therefore provides an important solution for this material. It is scientifically confirmed that co-processing of plastic and other wastes in cement kiln does not contribute to any incremental emissions. In fact, co-processing of RDF and other wastes help reduce the GHG emissions. It also helps to reduce or eliminate the growth of dump-yards or development of landfill sites.

Indian cement industry has installed capacity of about 500 Million TPY of cement. At this capacity, the industry is capable of utilising the entire RDF that can get generated in the country (about 6 to 10 Million TPA) and conserve about 3-5 Million TPA of coal without any major cause of concern. By this approach, the problem of management of almost entire quantum of non-recyclable plastic waste can be easily solved.

After dealing with recyclable and non-recyclable materials in a sustainable manner as described above, inert material remains as the only other material of concern. Depending upon the nature of the inert materials it is feasible to utilise it as soil conditioner, material for filling up low lying areas & embankments etc. Only the contaminated inert material, which is generally a very small portion of the total waste generated from the households, needs to be tackled through secured landfill approach. Hence it is feasible to achieve almost a zero-landfill status for the towns and cities through such a sustainable management approach for the household waste.

5. **Dealing with Plastic waste generated in households during the Covid-19 pandemic situation**

   Management of the use of masks and other PPEs, used by the society during this covid pandemic period, is getting substantial attraction. These masks and PPEs would be getting dropped in the dry MSW fraction. It is important to note here that, at households, the masks and PPEs are coming from healthy people (and not patients) and there is a very remote possibility of infection getting into the bins of the households. Options to avert the likelihood of coronavirus infecting the people handling the plastic waste coming out of households is being extensively debated currently.

   To deal with this remote possibility, there is need to institute appropriate lines of defence at various stages of the value chain through which the recyclable, non-recyclable and inert material are managed. These lines of defence need to be designed to ensure that the people handling the material are properly protected and unprotected people do not get exposed to the material being handled. Various options are being deliberated currently to address the need of these lines of defence. There is also an urgent need to bring out an appropriate policy framework towards the same.

INDIAN PLASTICS INSTITUTE

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MUMBAI CHAPTER : IPI Mumbai Chapter conducts One year part-time Diploma (DIPI) & Certificate course in Plastics Technology at ICT, Matunga (formerly UDCT), Mumbai between 6.30 p.m. to 8.30 p.m. (Monday to Friday).

- Course scheduled to commence from July 2020.

BANGALORE CHAPTER : IPI Bangalore Chapter conducts One year part-time Diploma (DIPI) & Certificate course in Plastics Technology at University Visvesvaraya College of Engineering (UVCE), Bangalore between 6.30 p.m. to 8.30 p.m. on Saturday Evening and Sunday Morning 10.00 a.m. to 1.00 p.m.).

- Course scheduled to commence from July 2020.

Syllabus and Prospectus with Application Forms are available at IPI Office, Andheri (E), Mumbai, on payment of Rs.250/-. The same can also be downloaded from our website www.ipiindia.org. Last date for receiving applications 27th July 2020

Minimum requirements:

Educational Qualifications	Experience in Plastic Industry
Diploma / Post Diploma / Degree in Engineering / Technology	Not essential
B.Sc. or Equivalent Qualification with Science Subjects	Not essential, but 1 year experience desirable
12” Std. Science with PPOT Certificate	Minimum of 2 years
12” Std. Science or 12” Std. Sciencewith ITI/NCVT Certificate	Minimum of 3 years

Those who do not have prescribed qualifications can enroll as refresher candidates. Certificates will be awarded on successful completion of the course. For further details please contact:

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(For intimation)

"Recycling Technologies for a Sustainable Future"

Dr. R. Rangaprasad,
Business Head, Packaging 360, Mumbai

Synopsis

As plastics have become an integral part of the packaging sector, involving food & beverages, FMCG, Pharmaceuticals, fresh horticultural produce, engineering & industrial goods, owing to their unique attributes for each product, the enormous amounts of waste generated after usage, has become a cause of concern.

In this paper, we track some of the notable milestones reached in the field of plastics recycling in the recent past & its potential to become a highly technology-driven industry.

Introduction

According to the reports for year 2017-18, CentralPollution Control Board (CPCB) has estimated thatIndia generates approximately 9.4 Million tonnesper annum plastic waste, (which amounts to26,000 tonnes of waste per day), and out of thisapproximately 5.6 Million tonnes per annum plasticwaste is recycled (i.e. 15,600 tonnes of waste perday) and 3.8Million tonnes per annum plastic waste isleft uncollected or littered (9,400 tonnes of waste perday).

While these stats are 38% higher than the globalaverage of 20%, there is no comprehensive methodsin place for plastic waste management. Additionally,there is a constant increase in plastics wastegeneration. One of the major reasons for this is that50% of plastic is discarded as waste after single use. This also adds to increase in the carbon footprint sincesingle use of plastic products increase the demand forvirgin plastic products.

Out of the 60% of recycled plastic:

- 70% is recycled at registered facilities
- 20% is recycled by Unorganized Sector
- 10% of the plastic is recycled at home

Source: SBM Plastics Waste Handbook

It is well known that PET bottle recycling in India has reached targets in excess of 90 %, well above those achieved in other countries.Hence, we will focus our discussion on emerging concepts in this field.

Understanding Recycling

Definitions of the draft EU Directive on Packaging Waste has been documented by Prof. Arnold Tucker in his article "Plastics Waste - Feedstock Recycling, Chemical Recycling and Incineration" way back in 2002.

1. Reuse
2. Material Recycling (plastic to plastic)
3. Chemical Recycling (plastic to plastic)
4. Feedstock Recycling (plastic to feedstock)
5. Energy Recovery

The following Table explains the various terminologies

Re-use, Recycling and Recovery of Plastic Waste
Definitions for a strong Circular Economy and the „Green Deal" of the EU Commission

1. **Reuse** implies the use of the same product without essential changes in a new use cycle

1. **Material recycling** implies the processing of **plastic waste** with **physical reactions**, without changing the chemical structure of polymers, **for a new or a similar application** through
   a. Melting (mechanical recycling)
   b. Dissolution (solvent-based purification)

2. **Chemical recycling** implies the processing of **plastic waste** with **chemical reactions**, thus changing the chemical structure of the polymers through
   a. Depolymerization (Solvolysis)
   b. Pyrolysis (Cracking)
   c. Gasification
   in such a way that the resulting chemicals (Feedstock) will be used to process and **polymerize the original polymer or plastic again**.

