NATIONAL SOLID WASTE ASSOCIATION OF INDIA

Waste MONITOR

VOLUME 2 ISSUE 1 JUN 2019
ONLY FOR PRIVATE CIRCULATION

CLIMATE CHANGE

CIRCULAR ECONOMY

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PLASTIC WASTE
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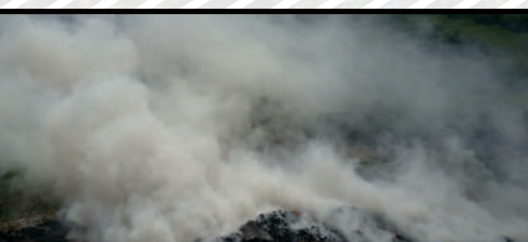


NATIONAL SOLID WASTE ASSOCIATION OF INDIA

ACTIVITIES
during the period of June 2018 to May 2019

PG DIPLOMA IN INTEGRATED SOLID WASTE MANAGEMENT & ENGINEERING BY EMINENT FACULTY & INDUSTRY EXPERTS AT K.J. SOMAIYA COLLEGE OF SCIENCE AND COMMERCE (7TH JUNE, 2018)

NSWAI PARTICIPATION IN IFAT INDIA 2018

CONFERENCE ON "SUSTAINABLE PRACTICES IN SOLID WASTE MANAGEMENT IN INDIA" SNDT WOMEN'S UNIVERSITY, JUHU, MUMBAI (1ST FEB, 2019)

DR. AMIYA KUMAR SAHU, PRESIDENT, NSWAI,
AS A GUEST OF HONOUR AT BISHOP HEBER COLLEGE TIRCHY, TAMILNADU AND
SIGNED MOU TO INTRODUCE PG DIPLOMA COURSE IN SOLID WASTE MANAGEMENT (22ND MARCH, 2019)

Contents

Waste MONITOR

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Published by
National Solid Waste Association of India
Mumbai

Only for Private Circulation

President's Note

Plastics and climate change are linked in a variety of ways. From air quality to ocean toxicity, plastics especially plastic bags contribute to eco-system disruption. Habitat destruction, fossil fuel emissions, and plastic pollution are some of the ways that plastics and climate change cannot be separated. Millions of oil barrels are used to manufacture plastic bags each year, which is equivalent to the amount of Strategic Oil Reserve. Such usage is wasteful and unnecessary way to deplete oil supply and contribute to CO2 build-up in our atmosphere.

An estimated 100,000 marine animals die each year from suffocating on or ingesting bags due to build up of plastic in our oceans. This number seems small when compared to the huge quantity of plastic bags that wash into our waterways. These small pieces of plastic are accumulating at an alarming rate in our oceans.

All this plastic is toxic and may be affecting our food supply. One of the main toxins is dioxin, an endocrine disruptor, or so-called gender-bender pollutant. Increased levels of man-made pollutants are showing up in remote areas like the arctic, affecting polar bears and other arctic mammals and further adding to the stress of adapting to new climate realities and habitat changes. We really should wonder how these pollutants are affecting us!

Many people responsibly dispose of their bags, but even when disposed of properly, they can pose a threat. Dioxin and other toxins can leach out of landfills, further contaminating waterways and oceans.

Waste Monitor intends to spread awareness about right practices by bridging the critical information gap in the waste management sector and assist industries, municipalities, NGOs and others by providing professional guidance from experts.

While it is a fact that we are currently inundated with information from various forms of media, Waste Monitor will attempt to bring in relevant information and meaningful intelligence on the sector for the stakeholders.

We will include news, analyses of current events, and success stories not just from India but also from across the globe that could be of interest to our readers. In this way, the bi-annual magazine will have an International outlook but with its concerns focusing on Indian reality. ■

Dr Amiya K Sahu
President

Editorial

Through each of the issues of Waste Monitor magazine, we attempt to highlight some specific topics related to conservation of environment. In this June 2019 issue, we attempt to focus on 3 topics, viz. Climate Change, Circular Economy & Plastic Waste.

The world can maximize chances of avoiding dangerous climate change by moving to a circular economy, thereby allowing societies to meet the goals of the Paris Agreement on Climate Action.
(https://unfccc.int/news/circular-economy-crucial-for-paris-climate-goals)

This is the key finding of *The Circularity Gap Report 2019*, released by the organization Circle Economy at Davos during the annual meeting of the World Economic Forum.

A circular economy is a regenerative system in which resource input and waste, emission and energy leakages are minimized by slowing, closing, and narrowing energy and material loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing and recycling.

The report highlights the vast scope to reduce greenhouse gas emissions by applying circular principles – notably re-use, re-manufacturing and re-cycling - to key sectors such as the built environment. Yet it notes that most governments barely consider circular economy measures in policies aimed at meeting the Paris Agreement target of limiting global warming to as close as possible to 1.5°C.

In light of the above in this issue, Dr. Prasad Modak illustrates the aspects of Circular Economy. We are sure this article will bring sufficient insight into Circular Economy.

Mr. S. K. Ray, while highlighting problems of Plastic Waste Management in India, co-relates it to Circular Economy in terms of better plastic waste management.

The Climate Change is related to GHG emissions, as everyone knows now. However while focusing on GHG, all the emphasis is on usual methane & carbon monoxide. One important emission is neglected, but it much more potent GHG i.e. carbon emission or in other words, carbon particles that are emitted, while openly burning the waste. Looking at its higher GHG effect, carbon emissions need to be studied more, as rightly pointed out by Prof. David Wilson.

Usually in the world, developed countries are looked upon as responsible countries in terms of waste management & more enlightened in terms of GHG emissions & climate change. However Dr. David Newman, brings out a very controversial issue of dumping of plastic waste by these same developed countries into unsuspecting third world, undeveloped countries to avoid the very responsibility of scientifically destroying this plastic waste. They very well know that in the underdeveloped countries it is most likely that this waste usually is disposed in unscientific way leading to severe GHG emissions. All this is just to save money i.e. investment & operating cost in waste disposal projects. Dr. David Newman highlights this selfish attitude of developed countries.

The e-Waste disposal is another well-known problem all over the world. It is a common knowledge that unscientific disposal of e-Waste leads to GHG emission. Dr. Laxmi Raghupati highlights the e-Waste disposal aspects in India.

The sewage treatment is done by aerobic treatment, wherein a significant quantity of bio-sludge is produced, which proves to be a disposal problem. This is experienced all over the world. The biodegradable waste disposal is another problem. In both these cases, GHG gas methane is emitted. Dr. Ashish Sahu, illustrates how a co-digestion of both sewage sludge & biodegradable food is done to help solve the problem of sewage sludge disposal. This novel method will prove to be a boon to all municipal bodies.

While all of the above articles co-relate to Climate Change on mega levels, at micro levels too there are some issues, which add to the problems. In India, there are several forest areas of tourist interests & places of pilgrimage, where negligent behavior of visiting people lead to plastic waste problems. If not controlled in proper manner, it will further add to the menace. Dr. T Sekhar brings out this point in poignant manner.

I am sure all these articles from very learned & experienced authors, will add to the readers' knowledge about Climate Change. The importance of Circular Economy to control the burgeoning problem of waste, especially the plastic waste, will be understood very well. Happy reading. ■

Dr. Harshvardhan Modak
Editor-in-Chief

Don't waste our Climate

> ***To gain an insight into such economy-wide savings in GHG emissions, it is necessary to move from IPCC 's narrow ' carbon accounting' to a methodology such as life cycle assessment (LCA). Better resource and waste management has the potential for reducing GHG emissions across the World economy by 15, 20 or 25% or even more.***
>
> **David C Wilson,** *Visiting Professor, Imperial College London*

David C Wilson *has worked as a waste and resource management consultant in both developed and emerging economies since the 1970s, including several projects in India. He has been a Visiting Professor at Imperial College London since 2000. He was appointed a Member of the Order of the British Empire (MBE) in the UK's 2006 New Years Honors List, 'for services to waste management in the UK and Europe'. He was the editor-in-chief and lead author for UNEP and ISWA's inaugural Global Waste Management Outlook (2015).*

A key challenge in implementing the Paris Climate Agreement is to prioritise opportunities for significant short- and medium-term reductions in greenhouse gas (GHG) emissions across the economy. I am frustrated that we as resource and waste management professionals are not doing more to promote the potential for our sector as one such 'entry point'. A major reason is the often-reported headline result that solid waste management contributed around 3% of total GHG emissions in 2010. I will argue here that this is a gross under-estimate of the potential reductions that could be achieved through better resource and waste management.

Climate science comes under intense scrutiny and the Intergovernmental Panel on Climate Change (IPCC) as its UN custodians rightly take a very careful approach in their official publications. They define their base year; segment the economy into sectors taking great care to avoid any overlaps which could lead to double counting; and only include emission sources for which the data meets a quality threshold.

The IPCC's definition of the waste sector includes 'solid waste disposal on land' (with the major emission being methane from landfills), 'wastewater handling' (methane from anaerobic digestion), 'waste incineration' without energy recovery and 'other' (which is effectively limited to composting). Other components of waste management, including transport, recycling, agricultural use of compost and waste incineration with energy recovery, are reported under other IPCC sectors.

Using this definition, the IPCC's latest 5th assessment report estimates the contribution of the waste sector to global GHG emissions in 2010 at 3-5%. Of this total, 97% is due to methane emissions, split roughly equally between methane from landfills and from wastewater. Methane is dominant, at least partly because it is around 30 times more powerful than CO_2 as a GHG.

Let us begin by considering the base date of 2010. More than half of global waste generation at that time was from high-income countries, which had already substantially reduced methane emissions from landfills. For example, changes in Germany's waste sector between 1990 and 2006 reduced the country's total GHG emissions by 5%, and this was in addition to the significant mitigation of methane emissions already achieved between the 1970s, when environmental controls were first introduced, and 1990. Beyond 2010, waste generation is rising fast in the medium- and low-income countries. So it appears that 2010 likely represented a minimum point in the contribution of the waste sector to total GHG emissions.

There is then the very narrow definition of the waste sector, which means that their estimates necessarily omits those emissions displaced through waste prevention, reuse, recycling and biogenic energy recovery, as these savings would be credited by the IPCC to other sectors of the economy. For example, using recycled materials in industrial production to displace virgin materials significantly reduces GHG emissions, both by reducing direct energy consumption in the production process – e.g. in glass production by 35%, paper and steel over 50%, plastics over 70% and aluminium over 90% – and by the indirect upstream avoidance of mining, processing and transport of primary raw materials.

To gain an insight into such economy-wide savings in GHG emissions, it is necessary to move from IPCC's narrow 'carbon accounting' to a methodology such as life cycle assessment (LCA). One study for the German government, applying LCA to four example countries - Germany, Turkey, Tunisia and Mexico - estimated that a 10-15% reduction in global GHG emissions could be achieved through improved solid waste management, including landfill mitigation and diversion, energy from waste and recycling[1].