4. **Feedstock recovery** implies the processing of **plastic waste** with **chemical reactions**, thus changing the chemical structure of the polymers through
   a. Depolymerization (Solvolysis)
   b. Pyrolysis (Cracking)
   c. Gasification
   in such a way that the resulting chemicals will be used **for another useful purpose** than producing the original polymer or plastic.

5. **Energy recovery** implies the input into a device where the **energy content of plastic waste is used**.

Source : Training Programme on Recycling developed by Dr. Gerald Altnau, Managing Director CreaCycle GmbH

Let's now proceed to capture notable milestones reached in some of these categories through various corporate initiatives.

Recent Advances in Plastics Recycling & Related Fields

INEOS, Plastic Energy to build pyrolysis-based chemical recycling plant

INEOS and Plastic Energy are to build a new pyrolysis-based chemical recycling plant to come on stream at the end of 2023.The plant will input around 30,000 tonnes/year of mixed, multi-layer, low density polyethylene (LDPE), linear low density polyethylene (LLDPE), high density polyethylene (HDPE) polypropylene (PP) and some polystyrene (PS). Plastic Energy uses a patented process called Thermal Anaerobic Conversion (TAC), which converts used plastic waste back to TACOIL, which is then used as a feedstock for polymer-chain production.

Ref: https://packaging360.in/news/ineos--plastic-energy-to-build-pyrolysis-based-chemical-recycling-plant

Newcycling® – the innovative recycling technology from APK AG

Outstanding functionality, light weight packaging, less plastic consumption, higher shelf life, less food waste. And that are just a few of the benefits PE/PA multilayer packaging can provide and makes it to a sustainable packaging solution.

Butindeed PE/PA multilayer packaging, as consisting of different plastic types, is a challenge to recycle for most conventional mechanical recycling technologies. And now? Switching from PE/PA multilayer packaging to a monolayer/Monomaterial solution and lose all the benefits of PE/PA multilayer packaging? Or maybe better to switch to other recycling technologies that can handle these materials and keep taking advantage of the value of PE/PA multilayer packaging.

With the Newcycling® process, APK AG is contributing to meeting sustainability targets and recycling quotas.

The Newcycling® technology is a solvent-based process that enables the selective separation of polymers in mixed plastic waste. The result is pure granulates that have virgin like properties.

Ref: https://packaging360.in/news/newcycling ----- the-innovative-recycling-technology-from-apk-ag

UFlex Gears up To Reduce Delhi-NCR Plastic Waste

UFlex, a pioneer in Multilayer Plastic Manufacturing and Waste recycling, is scaling up its recycling strength to help build a circular economy, by the way of setting up two lines that will wash and recycle post-consumer waste and subsequently give a second life to plastics. This pilot plant in its Noida facility commenced its operations and is aimed to mitigate the piling plastic dumps in Delhi-NCR by recycling collected post-consumer waste PET Bottles and Multi-layer Plastic packaging into chips and granules, put into further use to make products with economic value. In line with its global sustainability campaign 'Project Plastic Fix', UFlex will steer its efforts towards keeping plastic in the economy and out of the environment, converting waste into wealth.

Below are more details on washing-recycling lines in Noida plant:

1) PET Bottle Line (PCR Line) – The Post Consumer Recyclate (PCR line) at UFlex is set up with the objective to recycle PET bottles, used and discarded by consumers, to form chips. The PET bottles will go through the process of crushing and washing and will finally get dried up before it reaches the extruder to form chips. Since the PET bottles are transparent and virgin in nature, chips derived as a result of recycling process will further be upcycled to manufacture a range of PCR grade BOPET film from UFlex called Asclepius. The Asclepius film can be used and reused for multiple applications like packaging and label material, creating a loop economy.

   The PCR line will recycle used PET bottles collected by NGOs and Waste Collection Agencies from Delhi NCR area. The line has the capacity to recycle upto 600 tonnes of PET Bottle waste a month.

2) The MLP Film Line (PCPR Line) – The Post-Consumer Plastic Recyclate (PCPR) line at UFlex Noida plant will wash and recycle post-consumer MLP waste and convert them into granules. The PCPR line will also pass the waste through the same process of crushing and washing before forming granules. The granules derived can be used to form more than 10,000 industrial and household products like flower pots, outdoor furniture, bucket, dustbins, paver tiles, road dividers etc.

   The post-consumer MLP waste collected from Delhi-NCR will be sourced from NGOs, Producer Responsibility Organizations (PRO) as well as Producers & Brand Owners directly. The PCPR line has a capacity to wash and recycle upto 500 tonnes of MLP waste in a month.

Ref: https://packaging360.in/news/uflex-gears-up-to-reduce-delhi-ncr-plastic-waste

Styrenics Circular Solutions members to initiate evaluation of Pyrowave plastic-to-plastic chemical recycling technology

Styrenics Circular Solutions (SCS), the joint industry initiative to increase the circularity for styrenic polymers, and Pyrowave, a pioneer technology developer in the plastic-to-plastic chemical recycling, announced a new collaboration including an in-depth evaluation of Pyrowave's proprietary depolymerization technology. To formalize this collaboration, SCS members INEOS Styrolution, Total, Trinseo and Versalis (Eni), global leaders in the manufacturing of polystyrene and other styrenic materials, are signing an NDA with Pyrowave, a necessary and usual step in such project.

Ref:https://packaging360.in/news/styrenics-circular-solutions-members-to-initiate-evaluation-of-pyrowave-pla

Tackling Odor Issues in Recyclates

Plastic recyclates produced from waste packaging have to meet high sensory requirements in order to be used for new products. Plastic recyclates often have off-odors, some of which have not hitherto been identified. The Fraunhofer Institute for Process Engineering and Packaging IVV has analyzed the sensory properties of post-consumer shopping bags made of low-density polyethylene (LDPE) and originating from different collection systems. More than 60 odorous substances were identified using combined chemo-analytical methods. The information gained provides a targeted strategy for avoiding off-odors. The results of this collaborative study with the Chair of Aroma and Smell Research at the Friedrich-Alexander-Universität Erlangen-Nürnberg and the University of Alicante have now been published.

In order to meet the targets of the new EU Packaging and Packaging Waste Directive concerning the recycling of packaging waste, new markets for recyclates produced from waste plastic packaging must be found. Recyclates produced from waste plastic packaging must have no off-odors if they are to be used as secondary raw materials for the manufacture of high-quality consumer products. Indeed, the off-odors in plastic recyclates prevent a closed cycle for the recycling of plastic packaging materials. Currently, there is a particularly high reusage rate for recyclates produced from polyethylene terephthalate (PET) bottles.

Ref:https://packaging360.in/news/reduced-off-odor-of-plastic-recyclates

Fluorescent technology illuminates food packaging recycling

PRISM, a UK based consortium which includes Johnson Matthey, Brunel University, Mirage Inks and CCL Labels, is poised to separate plastic to food-grade quality in a single step, transforming the sorting process in recycling facilities, it says. The technology can rapidly and efficiently distinguish between food-grade and nonfood-grade polymers, identify black plastics and tag full-length shrink-sleeves.

Ref: https://packaging360.in/news/fluorescent-technology-illuminates-food-packaging-recycling

Certification& Validation of Recyclability

Enkase™ - Fluorination barrier technology by Inhance Technologies approved by RecyClass

The findings of an independent laboratory testing of Inhance Technologies' Enkase fluorination barrier technology show that it is fully compatible with the recycling stream of HDPE containers as it does not pose any recyclability issues. This innovative technology is a chemical transformation of the surface of the plastic container, consisting of a fluorination treatment using elemental fluorine to enhance the properties of HDPE for hydrocarbon barrier packaging.

The technology is used for rigid packaging that is mainly destined for consumer-packaged goods, pharmaceutical, health and beauty, industrial and agricultural chemicals. EnkaseTM allows for preventing permeation of various ingredients through the container walls. It ensures the shelf life of the content as well as its efficacy.

UK universities develop bio polymers recycling technique

Researchers at Bath University in the United Kingdom say they have developed a new way to break down plant-based plastics, also known as biopolymers, into their original "building blocks," potentially allowing products to be recycled repeatedly without a loss in the quality of the plastic.

Plastic scrap recycling in the U.K. is on the increase, say the researchers, but one of the problems with current plastic recycling methods is that plant-based polymers such as polylactic acid (PLA) often are not welcome in the mechanical recycling stream.

"You end up with a lower quality plastic with worse properties than the original," the researchers say of PLA in the packaging stream. "This means that plastic drinks bottles cannot simply be recycled into new drinks bottles continuously but instead are used for other lower grade products, such as water pipes, park benches and traffic cones."

The scientists, which include those at the University of Birmingham, say they have developed a new way of chemical recycling -- converting PLA plastics back into constituent chemical molecules -- so they can be used to make "new plastics of the same quality as the original."

Ref: https://packaging360.in/news/uk-universities-develop-biopolymers-recycling-technique

Conclusion

The industry & academia have made tremendous progress in the area of recycling technologies. Every unit operation in this process involving collection, sorting, separation, conversion has the potential to evolve into a highly technological industry.

None of the major types of plastic materials recycling technologies will totally dominate in the marketplace. Rather plastic waste and type of waste availability by given global geography will dictate the specific recycling technology mix. For the foreseeable future, a combination of recycling technologies will be in use.

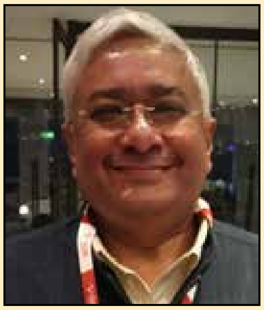
In any global geographic region, where efficiently sorted, higher quality, and potentially clear plastic waste is available; it will be best matched by lower-cost mechanical recycling. Limited polypropylene and polystyrene plastic waste streams lend themselves to pyrolysis and solvent-based recycling techniques.

- More specifically, geographies with high volumes of low-cost plastic wastes will lean to pyrolysis.
- In the same page, geographic regions where high volume, low quality PET predominates, depolymerization is the answer.

In India, however, PET recycling is already a model for others to emulate. Hence depolymerization may not be attractive at this stage.

The various developments show the tremendous business opportunities waiting to be unlocked for a sustainable environment.

Plastics Recycling in the New Normal.... Where do we go from here.....?



Sameer Joshi, Ph.D.
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- Plastics play a key role in protecting people, especially frontline workers, during the COVID-19 pandemic.
- Informal waste pickers are particularly vulnerable to the coronavirus pandemic.
- Corporations are rethinking recycling plans and sustainability commitments in the face of economic turmoil.
- The increase in single-use plastics will have long-term impacts. However which single use plastics will be not banned needs to be seen
- Affordable, omnipresent and versatile these plastics have been essential to keeping hospitals running and protecting our frontline workers during the COVID-19 pandemic. They're the backbone of the medical equipment and protective gear. They're even at the heart of innovative cross-industry collaborations to combat the virus; the luxury auto brand Ferrari, for instance said that it will produce the thermoplastic components needed for respiratory valves.

Apple designed plastic face shields for medical professionals and is shipping millions of them across the United States every week.

The demand skyrockets for masks, gloves, gowns and disposable bags, one thing is clear: plastics are indispensable, especially during a pandemic impact of COVID-19 and the extraordinary measures taken around the world have led to some tough questions for those working to combat plastic pollution. How do we support those in our community hit hardest by the outbreak? Can the recycling industry survive COVID-19? Can we still achieve a circular economy for plastics? And, how can we keep our work going in a world in which "normal" still seems so far away?

Yet with a general lack of job security or health benefits, waste pickers are also facing unprecedented threats to their safety and their livelihoods. Polystyrene, a.k.a. Styrofoam, the non-recyclable plastic that was being phased out pre-pandemic, is having resurgence as manufacturers such as Ineos Styrolution in Germany and Trinseo in the US see "double-digit percentage sales increases" in the food packaging and health care sectors, Bloomberg Green reports.

The pandemic could even reshape long-term behavior. In a 17-page draft document currently under review, the US Centers for Disease Control and Prevention recommends that reopening restaurants switch to disposable menus, plates, and utensils, and swap in single-portion condiments. Who knows how long these and other policies will stick?

Environmentalists also claim that the plastics industry is exploiting Covid-19 fears to demonize reusable's as potential vectors for the virus.

Indeed, the plastics industry is currently waging a "PR war" through front groups, corporate-funded research, and misrepresented medical studies in an effort to repeal existing and upcoming bans, says John Hocevar, director of Greenpeace's oceans campaign. THE oil prices, which makes virgin plastic cheaper to churn out than ever, aren't helping.

The plastic industry has really treated the Covid-19 emergency as an opportunity and is preying on people's fear to scare them into believing that single-use plastic is the best way to stay and so far, there isn't any independent scientific research that supports that."