Including waste prevention could further increase this estimate, although quantifying that is challenging to say the least. To take just the example of food waste, the UN Food and Agricultural Organisation (FAO) has estimated that 1.3 billion tonnes of edible food waste is generated every year, representing one third of all food produced for human consumption and enough to feed all the hungry people in the World twice over. Prevention of this food waste would reduce total global GHG emissions by 9%: more than the total emissions of any country other than the US and China. And it's not just GHG emissions: work by my colleague Stephen Smith at Imperial College suggests that prevention of edible food waste could also reduce global water use by 15%.

Overall, the inaugural Global Waste Management Outlook, published in 2015 by UNEP and ISWA and for which I was editor-in-chief, concluded that the potential impact of improved resource and waste management on reducing GHG emissions across a broad range of economic sectors could be 15-20%.

However, even that estimate still ignores the third restriction imposed by the IPCC's careful approach, that only emission sources for which the data meets a quality threshold is included. The main issue here for our sector is black carbon emissions from the open burning of wastes. The relative quantities may be small compared to methane from landfill, but black carbon is around 2,000 more powerful than CO_2 as a GHG, and has an even shorter half-life than methane. Both are classified as short-lived climate pollutants, which are particularly interesting for climate mitigation in the short term as the impacts will be felt much more quickly than for CO_2.

Modelling studies of the generation and impact of black carbon from open burning have attracted much publicity: the estimated contribution amounts to 5% of total GHG emissions[2], causing 270,000 premature deaths a year[3]. These estimates are based on broad assumptions and are particularly uncertain. Real data are understandably hard to come by as to how much solid wastes are disposed of by open burning, either by households or at uncontrolled dumpsites. Also, emission factors – i.e. how much black carbon is produced by burning a kilogram of waste – have been based on just a couple of field measurements. My PhD student at Imperial College London, Natalia Reyna, has been working to address these data gaps for the last few years, with one objective of helping to meet the IPCC's quality criterion so as to allow black carbon emissions to be included in their next assessment report due in 2022. Our early results suggest that the CO_2 equivalent of black carbon emissions from uncontrolled burning in backyards in Mexico was fifteen times larger compared to methane released from the decomposition of equivalent amounts of combustible biodegradable waste disposed at a final disposal site . This suggests that urgent action is needed to reduce domestic open burning of waste and that this would have a significant impact, both on improving local air quality and respiratory health, and on reducing climate change.

Putting all of this information together, one could make a case that better resource and waste management has the potential for reducing GHG emissions across the World economy by 15, 20 or 25% or even more. Such numbers by their nature are guesstimates, and as such are anathema to climate scientists. However, whatever number we choose to use, the message is still the same. Our sector provides a useful entry point to make very significant contributions to climate mitigation targets. And some of those reductions could be seen as 'low hanging fruits', and/or to offer significant reductions over a short time frame. Methane mitigation from landfill and also increased recycling has already served this purpose in developed countries in the early target periods under the Kyoto Convention from 1990-2010. Going forward, we can continue to target these and add also food waste prevention and the elimination of open burning of waste, both of which could also deliver significant carbon reductions in the near term.

The contribution of the resource and waste sector to climate mitigation is both an existing success story, and a reason to raise the political priority of further investment in the sector, in both developing and developed countries. As professionals, it is our job to make the case heard.

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Plastic Waste -An Indian Perspective

There are technical solutions to management of post-consumption plastic waste from mechanical recycling of waste to making useful products.

S K Ray, *Hon. Secretary & Member of Executive Committee*
Indian Center for Plastics in the Environment (ICPE)

Plastics have become ubiquitous to our daily lives. Within a shortspan of less than a century, demand for plastics have rapidly grown surpassing most of the traditional materials. Metals, paper or glass are being used by humanity for over thousands of years.

Demand for plastics has crossed that of steel. It would soon cross the demand for paper. Plastics as a family are extremely versatile, highly affordable and very convenient to use. The seat tributes contributed to its rapid growth in diverse fields from high-end fields of automotive, electronics, aeronautics and space science to mundane house-hold articles and numerous packaging applications. In all these areas plastic brings unprecedented benefits in terms of material and energy efficiency as well as performance and economics. Thus, in last seventy years demand for plastics increased nearly 250 folds. Bulk of this growth came from packaging sector and demand for consumer goods. Compared to other materials, anthropogenic experience in use of plastic is rather short. We are still in an early phase of learning in responsible use of plastics and management of waste.

While plastics have made valuable contribution, this rapid growth has also brought in unprecedented challenges in management of post-consumer waste. Between 8-12 million tons of plastic wastes is estimated to be annually entering the marine ecosystem. Nearly 8 billion tons of plastic waste is stated to have accumulated in the sea since the first use of this "miraculous material". One forecast making rounds is the possibility of "finding more plastic in the ocean than fishes by 2050". Graphic visuals in print and electronic media of distressed animals and birds impacted by plastic waste drive home the message on urgent need for actions by all stake-holders. The plastic industry has a critical role to play in this endeavor.

There could be a debate on exact quantity of plastic waste on land or in the sea. But the presence of large quantity of plastic waste in the environment is an undeniable fact. Their impact on our ecosystem is real. Indian plastic industry has offered a mature response by acknowledging the societal concern. It has joined other stakeholders to seek viable responses to this global challenge.

There are technical solutions to management of post-consumption plastic waste from mechanical recycling of waste to making useful products and use of difficult to recycle plastics in building of roads, co-processing in cement kilns, generating electricity and pyrolysis to liquid and gaseous hydrocarbons. Synthetic lumbers made from multilayer laminates and fashion fabrics from recycled PET bottle wastes are some of the upscaling opportunities.

We have, particularly in the twenty-first century, moved towards an apparently unsustainable path of "make, use and dispose" culture. This has triggered an avalanche of waste into the environment and plastic waste, with its high visibility. It attracts unprecedented attention from regulators, public and policy makers. Unlike other environmental issues like global warming, green house gas emissions and climate change, which are abstract in nature, plastic waste is highly visible and is easy to comprehend.

Technically all plastics can be recycled multiple times. At present the waste handling protocol does not promote and incentivize source segregation. As a result, most of the plastic waste loose between 60% to 90% of its original value. In the process bulk of the plastic waste either gets down-cycled or often the collection and segregation cost makes recycling economically unviable.

India has one of the lowest per capita use of plastics but has one of the highest rates of recycling of plastic in the world. Unfortunately, bulk of the recycling takes place in the informal sector, barring recycling of PET bottles. The informal sector needs substantive upgradation of technology, improvements in the working conditions and observe safety protocols.

Despite a wide range of technical solutions available to handle plastic waste, the overwhelming narrative today is in favor of regulatory initiatives to restrict or eliminate "single-use" plastics. While it is hard to define "single-use" plastics, majority views points to plastic carry-bags, PET water bottles, plastic straws, plastic drink stirrer, cutleries, EPS trays and plates etc.

In the context of the developed world, these probably are "single-use" plastics. But in Indian context, thick carry bags as well as PET bottles are used multiple times and hence may not fall in this category. Despite low per capita usage of plastics, India has perhaps one of the best records of recycling of plastics. Nearly 60% of all plastic waste and nearly 85% of PET bottles wastes are estimated to be recycled. This is much higher than the over-all global recycling rate of 10%-15%.

Rudimentary dry solid waste segregation at a collection center

Collection of waste at a dump site

Solitary focus on plastic waste may defeat the purpose of addressing the larger issue of solid waste management in cities and other human habitats. There are pockets of excellence within the country where civic bodies have dramatically improved solid waste management, including management of plastic wastes. Creation of robust waste handling infrastructures and active participation of citizens in management of wastes though an extensive awareness campaignare the primary factors.

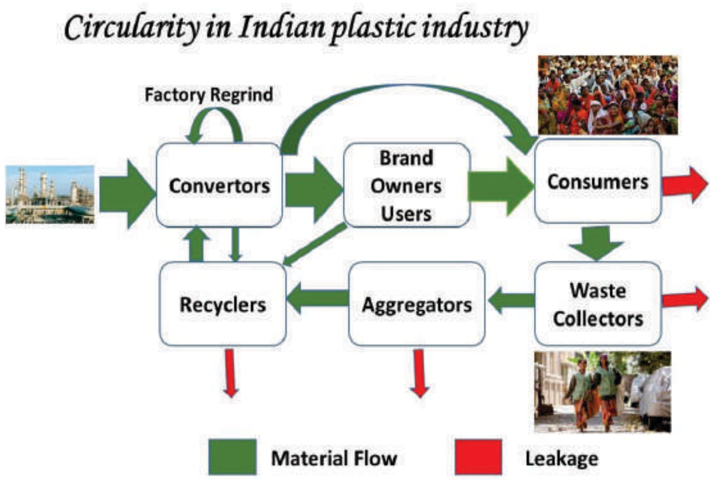
Studies conducted at Indian landfills found an average 4%-7% of plastic waste in municipal solid waste (MSW). This comes down to below 1% after waste pickers have collected recyclables from the dump/landfill sites. All wastes are valuable resources and plastic wastes are no exception. There is a need for mindset change. Aggressive pursuit of circular economy can address this in a substantive manner.

A robust solid waste management system and infrastructure can ensure that most of the plastic wastes are held back from reaching water bodies. Segregating wastes at it generating points and channelizing these for recycling or for recovery of energy are effective way forward. Multiple garbage bins at waste generating points, segregated transport can convert wastes into wealth.

Effective implementation of Extended Producers' Responsibility (EPR), as practiced in manycountries, can have significant positive impact in valorizing difficult recyclables in the waste streams to useful products or for end-of-life treatment by providing much needed viable gap funding. The Plastic Waste Management Rules 2016 in India has this feature. Both industry and Government are engaged in developing this in an implementable form. This would have salutary impact on plastic waste management in India.

While it is necessary to initiate urgent steps to arrest leakage of plastic wastes into the environment, simultaneous actions are required to be reclaim the accumulated wastes in land and the seas. It would be relatively easier to undertake this task on land but challenging for that from the seas. Most of the plastic wastes in inaccessible land locations are contributed primarily by tourists due to the compulsive littering habit and grossly inadequate solid waste management infrastructure at these locations. We can address this by building adequate infrastructures and a sustained campaign against littering instead of attempting to ban plastics necessary to carry food and water. Plastics become invaluable in relief operation carrying food, water, medicine and other relief materials. We however need to create both infrastructure and awareness for effective management of waste.

The policy prescription from ICPE is the pursuit of circular economy to address the challenges of plastic pollution. Prevailing circularity in Indian plastic industry needs active participation of all stake-holders to minimize leakages at all stages if not eliminate these wherever possible. Bulk of the leakages takes place at the consumer end. Both creation of adequate infrastructure and launching extensive awareness are critical elements if achieving this.



A holistic approach to solid waste management is needed to manage all waste, including plastic waste, is necessary instead of cherry picking a few plastic products for regulatory initiatives. The products which are often mentioned for regulatory initiative form a miniscule fraction of solid waste and would probably result in putting higher pressure on environmental resources than addressing the problem.■

Photo curtsey : Enfield council

Dumping of Unwanted Plastic Waste by OECD Countries into Developing Countries

The UK, in common with other OECD countries, is using India and other less economically developed eastern nations as dumping grounds for their waste.