Unlike disposable plastics, reusable bags and cups, he says, can be easily disinfected by washing with regular soap and hot water or throwing them in the dishwasher. Grocers might consider letting shoppers bag their own groceries or placing checked-out produce back in the cart so shoppers can load them straight into bins or bags in their cars.

In the new times personal protective equipment (like disposable face masks and gloves) and single-use packaging, discarded carelessly and left to flutter around the environment, pose the bigger threat to public health (not to mention generate even more plastic pollution.)

The concerns about the sanitation workers having to handle so much of this single-use plastic, including PPE, but also food and beverage packaging and bags are to be addresses

Because we're staying at home more, we're generating more trash Disposable plastic bags are only the tip of the landfill, though without comprehensive audits it's impossible to find out with any certainty if plastic consumption in the country is going up, headed down, or canceling itself out as reduced plastic employment by idling businesses makes up for increasing residential use. But we can extrapolate some trends.

With most restaurants shuttered and Americans hunkered down at home amid widespread lockdowns, takeout and food delivery services — which often employ disposable plastic containers — have skyrocketed in popularity. In the first quarter of 2020, the delivery marketplace Grubhub netted $363 million, a 12 percent jump in revenue over the same period last year. Its number of active diners currently hovers at around 23.9 million, a 24 percent increase from the 19.3 million who placed orders in the first quarter of 2019.

Amazon, which shipped more than 3 billion packages a year pre-pandemic, saw its revenue spike by 26 percent to $75.5 billion in the first three months of 2020 after it became a lifeline for shelter-at-homers scrambling for essential goods (toilet paper, Clorox wipes, hand sanitizer) and not-so-essential Most of those deliveries will come swaddled in plastic air pillows, shrink wrap, and poly-bags.

It seems an impossible situation. Some of the world's largest corporations promised to quickly slash their use of virgin plastic packaging. Yet the recycled material available to make bottles, bags and boxes has become harder to find and more expensive.

Markets already jagged from COVID-19 saw the price of crude oil drop below zero for the first time April 20, which also dragged down the value of virgin plastics. In the last three months, pricing nose-dived by 42 percent for high-density polyethylene HDPE) used in laundry bottles, by 43 percent for polypropylene used in yogurt tubs and by 14 percent for PET used in water bottles, according to RecyclingMarkets.net. Post-consumer recycled plastics look about as budget-friendly as diamonds

"It's the circle of life but not quite a circular economy," said GreenBiz Co-founder J. Where does this leave the businesses embracing circularity in plastics? More than 450 organizations have signed on to the New Plastics Economy commitment, sparked in 2018 by the Ellen MacArthur Foundation (EMF) and the U.N. Environment Program.

But have rock-bottom oil prices and the pandemic doomed the market for recycled plastics? In North America, already the supply of post-consumer plastic resin could only meet 6 percent of the demand, Closed Loop Partners Executive Director Allison Shapiro, who specializes in circular economy investments, said at a webinar in May 2020. If every company set a goal of 25 percent post-consumer content, they simply could not meet it. At the same time, the end market drives everything upstream.

Push for reduction and re-use: Rather than perpetuating the cycle of producing plastics for one-time use, even if they're composed of recycled material, companies should explore alternative business models for delivering products. Innovations such as Terracycle's "zero-waste" Loop service exemplify the opportunity. Even though Starbucks is rejecting reusable cups during the pandemic, Loop is still set to go national in summer of 2020

It s important, especially in this time, is to think about the reuse ecosystems that are potentially very risky that we're very comfortable with. The fundamental difference here is not that single-use or disposable is inherently safe, or that reuse is inherently unsafe: It's how you deploy those systems. Now is the time really to think act and do what the circular economy we talked of The following steps are needed

1. Cooperation is the starting point and a requirement for progress

Change is difficult to achieve without listening to all stakeholders, securing broad commitment and encouraging ownership of the process. Invest in the dialogue in different ways

2 Form a conceptual framework

Invest time in formulating a comprehensive situational picture or conceptual framework to have a baseline understanding of your country or area.

3 The road map must be agile to stay relevant

Continuous adaptation through supplemental actions is necessary to address changing needs.

4 Create measurement indicators, monitor development and set stages for the journey

Establish a clear set of indicators to measure progress toward goals and assess progress on a regular basis to capture lessons learned and adjust as needed

5 Invest in the execution
Make participation possible

Plastics Recyclers Europe (PRE) issued a statement on May 15, 2020 urging the EU and member states to include recycling as one of the sectors supported by their recovery plans and to continue implementing measures under its Circular Economy umbrella because of the current pressure on the industry.

PRE warned that the plastics recycling industry is closing production as a result of the crisis, citing low demand on the back of convertor closures, and the low price of virgin plastics along with decreased global activity.

It is certainly true that the recycling industry is facing significant short-term disruption and strain as a result of the COVID-19 pandemic including financial pressure not seen since the global economic downturn in 2008.

Packaging demand in April 2020 fell by 20-30% across European recycled polymers because of substitution back to virgin, despite underlying packaging demand remaining strong due to home workers using more packaged goods.

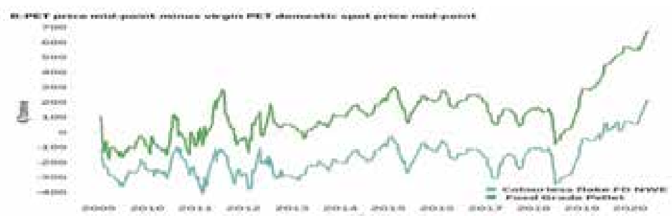
Demand for non-packaging applications has ground to a virtual standstill due to widespread closures, particularly from key end-uses such as automotive and outdoor furniture, which have been most severely affected. In recycled polymer markets such as recycled polypropylene (R-PP), for example, where the majority of end-use is for non-packaging applications such as automotive, outdoor furniture, construction and flower pots

- almost all European flower pots are now made from R-PP - demand in April fell by around 50% year-on-year.

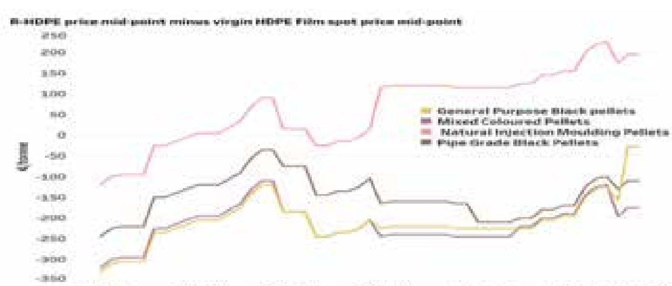
For maturing recycling markets such as recycled polyolefins (R-PO) growth in 2020 had been expected to be strong because of increased use from the cosmetics and household goods packaging sectors.