David Newman, *Former President of International Solid Waste Association [ISWA]*

Past President of ISWA (2012-2015). He was the Executive Director of Greenpeace Italy 1994-1997. From 1999 until 2014 he led the Italian composting and biogas association CIC. He led the Italian Bioplastics Association from 2011 to 2015. During this time (2012-13) he was personal advisor to the Italian Minister of Environment, Andrea Orlando. From 2012 to 2016 he was President of the International Solid Waste Association in Vienna and initiated the 2015 Global Waste Management Outlook report written by ISWA and UNEP. Presently he is President of the World Biogas Association since November 2016, co-author of the report Global Food Waste Management, an Implementation Guide for Cities, published in May 2018 by the WBA with C40 Cities Climate Leadership Group.

The latest data on plastic waste exports from the United Kingdom (UK) are shocking. A large rise in February 2019 shows how the UK industry itself is unable to handle the volumes of plastic waste they produce and is overwhelmed by lack of capacity for storing & disposing the same. So exporting is the best solution for them, especially to countries where waste management systems are poor or inexistent and where the plastic can be dumped at a relatively low cost, i.e. lower than incinerating it in Europe, lower than storing it in the UK.

The statistics in Table 1 shows that the UK produced around 2.3/2.4 million tonnes of plastic packaging waste. Half of this is not separately collected at all and simply land filled or incinerated with mixed waste not only in the UK, but also in European Union (EU), where it is exported as Refuse Derived Fuel (RDF).

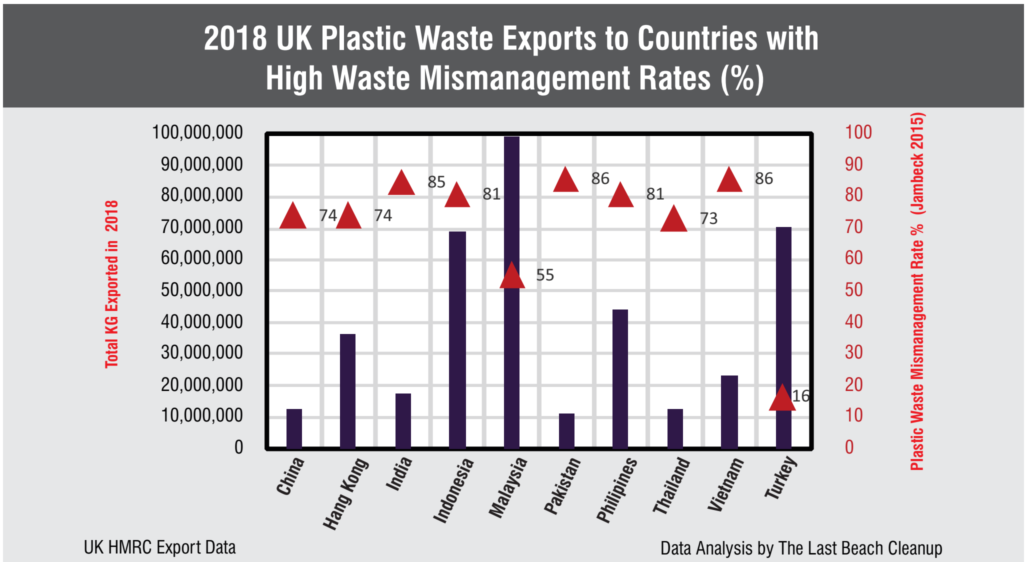
Table 1. Plastic Packaging Waste Arising UK 2016-17 and processing type

	(1000 Metric Tonnes)		
	2016	2017	2018 From UK HMRC Govt Data
Plastic Packaging Waste Generated	2,260	2,350	2,444
Net Plastic Waste Exported Outside of EU (Net of Imports)	647	520	437
Plastic Waste Reprocessed in UK	331	358	343
Total %: Exported & Reprocessed ("Recycled")	43.3%	37.4%	31.9%
Net Plastic Waste Dispatched to EU	59	55	89
Total %: Exported, Dispatched & Reprocessed ("Recycled")	45.9%	39.7%	35.6%
Plastic Waste Not Recovered	1,223	1,417	1,575
% Plastic Waste Not Recovered	54.1%	60.3%	64.4%

Somewhere between 55,000 and 89,000 tonnes of separately collected plastic waste was sent to the EU for burning or land filling. Poland has become a new destination as incinerators in northern Europe are occupied with their own plastic wastes. But most importantly, a further 440,000 to 650,000 tonnes were exported beyond the EU for so called, "recycling".

Now where does the waste exported for "recycling", actually go? This is illustrated in Graph 1 below.
The readers in India may be surprised to know that India is now an import market for

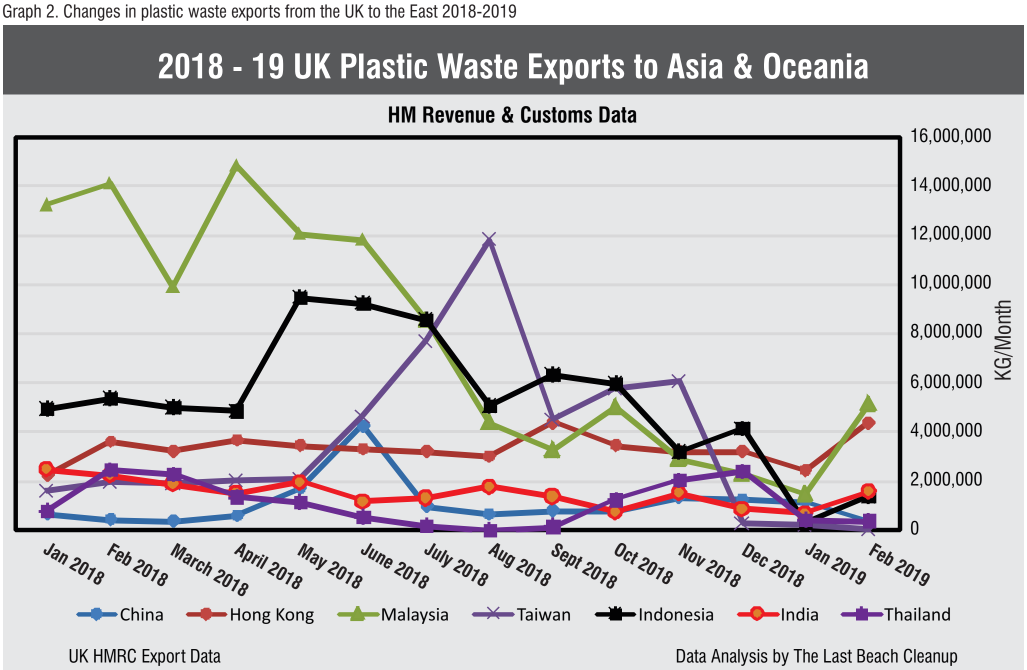
Graph 1. Exports of Plastic Waste from the UK 2018 to countries with low capacity to manage waste



plastic packaging waste from the UK. Almost 20,000 tonnes were exported to India in 2018. As if India does not have enough of its own plastic packaging waste to process and as if India has the ability to treat this waste in the first place. Since India definitely does not have the incinerating capacity, this is clearly disguised dumping.

The graph 2 shows how the movements of plastic packaging waste from the UK have been over the last year. As readers in India can see, shipments have held steady at around 2000 tonnes a month whilst greater amounts are being shipped to Malaysia and Hong Kong.

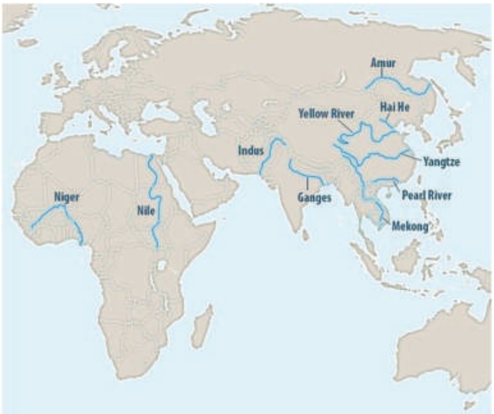
Graph 2. Changes in plastic waste exports from the UK to the East 2018-2019



All this shows that the UK, in common with other OECD countries, is using India and other less economically developed eastern nations as dumping grounds for their waste. Nothing new perhaps, legal and illegal waste shipments across the globe have been happening for centuries. What is shocking however is that this is accompanied by other phenomena. Let me explain.

Firstly, as a way of shifting the "blame" for plastics finishing in the oceans, the developed countries are claiming that poor waste management in countries like India is the reason.

A map below, showing that most plastics entering the ocean derive from very few Asian rivers explains to the unaware reader that the countries neighbouring those rivers are causing a huge environmental problem. The message is, if we want to solve plastic waste issues we have to get countries like India to sort out their waste management problems.



Misleading news report blaming rivers in Asia for plastic pollution in oceans is taken from following source: https://www.dailymail.co.uk/sciencetech/article-4970214/95-plastic-oceans-comes-just-TEN-rivers.html

Now this is true, BUT ONLY in part. Countries like China and India have for many years simply ignored that pollution from rising volumes of waste is an issue and have not been able to channel the right amount of funds or find the policies to deal with it.

But the story is ONLY PARTIAL. In reality, a lot of the untreated waste entering the rivers in Asia comes from the developed world in the first place. It arrives either as packaging on goods the OECD countries sell to developing countries, or is waste dumped there. It is a hypocritical claim to state that we simply need to improve waste management in certain poorer countries…..it shifts the blame away from those making the waste in the first place and those who are accomplices in producing the pollution, including multinational food and drink companies.

Next, the waste and recycling associations of the OECD countries are making a claim that if these shipments stop, the recycling in their countries would come to a halt. This is quite an amazing statement. Guilty of this are the Recycling Association in the UK, Solid Waste Association of North America (SWANA) in the USA. Even International Solid Waste Association (ISWA, of which I was President from 2012 to 2016) claims that sending waste to China and India is good for the "circular economy". Specifically, Simon Ellin, the CEO of the Recycling Association claims that "We do not want a situation where plastic packaging can only be recycled in the UK and that then makes plastic recycling more expensive."

Understood? It is ok to ship plastic waste to India where it is dumped but hard to accept treatment back in the UK because that may cost more money.

Similarly two years ago the USA waste association SWANA called on the Chinese Government to continue to allow USA plastic waste exports there and continues to lobby for open access to markets for its waste: "With 2018 nearly upon us, recycling programs from coast to coast are being adversely affected by China's actions," stated David Biderman, SWANA Executive Director and CEO. "Plastic film is being warehoused, recyclables in Oregon are going to landfills, and the uncertainty created by China's actions has created a significant disruption. ….. we call on China to postpone implementation…"

Understood? By saying "no" to US waste polluting its land, sea and rivers in China, the Chinese are creating "disruption" in the USA. Not the other way around. No, it is not the fault of the rich countries that they have been dumping their waste in the Third world for decades. It is the fault of these third world countries stopping this disgraceful trade.

The second phenomenon is that some of us are fighting back. At the international meeting of the parties to the Basle Convention on Trans Boundary Shipments of Hazardous Wastes, in last week of April 2019 the Norwegians planned to propose to list plastic waste as a material requiring specific import and exports licences. I supported this. India should also support it. The whole developing world should support this. The US and even perhaps the EU may oppose it. So stand up and fight on this occasion for your country and get the message across to your political leaders that you must support the Norwegian motion.

In any case, India can close its doors (as China has) to receiving waste from other countries. India simply needs to stop that. Some wastes, like paper and metals are of course part of international trade since decades and even centuries. Others, like waste electrical and electronics, waste plastics and packaging, are usually disguised dumping.

Conclusion

When the "West" blames India for polluting the oceans with plastics, remind the "West" that much of those plastics were sent to India by them, and that they should come and collect it and take it back. Developing countries should ban the importation of all plastic waste, whatever quality it is, until all parties accept new internationally agreed quality standards. The Basle convention could be the place to do this.

Investigate the importers of non-recyclable plastic waste who are clearly profiteering from lax rules and poor quality controls at the ports of certain developing countries. They should be made to pay for the environmental clean up their activities cause.

Invest in waste management systems to ensure their own wastes are not dumped and ending in the environment.

Support the proposal of Norway in the Basle Convention talks in April 2019 to make the shipment of plastic waste from OECD to less developed nations much more difficult. ■

Solid Waste interface in forest areas of India - Birds' Eye view

Concept of adopting scientifically validated carrying capacity-based visitor permits into wildlife and nature preserves is gaining ground in most sanctuaries and National Parks.

Dr. T. Sekar IFS (Retd.), *Former Principal Chief Conservator of Forests, Tamil Nadu*

Tourism- Advantage India
India, as a rich cultural and natural heritage country is bestowed with the varied and picturesque landscapes including its diverse forest types with biodiversity elements. Visitation to forest and wilderness areas is emerging as one of the fastest growing segments within the tourism industry. The country recorded a total tourist arrival of nearly 1,440 million tourists to various tourism areas in 2015, domestic tourists accounting for more than 95 per cent of the total.6 The average annual growth in the sector is more than 10 per cent in the last decade.

Awareness on ecological concerns relating to the specific tourism site, including a hill station is of critical importance to gauge the quality of tourism, visitation experience and possible negative impacts on the site. Intention of this paper is to present the reader an insight into the potential impacts of human interface with forest and wilderness areas with special reference to solid waste management.

Problems Peculiar to Hill Stations:
Today, luxury consumer items come in special packaging medium and use of any consumer item involves discarding of many items that come in form of the packing material, which get discarded & causes the accumulation of garbage. Likewise, piped water supply that is typical of any urban habitation leads to generation of large volumes of sewage. Almost 80% of the water used by human being gets discarded as domestic wastewater and ends up in gutters and drains. Net result is introduction of domestic solid and liquid waste into our urban environment.

Problems in Waste Handling and Management
Management of huge quantities of garbage and domestic sewage are matters of serious concern in the towns adjoining forests or those located in the hills. Increase in population makes the matter more complex. Hill stations also develop as tourist attraction. This adds to the inflow of sizeable floating population in such towns. Hill stations in India are already facing tremendous pressure due to lack of infrastructure, unfavorable climatic conditions, difficult terrain, budget deficit, and public apathy towards waste management. Constraints in availability of space and the uneven, undulating or sloping land surface offer serious limitations in developing a full-fledged and an efficient waste management system in hill areas or forested landscapes.

Hill stations like Srinagar, Shimla, Mussorie, Nainital, and Darjeeling are typical examples in the Himalayas, while towns like Udhagamandalam (Ooty), Conoor, Kodaikanal, Munnar, Medikere are hill towns facing the onslaught of urban wastes in the Western Ghats of the Southern states. Unfortunately, the policies and programs for improving the sanitation services in urban India remain silent about the peculiar characters of the hill towns, which demands special attention to the problem of waste management.

Nature Tourism Scenario

Nature-based tourism is emerging as the most important human activity that impinges severely on the quality of different natural endowments, on which the tourism activities are dependent. Such tourism in India bears one of the following three broad identities.

In the first genre, travelers visit a particular cultural heritage site within a forest area for the sole purpose of pilgrimage and worship e.g. Gangotri, Yamunotri etc.

The second category of visitation represents large groups of people traveling to some wildlife or forest area as part of their travel itinerary to popular tourist destinations like a hill station, coastal area or a beach resort. e. g. Ootacamund, & Mudumalai sanctuary, Mysore to Kerala or Tamil Nadu, breaking their journey en route at Bandipur tiger reserve is a typical example.

The third type deals with serious nature-lovers, who make an informed choice and undertake an exclusive trip to nature and wilderness preserves with a view to understand the nature in all its versatilities and combine the same with the thrills of adventure activities like trekking, hiking, cycling, canoeing, corralling, tent camping, forest night stay etc. This includes tour packages spanning a few days to tiger reserves and other wildlife protected areas

Pilgrimage Tourism to Forest Areas

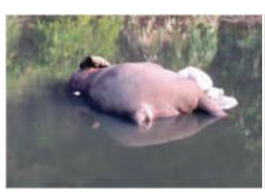
The author undertook an evaluation of the resource impacts of religious tourism to four pilgrimage sites located within wildlife sanctuaries in the Western Ghat forests of Tamilnadu. The study revealed that human-generated waste induces severe negative impacts like aesthetic, health and ecological.

In one of the studied temple sites located within the Kalakkadu Mundanthurai tiger reserve in southern Western Ghats, nearly 4,50,000 pilgrims arrive during the annual festival that lasts for only 11 days in July-August every year. Ecological consequences of such intensive use of a sensitive forest site find expression in many forms: removal of firewood or other forest produce, mainly for cooking; incendiary forest fires from cooking and negligent throwing of cigarette/beedi butts; trampling of the camp sites leading to loss of tree seedlings, saplings and shrubs; compaction of soil, decrease of soil pore space and water infiltration, thus increasing runoff and soil erosion.

Report suggests that the Kani tribals downstream this pilgrim site who rely on the Karaiyar river water are incapacitated for weeks on after the July-August festival.5 Similar health concerns arising from massive nature-dependent pilgrimage tourism are evident from other recent studies across the country. It is noted that annually about 50 million pilgrims, spread over 60 days at Sabarimala in Kerala produce at least 9,000 tones of excreta, much of which is dumped into river Pampa due to inadequate toilets. Similar situation exists in similar places all over India.

Careless disposal of the left-out food materials and throw away plastic containers in the forest land leads to enormous littering accounting for several tonnes of garbage. Besides creating an unsightly scene all around, accumulation of throwaway plastics has significant residuary impacts on native wild animal population too. There are many reports of wild animals succumbing in the past by accidental ingestion of plastics. In fact, post mortem report on the carcass of a sambhar deer in Sabarimala in December 2015 revealed ingestion of 4.7 kg of plastic waste and had raised an alarm. Casualty of an elephant under similar circumstances has been reported from the vicinity of Sabarimala.

An elephant herd at a dump site close to forest boundary



An elephant carcass

Plastic in the elephant dung

Wildlife Tourism Aka Tiger Tourism

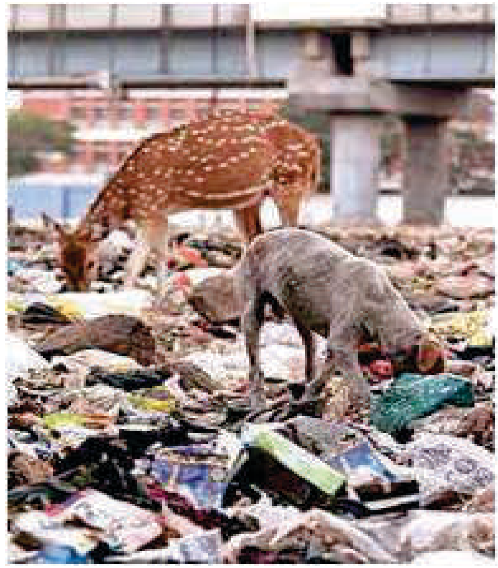
Wildlife tourism intends to promote non-consumptive use of wilderness areas, for the benefit of local communities dependent on these fragile landscapes. Tiger tourism has come to stay as synonymous to wildlife tourism today in India's context. Many of the well-known tiger reserves such as Kanha in Madhya Pradesh, Ranthambore in Rajasthan, Corbett in Uttarakhand, Bandipur and Nagarhole in Karnataka, Mudumalai in Tamil Nadu and Periyar in Kerala are much visited tiger-tourism destinations.

An analysis of tourism practice in four tiger reserves in India reveals that only few criteria among the four principles of eco-tourism, namely minimization of environmental impacts, generation of funds for conservation, benefits to local communities and education of visitors are met. Periyar Tiger Reserve stands out as an exception with innovative approaches involving local communities having brought about a significant positive change'.1 Tourist resorts near tiger reserves create problems like blocking waterhole access for wildlife, roads built in wrong places, garbage dumped with impunity and ungodly noise pollution are the order of the day. The experience is similar in other tiger resorts.

Visitation of the 'Another' kind

Open green spaces, gardens, public parks or small bits of wooded landscapes in urban neighborhoods attract innumerable visitors to escape from the boredom of urban life. Such spots are used for physical fitness activities like a stroll, jog or yoga, for recreation or mere pleasure of an outing. With very low or no entry fee and the least of regulations operating, throw away polythene carry bags, water sachets, PET bottles, food packaging with discarded food stuff are thrown out indiscriminately. Zoological parks, mini-zoos, Corporation/Municipal gardens, urban woodlots are typical examples. The wild creatures like the chital (spotted deer) rummaging through heaps of rubbish, strewn with plastic are becoming an increasingly common sight in the Sanjay Gandhi National Park in Mumbai.

Visitors throw the plastic wrappers of food items that attract the deer for their salt content. Plastic wastes fatally clog the digestive tracts of animals.



Spotted deer rummaging through garbage dump

Best practices to Mitigate Adverse Effects:

In general, it is noticed that there is difficulty in achieving compatibility between activities undertaken by tourists and the Protected Area objectives. However, wildlife tourism has to be recognized theoretically as one of the few industries with low ecological footprint, help protect wilderness and offer right livelihoods to large number of locals. To attain this magical goal, tourism must be subservient to wildlife conservation, must help consolidate and expand wildlife habitats and must benefit local communities. A host of best management practices could possibly reduce the wildlife tourism impacts. A lottery model of limited entry like the one in force for Kailash Manasrovar in Tibet, ban on private vehicle inside the forests to limit the damage will be some steps towards improvement.5 In this regard, concept of adopting scientifically validated carrying capacity-based visitor permits into wildlife and nature preserves is gaining ground in most sanctuaries and National Parks. Locating lodges, tented camps and other facilities on revenue lands outside the Protected Areas owned by locals and set up in consultation with the best tourism professionals has its advantages. Another idea of invoking India's Environmental Protection Act 1986 to declare areas abutting sanctuaries and national parks as eco-sensitive zones that prevent large-scale construction, heavy or polluting industries and mining will enhance the conservation benefits.