Delays to investment now make it increasingly likely that there will not be enough material to hit 2025 brand and regulatory targets, resulting in increased competition for material and an increased disconnect between virgin and recycled material pricing. Strong demand and lack of supply had already resulted in a disconnect between virgin and recycled polymer prices for grades most attractive to the packaging sector. A two-tier market between packaging applications - where prices are now largely driven by demand and sustainability factors- and non-packaging applications - where prices remain driven by cost-saving against virgin, had arisen.

The charts here show the spread between virgin and recycled polymer grades - with zero on the graph representing price parity, above zero meaning recycling prices are more expensive than virgin and below zero meaning they are cheaper. The first is the spread between R-PET colourless flakes and food-grade pellets and Virgin PET spot values.



The second graph shows the R-HDPE pellet price spreads with virgin HDPE film spot prices



The final graph shows the spread between natural R-PP pellet prices (which are a mix of homopolymer and copolymer) and the various grades of virgin spot prices.

All three graphs show the increase in volatility since the spread of the pandemic in March. This volatility has increased uncertainty in the market, and multiple players have switched from contract to spot pricing as a result - particularly in France where pre-pandemic post-consumer waste prices were typically agreed on a quarterly basis but are now typically being concluded on a spot basis across all recycled polymers.

FMCG brands remain committed to their recycling targets, with no delay so far announced. Some regulations, such as the Italy plastics tax that was due to come in to effect in June, have been pushed back. There has been an absence of new legislation, but no regulation has been abandoned and there has been no sign of any shift in regulatory approach once the coronavirus crisis has been overcome. There has also been no signal of any change in consumer attitudes to recycling, with the pressure to avoid waste remaining high.

Indeed, the economic fallout from COVID-19 may make further legislation more likely in the mid-term since plastic taxes, deposit return schemes and extended producer responsibility initiatives are simultaneously potentially revenue generating and unlikely to draw negative public reaction at a time when central governments are looking to recoup emergency expenditure. This could make them an attractive option for governments across the globe once the economic recovery is under way.

Virgin polymer prices have fallen sharply in response to COVID-19, particularly following the crash in crude oil values. This has placed significant pressure on non-packaging recycling grades in April and May, and a growing disconnect between virgin and recycled values has also added pressure on packaging grades so that recycled values do not price too high above virgin. Nevertheless, even outside of R-PET, substitution back to virgin is not the sole result of low virgin values. It is also being driven by security of supply concerns, ease of use, and limited workforces.

This reduction in demand may well prove to be a short-term consequence of COVID-19 logistics disruption, with consumption returning alongside workforces once lockdown restrictions ease. The specific potential opportunities in the present crisis lie with brand owners and petrochemical firms.

The sustainability agenda is unlikely to subside in the mid-to-long term. Without investment, shortages are likely, and some firms can be expected to miss their targets.

Brand owners and petrochemical firms can no longer ignore sustainability without facing significant consumer backlash, regulatory consequences and potential lost business.

At the same time, it would in the longer-term ensure these firms achieved their targets and embed them more deeply in supply chains at a time when investment is likely to come at a discount. It would also signal a deep-seated commitment to the sustainability agenda.

(GRAPHS COURTESY ICIS.COM)

Recycling plastic waste into composite products

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Guide: Dr. Shantanu Bhowmik, Professor: Department of Aerospace Engineering and Head Research & Projects
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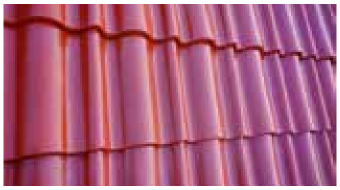
Abstract : The project is supported by Amrita Technology Business Incubator (TBI) with the help of grant from Nidhi-Prayas. The students have incorporated a recycling startup R-Cube Plastics incubated at Amrita TBI. They have developed low cost and low weight roof tiles and pavement tiles. A single pavement tile could withstand upto 2 ton of compressive load. The strength of the product is equivalent to concrete, which is made from 100% recycled plastic.

Pavement tiles



Pavement tiles

Problem worth solving

Plastic is the most used man-made material in the world. It plays a major role in almost all industries like packaging, electronics and appliances, construction and transport. Unfortunately, most of the plastic items are a one-time use product and then they are disposed into the environment. Due to Plastic being relatively non-degradable in nature, they are predicted to have harmful impact on the environment. They tend to be either thrown into the ocean or made into huge garbage mountains in landfills. The reasonable way to be free of all plastics waste would be recycling them into products with a longer lifespan. But the major problem in recycling is that in the process properties of plastics are reduced by half to that of virgin plastics, due to which only 9% of the total 9 billion tons of plastic has been recycled. Even though we ban the use of single use plastics that will just account to 5-10% of the plastics waste generated. We are still left the 90% of the plastics generated per day.

In addition, when the plastic waste is thrown into the ocean the aquatic animals mistake those plastic waste as food and consumes them, because of which many aquatic species are in the verge of extinction in the last few years. The plastic when encountered by UV rays in the ocean also break down into microplastics which in turn is consumed by the planktons which are the producers in the food chain, thus risk entering into the food chain and affecting almost all the living organism in our world.

Our Solution

The major disadvantage of recycled plastics is its quality and strength. By the proposed process, recycled products can be provided to customers with better property at a lower cost than virgin plastics. Our solution can be applied to all the major plastics in the plastic industry namely LDPE, HDPE, PET, PP. Currently only PET bottles has an efficient recycle process. The plastic industries can be considered as a competitor. While in most circumstances you use a blend of virgin and recycled materials, with the proposed developed solution you are able to create products with 100% recycled plastics.

Target Market

The product would drastically help to improve the environment and it has been noted 73% of the millennials are ready to pay more if the products have a cause or if it's helpful to the environment*. According to their latest "Eco Pulse" trending data, they have found that 90% of millennials will buy from a brand whose social and environmental practices they trust, and 95% of them will recommend that brand to a friend*. The target market proposed would be Millennials.