Present Guidelines

Ministry of Environment and Forests published its eco-tourism guidelines in and around Protected Areas with a clear conservation bias in June 2011, which also within its ambit bring religious tourism in the forests and Protected Areas. The document incorporates detailed set of framework guidelines on selection, planning, development, implementation and monitoring of eco-tourism in India. Likewise, the National Tiger Conservation Authority (NTCA) issued comprehensive revised guidelines, namely 'Strategy, tiger conservation and tourism in and around tiger reserves' under the Wildlife Protection Act for all the tiger reserves. The guideline envisages that a maximum of 20 per cent of the core area/critical tiger habitat may be permitted for regulated, low-impact tourist visitation.

Future Strategies for Waste Management in Hill Stations and Wildlife Areas:

Development of comprehensive state of the art of waste management systems with opportunity for waste reduction, waste segregation, waste reuse and recycling facilities will auger well for urban centres in hill stations. Handling and management of wastes in a wildlife protected area subject to tourism pressure must find categorical mention in the respective management plan for a sanctuary or national park and in the Tiger Conservation Plan in case of a tiger reserves, which guide the perspective management of such preserves. Devising a proper tourism plan within the prevailing regulatory framework for such areas based on systematic, quantified information on the impact of tourism visitation on the ecological characteristics and bench mark biodiversity values of the forests is a sin quo non, if the area managers want to minimize the ecological foot print. Visitor use and pressure on habitat should be monitored and waste management infrastructure evaluated judiciously towards this objective.

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Photo curtsey : The sun

Evolution of Circular Economy

Essentially, Circular Economy aims to redesign the production and consumption systems. It presents a new model for sustainable development and green economies riding on the experience of several strategies and programs developed over the past three decades.

Dr. Prasad Modak
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Background

India faces many environmental challenges today. Our limited resources are under threat due to intensive depletion and serious degradation. Further, we realize that risks to our resource security are compounded due to looming threats of climate change. Policies and strategies to respond to these challenges need mainstreaming of sustainability across all developmental sectors.

Strangely and oddly enough, the national governments, particularly the Ministries of Environment, have focused more on the management of residues rather than management of the resources. Legislation was evolved to set limits on the residues that will have to be met prior to disposal but not much attention was given on the limits of extraction of resources and resource pricing.

Resource extraction across the world is getting more and more intensive. Material flows (both of virgin and used or secondary materials) are getting skewed. Green fencing of waste materials is already happening in countries like China (called as the China Sword) where import of waste materials is restricted demanding strict contamination standards. Some of the important factors responsible for the shift are market globalization, presence of perverse subsidies (i.e. unrealistic resource pricing) and unevenness in environmental governance.

Shift from Linear Models of Growth towards Circular Models

In the residue focused Governance, like in India, legislations were developed that began with addressing wastewater streams but soon air emissions, solid and hazardous wastes were included. In the last two decades, specific residues such as municipal solid wastes, construction and demolition wastes, plastic waste, electronic (e) waste were also addressed by setting limits and requirements for safe disposal. Consequently, the investments on the end of pipe management of residues increased. The polluters were caught in a cleft-stick.

The polluters realized that to reduce cost of the end of pipe treatment and remain competitive, efforts were required to reduce generation of residues at the source. Concepts such as waste minimization and pollution prevention therefore emerged and the polluters did every effort to reduce residue generation by deploying better housekeeping and practicing reuse, recycling, recovery to the extent possible. This required a behavioural change, application of management systems, use of productivity improvement tools and adoption to modern technologies.

The investments for management of residues essentially moved upstream leading to "ecological modernization". Unlike end of pipe investments, the "upstream" investments had a payback or economic returns. Strategies such as Cleaner Production, Green Productivity and Ecoefficiency emerged. These strategies showed a link between resources (in specific the resource use efficiency) and the residues that could be converted as a resource.

Over a period, the legislation on residues expanded and became more comprehensive and started addressing the life cycle. Figure 1 shows an illustration of evolution of limits, expectations and requirements for the pulp and paper sector.

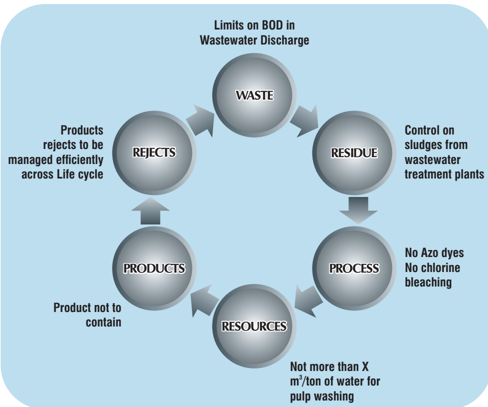

Figure 1 : Evolution of environmental standards across life cycle - Case of pulp and paper sector

Clearly, enforcement of such limits could not be carried out solely by the Government. It required a partnership approach where the markets (consumers, retailers) and investors were also involved. An enunciation of an umbrella policy and coordination between ministries was also necessary. The new paradigm of governance addressed both resources and residues, across the life cycle and in partnership with G-B-FI-C (Government, Business, Financing Institutions and Communities). The linear growth models that were earlier practiced were not tenable and circular models of growth became the goal. Once material flows became circular, compliance was expected to become of interest to every stakeholder. It was a clear win-win situation. This is where we see the evolution of Circular Economy.

Circular Economy offered a platform for all stakeholders to get involved for sustainable and inclusive development. In addition to addressing environmental sustainability, Circular Economy improved the businesses competitiveness, generated employment, increased green investment flows, built on partnerships and helped in establishing a transparent and inclusive governance. So what is Circular Economy?

Essentially, Circular Economy aims to redesign the production and consumption systems. It presents a new model for sustainable development and green economies riding on the experience of several strategies and programs developed over the past three decades. Figure 2 depicts the evolution of the concept of Circular Economy.

Evolution of the Concept of Circular Economy

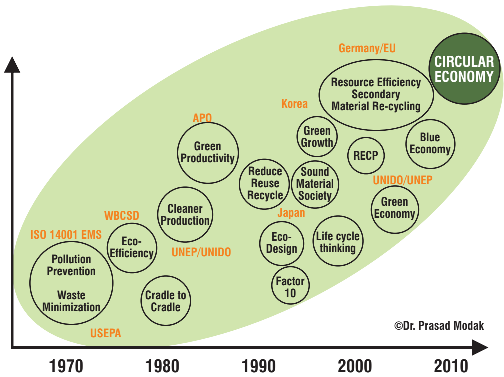

Figure 2: Evolution of the concept of Circular Economy

One of the landmark legislations to push Circular Economy was the Sound Material Society Act (2000) in Japan. This act followed the mantra of 3Rs viz. Reduce, Reuse and Recycle and demonstrated a decoupling between GDP growth in Japan with waste materials reaching the landfills. China legislated Circular Economy Law in 2007 focusing on "circular" industrial estates and setting up large scale Material Recycling Facilities (MRF). Government of Korea promoted the concept of Circular Economy through its Green Growth initiative stressing low carbon growth.

The European Union came up with country specific targets, indicators and reporting requirements on Circular Economy. Germany launched programs Progress-I and Progress-II that focused on increasing Resource Efficiency (RE) and thus the Domestic Material Recycling Rates (DMR). The Government of South Australia developed a strategic action plan for Circular Economy with impressive ground results. Gradually, several countries across the world as well as large corporations started transiting towards Circular Economy. Figure 3 shows the key elements of such as transition between the linear models of growth and the growth models that encourage circularity.

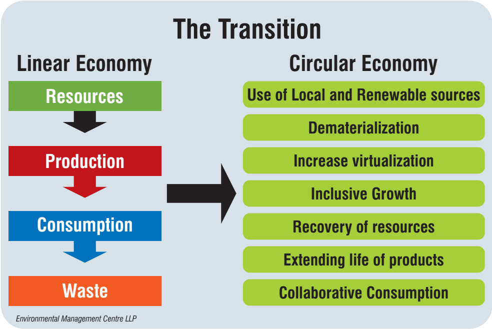

Figure 3: Transition from Linear to Circular Economy

Understanding the 6Rs of Circular Economy

The concept of Circular Economy added additional 3Rs namely- Repair, Refurbish and Remanufacture. These additional 3Rs strengthened three significant components viz. social (employment and engagement, especially of the informal sector), innovation (for the start-ups) and green investments. Box 1 describes characteristics of these additional 3Rs.

Box -1 Repair, Refurbishing and Remanufacturing

Repair is restoration of a broken, damaged, or failed device, equipment, part, or property to an acceptable operating or usable condition. Repair can involve replacement. Refurbishing is refinishing and sanitization (beyond repair) to serve the original function with better aesthetics. Repaired and refurbished products, although in good condition, may not be comparable with new or remanufactured products.

In remanufacturing, the product is resold with performance and specifications comparable to new products.

In the context of these 6Rs, the concepts of "outer" and "inner circle" and the bulls eye of Avoid, Reduce and Redesign become important (see Figure 4).

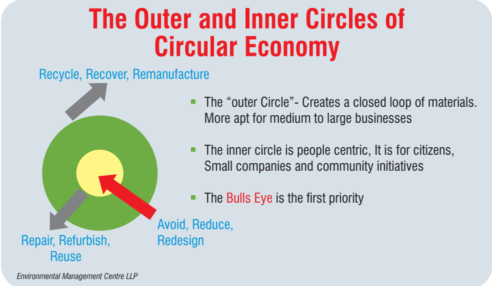

Figure 4 Outer and Inner Circles of Circular Economy

The "outer circle" approach creates a closed loop of materials through recycling. In the case of electronic goods, this means recovering of precious metals lodged in our gadgets, something only feasible with a sophisticated technology, requiring a scale and where medium to large companies profit.

The "inner circle" approach is essentially following route of repair, refurbishing and remanufacturing. It is the inner circle approach where we transform our living from the single-use and throw away culture. When we follow inner circle approach, it helps us to save money, conserve our resources, generate employment and come up with innovations. We extend product's life cycle through reuse. The inner circle is people centric; it is for citizens and supports small companies.

We need both the circles but the bull's eye of avoid, reduce and redesign should be the priority.

How do we know if the repaired, refurbished or remanufactured product is of good quality and equally functional as well as ensures safety? It is important therefore that standards should be comparable to those of the "virgin" products and specify permissible recycled content and composition. For example, the "Remade in Italy" label certifies the use of recycled material / reuse in products. The Remade in Italy ® label highlights the environmental values of the material / product and is characterized by the assignment of a class, based on the percentage of recycled / reused material present. Besides, the standard, "traceability" (showing the trail of material flows) is also going to be critical in the secondary market of remanufactured goods. In the interest of 6Rs, the business of reverse logistic chains, i.e. collection and transport systems has emerged. Several off the shelf or plugin type technology platforms have evolved such as [1]**12return** that help create reverse supply chains from consumers to service providers, operated by the waste "aggregators".

There have been interesting policy reforms too. The repair culture did not have much root in the developed economies due to high costs of labour. Realizing the importance of its

[1]12Return see https://www.12return.com/

promotion however, countries in the European Union (EU) have come up with tax incentives. In Sweden, a tax-refund scheme operates that on the labour segment of household repair bills for white goods and electronics. On similar lines, in Austria, there is a proposal to make repair cheaper by reimbursement of 50% of the labour costs of repair.

In France, there are differentiated Extended Producer Responsibility (EPR) schemes where fees depend on how easily you can dismantle a product for repair, on the availability of spare parts or on whether the information/instructions on how to repair a product are available. These fees are lowered for producers who inform consumers how long spare parts will be available for the product on purchase.

In the United States of America, more than eighteen States have proposed "Right to Repair" legislation. The Right to Repair bill will make easier for people to repair their broken electronic equipment—like cell phones, computers, appliances, cameras, and even tractors. The legislation would require manufacturers to release repair information to the public and sell spare parts to owners and independent repair shops. It is going to be however a bumpy ride as giants like Apple and Microsoft are gearing up to oppose this legislation in at least one State.

[2]**Restart Project** – a London-based social enterprise – encourages and empowers people to use their electronics longer in order to save money and reduce waste. Restart helps people learn to repair their own electronics in community events (parties) and in workplaces and speak publicly about repair and product resilience. Today, Restart is working with 54 people in 10 countries who are planning on replicating and adapting the Restart model.

Conceived to help people reduce waste, social entrepreneur Martine Postma organized the first **Repair Cafe** in October 2009 in Amsterdam. Its success prompted her to start the Repair Café Foundation in 2011. Since then, this non-profit organization has helped local groups start their own Repair Cafés. Today, there are more than 1,400 such cafés in 33 countries, from the US to Japan. According to the foundation's 2016 annual report, repairing prevented about 250,000kg of waste from heading to landfills.

Antara Mukherji, co-founded **Repair Café Bengaluru** in November 2015 with Purna Sarkar. Since its inception, Repair Café Bengaluru has organized 19 workshops where adults pay a programme fee and learn how to repair household things ranging from an iron to an induction top. The organization says it has repaired more than 700 products and saved about 1,300kg of waste from ending up in landfills.

But in India, across the country, there are repair shops that can fix anything and everything. In Delhi's Nizamuddin Basti area, old Swiss watches are repaired and sold, from Favre-Leuba to Rolex; Nehru Place in Delhi thrives on the economics of repair; a 80-year-old shop in Chatta Bazaar Road in Hyderabad's Old City is the ultimate repair destination for vintage radios, record players and cassette decks—the list goes on. Chor Bazars or Thieves market are hubs of innovation when it comes to repair, refurbish and remanufacturing.

The skill of repairing, refurbishing and remanufacturing is dying slowly. Repairing is often considered as a vocation for the uneducated/underprivileged or a mere hobby. In large cities, you would not see repairwalas going from street to street, offering to fix broken items. We now have web-based repair services, taking advantage of the internet – but these companies need to quantify, record and communicate the environmental and social benefits,

Our engineering curriculums must include a course on repair, refurbish and remanufacturing with a workshop. It will help the students to look for alternatives, think out of the box and innovate". We should leverage on India's Make in India, Zero defect and Skill India programs.

To sum up, we need product designs that are repair friendly. We should frame incentives and disincentives. We also need recycled product standards, smart reverse logistics and schemes on skill building. The inner circle will then operate on a scale it deserves and will resonate well with the outer circle.

[2] The Restart project see https://therestartproject.org/

Upstream and Downstream Strategies of Circular Economy

One of the most effective "Upstream" strategies to address this increasing threat to resources is to reduce consumption and redesign the products we make and the services we offer. This is the bull's eye of the Inner and Outer circles.

The "Upstream" strategy requires change in the behavioural patterns or the way we live. Given the rising rate of urbanization, the increasingly prosperous middle class (especially in Asia) and the promotion of consumerism through media, it is extremely difficult to expect this change will ever happen! If you say no to a product because you feel there is no need, someone will simply dump the product on you (as a free trial or as a friendly gift) to trap you or enslave you!!

The second "Upstream" strategy of redesign requires innovation, risk appetite and top management commitment – and this cannot be achieved overnight. Today, we only have a handful of eco-design schools in India.

Here, companies need to exhibit out of-the-box thinking to find ways to reduce material and energy intensity and increase recycled content in their products. Products need to be redesigned to reduce/eliminate hazardous substances, increase recyclability (and improve safety during recycling) and make remanufacturing possible with most of the components getting reused.

We need to educate the citizens on the consumption itself and guide them to make "green choices" i.e. avoiding use of products to the extent possible that use harmful chemicals and non-biodegradable materials in the first instance. This will ensure "circularity". The production patterns should be influenced by responsible consumption. The manufacturers will need to extend their involvement beyond the factory gates and across the life cycle.

But working only on upstream is not going to work as due to increasing consumption and years of inefficiencies in manufacturing practices, waste volumes across the world have been on a steep rise. This has led to a sunrise in the global waste recycling industry. This industry is thriving on the "Downstream" strategies of waste recycling and recovery– extracting metals, biosolids, Refuse or Solid Derived Fuels, bio-gas, syngas, heat, electricity, engineered materials etc. from and reversing material flows and thereby reducing the consumption of virgin resources. The global waste recycling industry today supports significant employment – both in formal and informal sectors. Millions of poor people in the world's largest cities earn their livelihood because waste is around.

The waste recycling industry has come up with numerous innovations. In 2017, a rPET initiative was launched globally at the Textile Exchange Recycled Polyester Round Table. The goal was to encourage brands to accelerate their publicly use of recycled polyester by 25% by 2020. The brands included Adidas, Dibella, Eileen Fisher, Gap Inc., H&M, IKEA, Lindex, MetaWear, Target and Timberland, Patagonia has been a leader since 1993. India, Reliance Industries has launched a fashion brand R-Elan "powered" based on Green Gold (See Figure 5) that is developed through processing of used PET bottles. A pair of jeans of E-Elan is estimated to save 24% of GHG emissions, 3218 litres of water, 33% of consumption of pesticides and divert 15 PET bottles to the landfill.

Figure 5 : Green Gold and R-Elan fashion brand by Reliance Industries

Recycling has many benefits. Firstly, it conserves natural resources as extraction of virgin materials is reduced. Further, recycling diverts waste that is to be sent to incinerators and landfill. Landfills take up valuable space and emit methane, a potent greenhouse gas; and although incinerators are not as polluting as they once were, they still produce noxious emissions. Unless you segregate waste at source you cannot do effective recycling. So, segregation of waste at source and recycling must go hand in hand. There is too much emphasis or hype on recycling alone that most think that Circular Economy means recycling.

Sadly, waste recycling industry wants more waste to be produced– so that the waste recycling business can grow and survive. The strategy of "Reduce" at "upstream" can affect the "downstream" opportunities of recycling and recovery.

There are examples where a CEO of a waste-to-energy plant who used to hate bans on plastics as they would reduce the calorific value of waste. A Common Effluent Treatment Plant (CETP) company discouraged members of the CETP to reduce the effluent volumes by specifying in the contract a guarantee for effluent supply. So, has been the case in many Public Private Partnership contracts (PPP) for managing Municipal Solid Waste wherein waste supply guarantee is an essential precondition. 'Don't you ever reduce waste that you have committed', the PPP partner warns.

There are many such examples of conflicting interests between the stakeholders involved "upstream" and "downstream". In reduce, top management, product designers and consumers play a dominant role whereas in recycle, waste pickers, community and waste processing specialists have a greater interest. The two groups rarely have a dialogue. This defeats sustainability and does not encourage Circular Economy in true sense. What we need is an integrated approach.

The solution, therefore, according to economists, activists and many in the design community, is to get smarter about both the design and disposal of materials, and shift responsibility away from local governments and into the hands of manufacturers. This is where legislation on EPR plays a role. Products as well as packaging need to be designed with recycling in mind. Waste generation should be considered as a design flaw. Remedying this problem may require a complete rethinking of industrial manufacturing. This may sound like wishful thinking, but the key question is **can we design products to make recycling easier?**[3]

To come up with a partnership approach involving key stakeholders and addressing both inner and outer circles, new business models need to be identified and nurtured. Figure 6 describes a typology of the business models that map the life cycle.

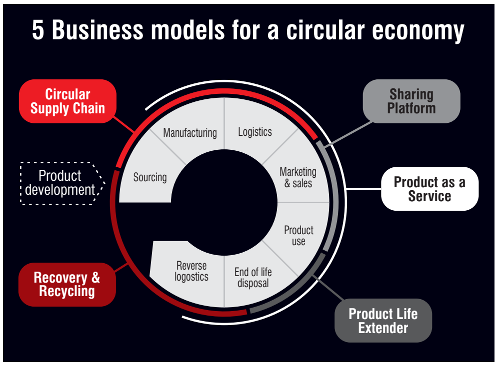

Figure 6 : Five Business Models for a Circular Economy[4]

Circular Economy in India

India is estimated to become the fourth largest economy in the world in about two decades. This economic growth is however going to come with challenges such as urbanization with increased vulnerability (especially due to climate change), poor resource quality and scarcity and high level of unevenness in the socio-economic matrix due to acute poverty. India, if it makes the right and systemic choices, has a potential to move towards positive, regenerative, and value-creating development. Its young population, growing use of IT, increasing emphasis on social and financial inclusion as well as the emerging manufacturing sector can make this happen. For this, the conventional linear 'take, make, dispose' model of growth must change and an enabling policy framework at the national and sectoral level needs to be evolved.

[3] can we design the product to make recycling easier? See http://www.economist.com/node/9249262

[4] Drawn from https://www.accenture.com/t20150523T053139__w__/us-en/_acnmedia/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Strategy_6/Accenture-Circular-Advantage-Innovative-Business-Models-Technologies-Value-Growth.pdf

Developing a national policy framework on Circular Economy therefore makes sense. This framework should address both management of resources and residues and the key stakeholders involved.

The recent report by the Ellen MacArthur Foundation on India shows that a Circular Economy path to development could bring India annual benefits of ₹40 lakh crores (US$ 624 billion) in 2050 compared with the current development path – a benefit equivalent to 30% of India's current GDP. Following a Circular Economy path would also reduce negative externalities. For example, Greenhouse Gas emissions (GHGs) would be 44% lower in 2050 compared to the current development path, and other externalities like congestion and pollution would fall significantly, providing health and economic benefits to Indian citizens. This conclusion was drawn based on high-level economic analysis of three focus areas viz. cities and construction, food and agriculture, and mobility and vehicle manufacturing.

The Ministry of Environment and Forests and Climate Change (MoEF&CC) of Government of India set up the India Resource Panel (InRP) in 2016 to examine the material and energy flows across key sectors following a life cycle approach and to assess resource efficiency. Sectors such as Construction, Automobiles, Iron & Steel and Metals were considered, and key cross-cutting areas were examined. Recommendations of InRP were taken up by India's NITI Ayog (earlier Planning Commission) leading to a paper on Strategy for Resource Efficiency. More recently, NITI Ayog released four sectoral publications on Steel, Aluminium, Construction & Demolition Waste and Waste from Electronic and Electrical Goods. In addition, an overarching report on the status was produced with 32 recommendations addressing both "inner" and "outer" circles, emphasizing strengthening of the informal sector, remanufacturing council and harmonizing waste management related regulations following a life cycle approach. Promotion of innovation and green investment flows following a PPP approach were also included as key interventions. Building a vibrant recycling industry in India was stressed given the recent green fencing of waste materials by China. Currently, MoEF&CC is finalizing a national policy on resource efficiency and Circular Economy on this basis.