Products

The main advantage of the raw material is that it is moldable into any desirable products. Some examples of applications are as

- Infrastructure : - Lumber - Roof Tiles - Floor Tiles - Doors - Bins
- Furniture : - Tabletop Planks - Bench
- Road & safety : - Divider Blocks
- Outdoor Sports : - Boats

In conclusion, one of the biggest beneficiary is Country's economy. By recycling plastic wastes into useful products we can evolve a new economic vertical creating 6 times more jobs than just discarding plastic wastes. The waste plastics need not be discarded in landfills and the real estate can be used for city developments including parks and much needed healthcare.

Recycling of Thermosets: An Upcoming Challenge

Arnav H. Joshi

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Polymers are observed in different areas of day to day life from small household articles to large industrial articles. A polymer is a macromolecule formed by a chemical reaction between a number of repeating units of the same or different monomers. About 10% of crude oil obtained from petroleum resources is used for the manufacturing of polymers; there is a safety concern with both feedstock as well as the end of life of these materials. As we know, the use of polymers has made modern life very simple as these materials were discovered for replacement of heavy metallic components because of manufacturing costs, weight-to-strength ratio, and amount of energy required. At the same time, the excessive use of polymers is causing various types of waste generation. The waste generated is non-biodegradable and remains in the water, soil without getting affected for about 400 years. Therefore polymer waste management requires an immediate solution to the problem for sustainable development. In this article we are going to take an overview of how recycling of thermoset materials is going to be an upcoming problem in front of the world and what are various possible solutions in order to control the amount of waste generated.

There are mainly three types of disposal technologies used for reducing the polymer waste, namely, landfill, incineration (combustion of organic substances present in the material and converting it into ash, flue gas and energy in the form of heat) and recycling (conversion of waste generated into new materials and objects) in the world (Refer to figure 1).

Figure 1. Methods used for polymer waste management in the world (in percent). [https://datatopics.worldbank.org/what-a-waste/trends_in_solid_waste_management.html]

The polymers are classified as thermoplastics, elastomers, and thermosets. The recycling of thermoplastics is relatively easy to carry out than for thermosets and thermoset containing composites. In thermoplastic recycling, the molded products can be again remolded into different shapes by application of heat, for different applications for several times with deterioration in physical and mechanical properties whereas for thermoset materials on application of heat results in an irreversible hardening formed by curing of soft solid, by curing of viscous liquid prepolymer or resin. This results in the formation of crosslinks in the structure. This crosslinking gives the material a permanent shape that cannot be remolded. Most of the thermoset materials on heating to a very high temperature starts degrading without undergoing the melting phase.

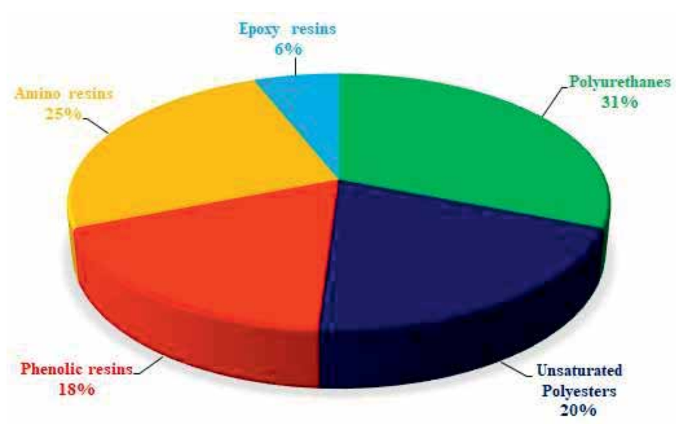


Figure 2. Annual Thermoset consumption in the world (in percent). [1]

Thermosetting materials such as epoxies, unsaturated polyesters, vinyl esters, polyurethanes, and phenol-formaldehyde are widely used in paints, adhesives, and sealants, foams for upholstery and insulation, automotive and transportation, electrical and electronic applications (Refer to figure 2).

The methods of thermoset recycling are classified into four types (Refer to figure 3).

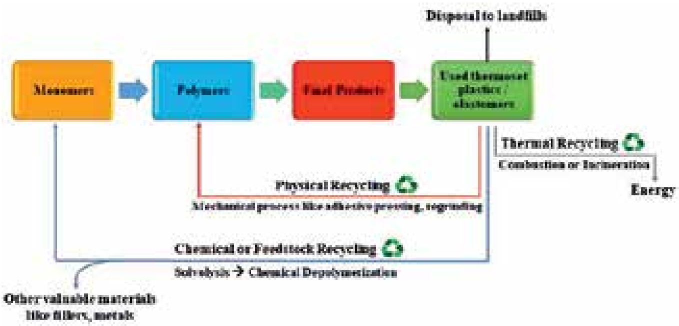


Figure 3. Schematic representation of polymer waste management process. [2]

Physical recycling: [3]

Mechanical or secondary recycling is a process where the recycling of thermosetting waste is carried out by physical means. In this technique, there is a change in the physical form of the polymer from larger scrap particles into small pieces which are known as recyclates. For example, a grinding or shredding process is carried out for reducing the size of the waste material scrap and reusing it as fillers or partial reinforcement in a new composite material, binding of the pieces of shredded material together with the help of binder and then molding the product using compression or injection molding. In the case of adhesive pressing method, the surface of polymer particles is coated with the help of an adhesive binder and bonded in a heated press (Refer to figure 4). A large amount of mechanical energy is consumed.

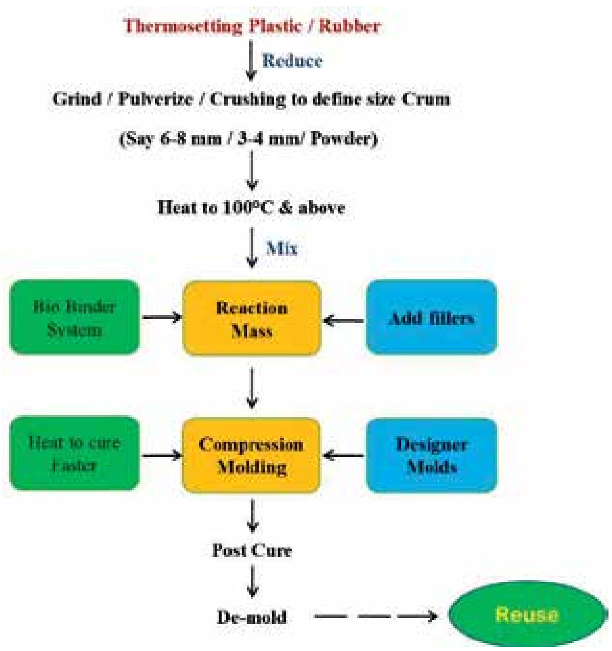


Figure 4. Mechanical recycling flow diagram

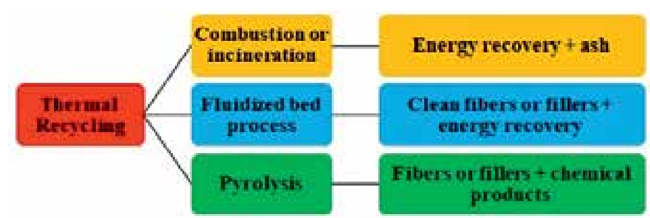
Chemical or feedstock recycling: [3]