The Government of India has embarked on several iconic projects to improve and expand its infrastructure (transport, cities and energy) and undertake ecological modernization of important sectors such as water, agriculture and food. In these Mega projects, Foreign Direct Investment is encouraged, and these investors are asking for good practices on Environmental and Social Governance (ESG) apart from conventional compliance. The 100 Smart Cities program, Make in India initiative, Swatch Bharat Abhiyan (Clean India), Namami Gange (Ganga River Action Plan), Interlinking of Rivers, Climate Resilient Agriculture etc. are a few examples. In all these projects, an application of the principles of the Circular Economy is extremely relevant. It is however necessary that leadership on the Circular Economy is built in Cities, Industries, Investors, Project Developers and with Policy makers and Regulators.

Circular Economy is thus a concept that brings management and resources and residues together in the interest of economy, livelihoods and the environment. If implemented well then it will spur innovation and stimulate green investments. ■

Plastic Waste Management: Impacts of Circular Economy

Now-a-days, the concept of plastic circular economy is being tossed around. While, contamination of plastic waste, unknown composition and mixed plastics hinders recycling, which is a component of circular economy, lower price for virgin raw material makes recycling economically non-feasible.

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Abstract

Since world war II, plastic has been one of the most manufactured commodities in the world and the production of plastics continues to increase every year. In 2016, 335 million tonnes of plastic material was manufactured globally. China, America and European Union are the biggest producers of plastics. Plastic commodities are part of every sector of human life, from packaging, consumer products to building and constructions, electrical and electronics and automotive industries. As a consequence plastic waste is also being generated in staggering numbers as well. In 2016 alone, 241 million tonnes of plastic waste was generated globally. In consequence, 5 to 13 million tonnes of plastics, 1.5 to 4% of the total global plastic production, ends up in the oceans every year and hence plastic accounts for 60 – 80% of marine litter. Marine plastic litter, especially microplastics, poses grave threats to marine life as marine fauna ingests microplastics which leads to several negative impacts. Recent studies show that humans may be ingesting microplastics, as well, through seafood consumption. Generation of plastic waste is associated with the affluence of a country, and with majority of countries striving towards development, the amount of plastic waste generation is increasing exponentially. Plastic recycling in developed countries is not a big problem. For instance, in European Union, 69.2% of plastic waste generated is either sent for recycling or waste-to-energy. However, plastic waste recycling poses the biggest challenge in developing countries where approximately 88% Municipal Solid Waste (MSW) is sent to landfill. Additionally, MSW in majority of developing countries is unsegregated which reduced the recycling value of plastic waste and therefore is sent to landfill. Contamination of plastic waste is one challenge in recycling plastic waste, the other challenge is posed by mixed polymer waste since reprocessing of mixed polymer waste poses some challenges as compared to mono-plastic. The unknown (pro rata) composition of mixed plastics also poses a moment of concern when choosing recycling. However, chemical recycling, in-spite of mechanical recycling, may help tackling with recycling of contaminated plastic waste and/or mixed plastic with unknown composition. Now-a-days, the concept of plastic circular economy is being tossed around. While, contamination of plastic waste, unknown composition and mixed plastics hinders recycling, which is a component of circular economy, lower price for virgin raw material makes recycling economically non-feasible. World Economic Forum estimates the after-use costs of plastic packaging alone to be around $40 billion per year. Extended Producer Responsibility (EPR) programs is one of the drivers that could enhance circular economy practices where manufacturers and importers of priority products are obliged to take care of their end-of-life products. Plastic recycling has generally been discovered to be uneconomical without significant subsidies due to high process costs incurred to produce monomers from plastic waste. Adaptation of economic incentives such as Container Deposit Legislation (CDL) or disincentives such as plastic bag levies or disposal taxes are effective drivers to motivate recycling behavior amongst the public.

Keywords: Plastic; Plastic waste; Plastic waste management; Plastic recycling; Circular economy

Introduction

Plastic is one of the world's greatest industrial innovations, widely used in various sectors such as in packaging, construction, automotive manufacture, furniture, toys, shoes, household appliances, electrical and electronic goods, and agriculture (Cole et al., 2011). The cumulative value of worldwide plastic production has increased from 1.4 million tonnes in 1950s to an increase of nearly 200-fold, reaching 7.8 billion tonnes in 2015, and is expected to reach 30 billion tonnes by 2050 (Plastics Europe, 2018). Historically, plastics were mostly produced in Europe and the United States, however, this has recently shifted to Asia. China is now the leading producer with 28% of global production in 2015, while the rest of Asia, including Japan, produced 21% (i.e. nearly half the global production) (Plastics Europe, 2015).

Plastics contribute to economic growth, for instance the European plastics industry reported a turnover of more than 340 billion euros in 2015 which directly employs over 1.5 million people, and in the United States, plastic industry sustained 954,000 jobs in 2015 while making a revenue of $418 billion (Jacob, 2017). However, their current production and use pattern, on a linear model of 'take, make, use, and dispose', is a primary driver of natural resource depletion, waste, environmental degradation, climate change, with adverse human health effects (Ricardo & Sunday, 2018). In Europe for example, plastic waste embodies 11%-wt of the total waste (Alassali et al., 2018) and in 2014 alone, nearly 26 million tonnes of post-consumer plastics waste ended in the official waste streams, where about 31%-wt was disposed in landfills (Plastic Europe, 2016). Globally, it is estimated that only 9% of the 6,300 million tonnes of plastic waste generated between 1950 and 2015 was recycled (Geyer et al. 2017). It is estimated that between USD 80 and 120 billion worth of material value is lost to the global economy annually because of the low recycling rate of most plastic packaging (MacArthur et al., 2016).

Circular economy aims at transforming waste back into a resource, by reversing the dominant linear trend of extracting, processing, consuming or using and then disposing of raw materials, with the ultimate goal of preserving natural resources while maintaining the economic growth and minimizing the environmental impacts (Ghisellini et al., 2016, Lieder & Rashid, 2016).

Current practices of plastic waste management (developing countries vs developed countries)

Plastic waste management is influenced by waste management practices of respective countries. For instance, in developing countries only landfilling or (mainly mechanical) recycling of plastic waste is practiced whereas, in developed countries energy recovery and chemical recycling of plastic waste is also practiced. But plastic waste management in developed countries is not as straight forward as in developing countries. In 2016, approximately 15 million metric tonnes of plastic waste was exported globally, mainly from developed countries (Qu et al., 2019).

In 2014, European Union recycled 29.7% of plastic waste (7.7 million tonnes) whereas, 39.5% of collected plastic waste utilized for energy recovery (PlasticsEurope, 2015). According QDB report (2017), approximately half of plastic waste collected for recycling was exported to China and Hong Kong. Similarly, United States recycled 9.2% (3 million tonnes) of plastic waste in 2013 and exported 2.1 million tonnes of this plastic waste to China (QDB, 2017). The plastic packaging waste recycling in Austria is 3% whereas, energy recovery rates are higher (Kranzinger et al., 2017). In Qatar, only 12.5% of plastic waste generated (30,000 tonnes) was collected for recycling in 2015 (Hahladakis & Aljabri, 2019).

Majority of developing countries dispose plastic waste along with other components of Municipal Solid Waste (MSW) into landfills or in open dumps. Plastic waste generation in sixty cities of India is 15,342 tonnes per day, where 60% of this plastic waste (9205 tonnes) is recycled and remaining 40% plastic waste (6137 tonnes) is sent to landfills for final disposal (Ryan et al., 2019). Informal sector in India contributes to plastic recycling as they collect and segregate PET bottles for their livelihood (Nayak, 2013). Due to informal sector PET recycling rate of 70%, is higher for India as compared to other countries (Ryan et al., 2019). Malaysia generated approximately 1.8 million tonnes of plastic waste in 2016 (Pauze, 2016) where only 15% of plastic waste was recycled (Bedi, 2018). According to Oyake-Ombis et al., (2015), plastic waste in African countries is either left uncollected or if it is collected with other waste streams of MSW, it is disposed of in landfills or illegally in open dumps. Thus, majority of plastic waste leaks into the environment, especially ending up as marine litter.

Hence, landfilling is still the preferred method of plastic waste management in most of the countries. Global recycling rates are underwhelming for adoption of circular economy as majority of plastic waste escapes from the loop (technically energy recovery from plastic waste results in loss of material thus reducing the chances of recycling/ reusing).

Impacts of mismanaged plastic waste

Plastic that is either littered or inadequately disposed (i.e. not formally managed and includes disposal in open dumps) is termed as mismanaged plastic waste. These mismanaged plastic waste may enter the ocean via inland waterways, wastewater outflows, and/or transported by wind (Jambeck et al., 2015). Estimates are 5 to 13 million tonnes of plastics, or 1.5 to 4% of global plastics production end up in the oceans every year and plastic accounts for over 80% of marine debris (Penca, 2018). Additionally, the amount of marine debris generated by a specific country is the function of that country's plastic waste generation and mismanaged of plastic waste. Table 1 illustrates worldwide ranking for 20 countries based on amount of plastic waste generated, mismanaged plastic waste and reported marine debris (Adapted from Jambeck et al., 2015).

Rank	Country	Plastic Waste Generation *(MT/year)	Mismanaged Plastic Waste (%)	Marine Debris *(MT/year)
1	China	8.82	27.7	1.32-3.53
2	Indonesia	3.22	10.1	0.48-1.29
3	Philippines	1.88	5.9	0.28-0.75
4	Vietnam	1.83	5.8	0.28-0.73
5	Sri Lanka	1.59	5.0	0.24-0.64
6	Thailand	1.03	3.2	0.15-0.41
7	Egypt	0.97	3.0	0.15-0.39
8	Malaysia	0.94	2.9	0.14-0.37
9	Nigeria	0.85	2.7	0.13-0.34
10	Bangladesh	0.79	2.5	0.12-0.31
11	South Africa	0.63	2.0	0.09-0.25
12	India	0.60	1.9	0.09-0.24
13	Algeria	0.52	1.6	0.08-0.21
14	Turkey	0.49	1.5	0.07-0.19
15	Pakistan	0.48	1.5	0.07-0.19
16	Brazil	0.47	1.5	0.07-0.19
17	Burma	0.46	1.4	0.07-0.18
18	Morocco	0.31	1.0	0.05-0.12
19	North Korea	0.30	1.0	0.05-0.12
20	United States	0.28	0.9	0.04-0.11

*(MT/year) = Million tonnes per year.

Apart from that, the impact of mismanaged plastic waste on land contributes to the spread of disease by providing standing water for mosquitoes to use as breeding grounds and it enable the spreading of diseases such as Zika virus, Dengue fever, Malaria and Chikungunya (Jambeck et al., 2018). Additionally, in 2015, plastic products caused a significant flooding event in which at least 150 people died and millions of dollars of damage occurred when plastic bags and other plastic consumer goods accumulated in waterways and clogged drains during heavy rains in the Ghanaian capital of Accra (Drew, 2015). On the whole, mismanaged plastic waste harms physical habitats, transports chemical pollutants, threatens aquatic life, and interferes with human health, environment and the economy (Schuyler et al., 2018).