In chemical recycling or feedstock recycling the disintegration or depolymerization of thermoset polymer matrix into their original reagents or in the form of the small organic compound takes place with the help of chemical reagents, catalysts, temperature, and pressure. This process is widely used for the recovery of monomers and their derivatives, reinforcements like glass fibers, carbon fibers. These monomers can be again re-used for polymerization of the original polymer. On partial depolymerization into oligomers or other organic compounds as they can be used as a feedstock or as a raw material for obtaining new materials. The depolymerization of resin is achieved using hydrolysis (using water), alcoholysis (using alcohols), glycolysis (using glycols), and aminolysis (using amines). During the solvolysis process, the reaction parameters such as solvent concentration, reaction time, reaction temperature (upto 100 for hydrolysis, alcoholysis, and aminolysis process and greater than 150 for glycolysis process) and pressure play an important role in determining the rate of depolymerization and also its efficiency. Due to low energy requirements, ability to feedstock, and also material flow being cyclic, this process is very profitable and beneficial for achieving sustainability.

Thermal recycling: [3]

Thermal recycling is a process where the breakdown of the polymer matrix takes place by the application of heat. Due to higher processing temperature, the volatile materials (mostly organic materials) undergo degradation leaving behind inorganic materials. This process can be used for the recovery of glass fibers, inorganic fillers from composites. The quaternary recycling method is classified as (Refer to figure 5),

Figure 5. Classification of Thermal recycling [3]



In combustion or incineration, the energy recovery can be carried out from a large amount of residue present in the organic content. In the fluidized bed process, thermal degradation is carried out for the recovery of fillers, fibers, and energy. Pyrolysis technique utilizes a heated, oxygen-free environment to pyrolyze waste material into gases and a mixture of monomers is used to carry out the recovery of chemical fillers and fibers after degradation is completed.

References:

1 *Shrikant K. Bobade, Nagarjuna Reddy Paluvai, Smita Mohanty & S. K. Nayak, "Bio-Based Thermosetting Resins for Future Generation: A Review", Polymer-Plastics Technology and Engineering, 55 (17), 1863-1896 (2016). [https://doi.org/10.1080/03602559.2016.1185624]*

2 *Meltem Okan, Halil Murat Aydin, Murat Barsbay (2018), "Current Approaches to Waste Polymer Utilization and Minimization: A Review", Journal of Chemical Technology & Biotechnology, 94, 8-21 (2019). [https://doi.org/10.1002/jctb.5778]*

3 *Sankar Karuppannan Gopalraj, Timo Kärki (2020), "A review on the recycling of waste carbon fibre / glass fibre -reinforced composites : fibre recovery , properties and life -cycle analysis", SN Applied Sciences, 2(3), 1–21. [https://doi.org/10.1007/s42452-020-2195-4]*

Role of Healthcare Plastics In The Circular Economy

MEDICAL PLASTICS
For Healthcare, Medicare & Hygiene

D. L. Pandya
Editor & CEO
Medical Plastics Data Service

In the twentieth century, the dominant model of production and consumption was linear. Firms made products, and consumers used and disposed them of. More recently, however, the trend is to reduce, recycle and reuse products, thus giving rise to a circular economy.

The Rise of the Circular Economy

A circular economy is restorative and regenerative by design. This means that materials constantly flow around a 'closed loop' system, rather than being used once and then discarded. As a result, the value of materials, including plastics, is not lost by being thrown away.

World Economic Forum has estimated that circular business models could increase value of the global economy by $1 trillion annually by 2025, and create 100,000 jobs over the next five years.

According to Ellen MacArthur Foundation, India could reap $624 billion in annual benefits in 2050 and reduce greenhouse gas emissions by 44 per cent by adopting the circular economy principles – through reuse and recycling of waste and resources. If done right, India could lead the world into a circular low-carbon economy.

India could gain much if it were to adopt the circular economy. Each day, India generates over 100,000 tonnes of solid waste, more than any other nation.

Plastics are a significant share of Hospital General Waste

85% plastic waste generated is non-hazardous.

Between 20-25 % of such waste could be attributed to plastic packaging and products.

The quantity of healthcare waste produced in a typical developing country depends on a wide range of factors and may range from 0.5 to 2.5 kg per bed per day.

As per US Healthcare Plastics Recycling Council , By weight, almost 5 million pounds (or 40%) of plastic scrap generated at US hospitals is sterilisation wrap. Another 25% comprises other types of flexible non-woven and film packaging, while 19% represents paper, roughly 10% are rigid plastics. Around 5% is a mix of glass, metal, and foil.

Healthcare facilities across America generate around 14 000 tons of waste per day. Up to 25% of this is made up of plastic products such as packaging.

Good Potential for Recycling

All Healthcare Plastics Can be safely and effectively Recycled and Widely Accepted As A Valuable Resource.

Some of the most common recyclable medical plastics include the following:

Tyvek, made from high-density polyethylene, is a common material used in sterile barrier packaging.

Sterilization wrap, often referred to as blue wrap, is a sterile material made from polypropylene (PP) that protects surgical instruments and other items from contamination.

Saline bottles are a common operating room product, typically made from PP.

Water pitchers, basins and trays are common patient care products, typically made from polyethylene terephthalate.

The fact is that a lot of materials are incinerated or landfilled without reason.

All Hospitals Must Find New and Innovative Ways To Reduce Waste Generation While Diverting More Material From The Land Fill and Ensuring Safe Disposal for More Toxic Waste Streams.

Ways to Minimize the Impact of Medical Plastic Disposables

Environmentally minded staff in hospitals have been the primary driving force in the successful implementation of recycling systems. However, the entire supply chain has a role to play. That begins with the medical device manufacturer, who should keep end-of-life issues in mind when designing devices, and extends to hospital purchasers and healthcare professionals, who are doing the actual sorting, and to the recycler and converter, who are going to buy the recyclate and make new products.

Where disposables are the only safe option, there are ways to reduce their footprint, starting with how they are packaged. Sometimes the packaging is quite excessive, an instrument might be packaged in a package in another package. The hospitals should get together and insists on manufacturers to reduce packaging.

AN INSPIRATIONAL JOURNEY

Shri Madhusudan Balvantrai Shah

Shri Madhusudan Balvantrai Shah was one of the most versatile plastics professional turned successful entrepreneur, and, respected by one and all for his missionary service to the plastics industry. Till the end he remained enthusiastic learner as well as teacher of plastics all through his life. He was a first class Plastics Technologist, with over 6 decades of wealth of experience in various plastics fields, was a well known personality both in the Indian plastics industry & globally too in various countries especially in Europe & Asia.

Knowledge Seeking

Shri Madhu Shah, - Madhubhai to his friends, obtained his B.Sc (Hons.) degree in 1956 from Bombay University. He then joined University Dept. of Chemical Technology and studied Plastics Technology under Prof. N R Kamat. He chose little known field of Plastics for making his career over other more popular career streams. This nature being different to others remained as his characteristic throughout his life. He graduated from UDCT obtaining B.Sc Tech in Plastics Technology with first class in the year 1958.

In his pursuit of gaining in-depth knowledge, he chose to work in plastics processing factory. The hands-on working experience on shop-floor helped him experiment with his creativity to find innovative solutions to various problems encountered in processes and build skills to relate with people. Some of his early accomplishments were means developed to segregate tons of plastics PS, PE, CA, CAB etc- swept off the floor with non-plastic extraneous materials into individual reusable plastics raw materials., producing LDPE film for laminating on bituminized Hessian cloth, developing Poly-sleeves for Tea Garden Nurseries (Tea-saplings). This phase was followed by new product developments such as

(a) Direct Polycoated jute with permissible low WVP, a challenge overcome by machine modifications and improved process technology on Zimmer

(b) developing special polycoated / sandwiched papers for Defence to meet stringent requirements

(c) producing blow molded bottle crate (BEKUM)

(d) producing rigid PVC clear / opaque bottles- and product launch to successful commercialization of products.

The Visionary

In 1979, Madhubhai joined SLM-Maneklal, where he took upon the challenge of convincing entrepreneurs to buy sophisticated automatic but costly Kautex-Maneklal, Blow molding & Toshiba-Maneklal Injection molding machines . He designed strong value aided customer support services to help them succeed in new / existing ventures.

Having gained wide experience on product, processing and building people relationships during his professional career, Madhubhai started his entrepreneurial career in 1984. First it was a consultancy firm to help entrepreneurs set up new projects after proper market survey and/or to upgrade the production technology in the existing plants so that the company becomes producer of top class product and remains competitive.

In 1991 onwards his emphasis changed over to marketing. In view of his exposure to the international plastics industry, he could easily develop business relationships especially with technocrat owned overseas companies producing high-tech products at competitive price. Thus born was Madhu Marketing & Services providing innovative pioneering solutions, and, a quality supplier of Machines, Hot Runner Systems, Conventional / Innovative Ancillaries / Molds & Mold parts & complete Tooled up project, many of these technologies being introduced for the first time in the Indian Plastics Industry. In view of his pioneering efforts, he is widely regarded as the 'father' of the Hot Runner Industry evolution in India.

As a further service to the Plastics Industry, Madhubhai established 'TECHNOLOGY CENTRE' of Madhu Machines & Systems Pvt Ltd, in Bangalore. The centre provides additional knowledge to students passing out from institutes like NTTF, CIPET, IPI etc. on Plastics Processing machines, Innovative ancillaries, Hot runner system, Mold parts, etc. The company, in its current form was established at Vadodara and further expanded in manufacturing activity at Bangalore since 2012 producing Speciality Ancillaries, Additional Injection Units and Hot Runner Controllers under its own brand for domestic and overseas markets. The company now has two manufacturing units in Bangalore with service support infrastructure across all major plastics industrial centres throughout the country.

An Industry Patron

Madhubhai firmly believed in paying back to the plastics industry from which he had benefited all along. He was active member and Secretary of Plastics & Rubber Institute (Bombay Chapter) in 70's. His dedication and commitment to Plastics Industry and Plastics Institute has been total. In recognition of his contribution to the development of plastics industry and services to the Plastics and Rubber Institute (LOND) and later to Indian Plastics Institute, he was awarded AMPRI (LOND) in 1974, FPRI (LOND) in 1984 & FIPI (Ind) in 2003. Another highlight was when he was recongnized by the Austrian Chamber of Commerce for having furthered & greatly influenced the Indo-Austrian trade for equipment used in the plastics industry in the year 2008. He was awarded the most prestigious "Lifetime Achievement Award" by IPI in 2013.

He has actively served as Convener and Chairman Vadodara Chapter, Chairman of International Conference Committee for two terms and President of IPI. He was also Managing Committee member of PLASTINDIA FOUNDATION for 3 years (2003-2006). He was Chairman of Education Committee of PIF during the said period. He conducted 2 day Programmes on 'UPGRADATION OF PRODUCTION TECHNOLOGY' at Mumbai, Kolkata and Chennai. He has also served as Paper Setter and Examiner at UDCT & HBTI (Kanpur) & Hon. Lecturer at IIP, GIRDA & IPI. Madhubhai greatly contributed towards the conceptualization and modernization of the diploma (DIPI) course at Indian Plastics Institute.

A Complete Human Being...

Throughout his life, Madhubhai was connected with various social service activities and especially involved with Brahma Kumaris. His passion for singing and playing music kept him connected with finer joys of life.

Madhubhai will be long remembered for his enthusiasm, entrepreneurship and servitude towards the Plastics Industry.

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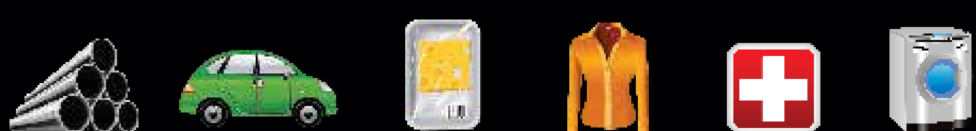

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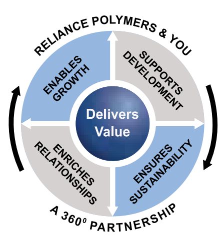

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