Technology of plastic waste management / recycling

Different composition of plastic i.e. Polyethylene (PE), Polystyrene (PS) etc., has different characteristics therefore it is imperative that plastic waste is sorted, especially based on composition as recycled plastic resins must have same qualities as virgin plastic resins in order to replace virgin plastic resins (QDB, 2017). There are two main types of processes of plastic recycling; mechanical recycling and chemical recycling. The process of mechanical recycling is shown in Figure 1. The steps in mechanical recycling may not occur in the same order shown in Figure 1 or some steps can be repeated depending on the plastic waste (Ragaert et al., 2017). One drawback of mechanical recycling is that it can lead to thermal-mechanical degradation (Beyler & Hirschler, 2002), thus may result in reduction in molecular weight (Qian et al., 2011) and as well as, elongation at break (La Mantia & Vinci, 1994). Similarly, plastic waste collected for recycling may also have gone through some extent of degradation (Ragaert et al., 2017). However, this impact of mechanical recycling can be compensated by introducing respective additives, especially stabilizers (Ragaert et al., 2017).

Figure 1 Mechanical Recycling of Plastic Waste (Adapted from QDB, 2017)

Chemical recycling involves converting plastic waste into feedstock by Depolymerization process (Singh et al., 2017). When plastic is converted into monomers with the use of chemicals, the process is known as solvolysis, whereas the use of heat in depolymerization leads to process of thermolysis (Kumar et al., 2011). The other processes of chemical recycling are pyrolysis (in the absence of oxygen) and gasification (in controlled environment) (Ragaert et al., 2017). Pyrolysis is suitable for uncontaminated plastic or in terms of composition, for polytetrafluoroethylene (PTFE), polyamide (PA), PS and plexi-glass (PMMA) as they can be depolymerized mainly into their respective monomers. But plastics such as Polypropylene (PP) and PE have skewed product spectrum thus the yield from pyrolysis can vary (Ragaert et al., 2017). Therefore, further processing can be required.

Challenges in circular economy

• Cheaper raw material

The stumbling block of circular economy arises when plastic material cannot easily be reused when processing a used plastic material is too costly. According to research by the World Economic Forum, estimates of the after-use costs of plastic packaging alone reach up to $40 billion per year, exceeding the actual profits that stem from plastic packaging in the first place (Lauren, 2016).

Apart from that, a successful circular economy is hard to achieve since some industrial branches demand high standards of raw material quality; hence, the acceptance of recycled plastic is rather low (Simon, 2019). In addition, since plastics are made from petroleum, the low cost of raw materials are closely related to the drop of oil prices. So as oil prices plummet, so does the cost of making new plastic bottles and other products (Sarah, 2016). This, in turn, is making product manufacturers to merely buy new plastics and indirectly strain every part of the recycling industry. For example, in United States of America, the biggest recycler in the country has reduced the number of recycling facilities it operates, from 130 to 100 in 2014 and 2015. The revenues from recycling operations dropped 16 percent, from over $1 billion to $878 million due to decrease in demand and shrinking profit margins (David, 2016).

• Implications of china's ban of plastic import on waste management

In 2016, 7.3 million metric tonnes of plastic waste was imported in China where more than three quarters of plastic waste exported from developed countries (Qu et al., 2019). After China's ban on the import of plastic waste of lower quality (<99%) from the start of 2018 caused little or no change in the transboundary movement of plastic waste except that it was sent to other countries. Instead of adopting sustainable alternatives in their country, they search for alternative countries for exporting their plastic waste. Hence, countries in Southeast Asia became the focus such as Malaysia, Thailand, and Indonesia (Parker, 2018). For instance, developed countries like US, Japan, Britain, Germany, Belgium, France, Spain, and Estonia have been exporting their plastic waste to Malaysia (Chu, 2018). Approximately, 754,000 tonnes of plastic waste was exported to Malaysia from January to July 2018 by these countries (Greenpeace International, 2018). The increase in plastic waste import also resulted in establishment of illegal recycling facilities in Malaysia (The Straits Times, 2018; Greenpeace International, 2018).

Thus, the China's ban on plastic waste import has created challenges for developed countries to rethink their strategy of plastic waste management. Qu et al., (2019) stated that while developed countries are facing stern challenge at present, there is an opportunity for local plastic recycling industries in developed countries. But China's ban also created a challenge for other developing countries that have started accepting plastic waste from developing countries, as current recycling industries in developing countries do not have capacity for higher amount of plastic waste.

• ***Generation of low-value plastic waste***

The concentration of valuable materials in discarded products is one of the critical parameters that will determine the feasibility of the recovery process and the circularity of the economy (Cobo et al., 2018). In plastic circular economy, the quality of recycled plastics and the functionality of the substances present in the materials are the two vital qualitative aspects that need to be taken into account (Steinmann et al., 2019). Mixed plastic from municipal solid waste, particularly household waste, is a highly heterogeneous waste stream, as it includes a variety of different immiscible polymers, product types and design, which include both chemical and physical contamination from the production, use and waste management phases (Ragaert et al., 2017; Eriksen et al., 2018).

Recycling of these plastics often includes considerable material losses leading to recycled plastic with poor material properties (Eygen et al., 2018). These limit the ability and applicability of the recycled plastics in plastic recycling systems, to close the material loops (Hahladakis et al., 2018; Eriksen & Astrup, 2019). In addition, several authors agree that the non-recyclability of plastics may stem from the extensive usage of composite plastics that are technically low-value plastic wastes (Reck & Graedel, 2012). Intrinsically, low-value plastic wastes are more likely to end up in landfill or energy recovery facilities (Hahladakis & Iacovidou, 2018). The answer to this question might root in the design of the primary product, which is crucial in order to improve the quality of the secondary material. However, in tackling the issue of low-value plastic waste in plastic circular economy, different classifications of waste treatment options have been proposed, such as through mechanical recycling (Alassali et al., 2018).

Drivers of circular economy

• ***Extended producer responsibility***

In 1991, Extended Producer Responsibility (EPR) was first implemented as a means to address the problem of landfill shortage in Germany through the Packaging Ordinance (Dubois, 2012). Ever since, the last decade has seen a considerable increase in implementation and interest in EPR programs. This program ensures the price of the product includes the cost of its safe disposal, which will eventually reduce the environmental impact of the waste and lead to lower cost of production for the new product. Additionally, EPR aims towards reducing waste disposal, resource conservation, increase recycling rates and promoting eco-design products (Kaffine & O'Reilly, 2015).

Under EPR, manufacturers and importers of priority products are obliged to take care of their end-of-life products (e.g. packaging, pharmaceutics, batteries, and vehicles) (Banguera et al., 2018). The end-of-life products can be effectively tracked and recaptured with transparency across supply chains coupled with government policies and market levers to incentivize the designing out of waste. Figure 2 shows the strategies under EPR that assigns the responsibility of disposal of the waste to the manufacturer of the goods.

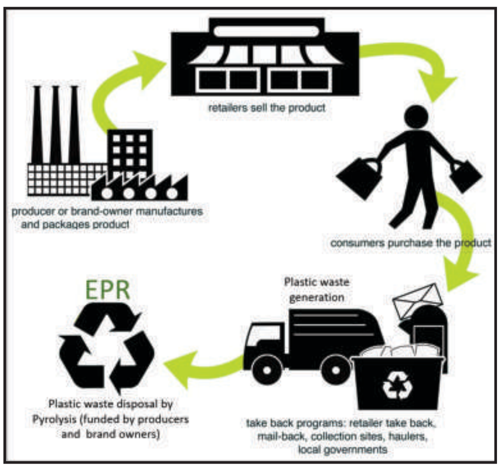

Figure 2. Strategies in EPR (Plastic Waste, 2019).

Nevertheless, there is no point of designing a product for disassembly if the take-back mechanisms are not in place to recover those component parts effectively. Therefore, in order to ensure each raw material can be taken back into the production cycle to create new high-grade products, each raw material has to be evaluated to assess the worthiness of a particular compound.

Norwegian amended waste regulation (No. 1289/2017) is a good example of EPR's role to trim down packaging waste. Producers are obliged to pay for the collection of their product as stated in the financial tool as provided in the regulation. To finance the collection, soring, recycling and other processes of the waste packaging, those producers who supply the Norwegian market with a minimum of 1000 kg of a packaging type per year, need to join an approved compliance scheme. Apart from that, packaging may only be placed on the Norwegian market if it meets the design, reuse and recycling requirements as defined by the regulation. In addition, a proportion of the materials shall be recyclable into marketable products in compliance with community standards. The generation of waste and the percentage decrease in packaging placed on the Norwegian market are reported on an annual basis in order to observe any decrement over the years (Raubenheimer & McIlgorm, 2018).

- ***Subsidies on plastic recycling***

Plastic recycling has generally been discovered to be uneconomic without significant subsidies. Reason behind is because of the low price of petrochemical feedstock compared with process costs incurred to produce monomers from plastic waste (Patel et al., 2000). Ultimately, industries might have to resort to government subsidies in order to survive when there is no value left in recyclables.

Typically, subsidy aims to avoid the possibility of government-imposed punitive legislation and to alleviate the impact of plastic-based litter. Advance Recycling Fee's (ARF), levied on product sales, are one of the means of generating revenue, paid to recycling companies per unit or weight of post-consumer waste recycled, as a 'back-end recycling subsidy' (Sinha-Khetriwal et al. 2005). Main reason why the recycling subsidy is administered per weight of post-consumer inputs, as opposed to the volume of recycled outputs, is because the efficiency losses vary greatly with the recycled end-use product and would typically encourage down-cycling within a recycling value chain (Huysman et al. 2014).

A number of industries like PET Recycling Company (PETCO) (see case study), Californian; Swiss and Taiwanese e-waste programmes and the Californian used-oil programme have been implementing subsidies on plastic recycling (Sinha-Khetriwal et al. 2005; Nixon & Saphores 2007; Black, 2016).

- ***Deposit return and reward schemes***

Implementation of economic incentives through refund and reward system and Container Deposit Legislation (CDL) are believed to be amongst the effective ways to cut energy costs due to the substitution of recycled materials for virgin materials (Lavee, 2010). In general, the system benefits the public through the value of recyclable materials from their own waste stream, and in a way motivate recycling behavior amongst the general public. From an economic outlook, although incentives are costly to be executed, but they significantly increase materials recovery (Lerner, 2010) and prevent the potential negative impacts of disincentives (e.g. plastic bag levies and disposal taxes) such as illegal dumping to avoid taxation, as well as, increment in the amount of waste in landfills and the amount of litter that ends up in the marine environment (Walls, 2011). The ocean is estimated to already contain over 150 tonnes of plastics where more than 100 million particles of macroplastic (i.e. >25 mm in size) and more than 51 trillion particles of microplastics (i.e. <5mm in size) are floating on the ocean surface (Eriksen et al., 2014).

In Japan, refund and reward system is implemented since 2006, where recyclable plastics which are returned to the recycling center through installation of vending machines and smart card technology, are rewarded with points or coupons, which are redeemable for goods in participating supermarkets (Numata, 2016). In the United States, CDL initiative has been adopted in 10 of the 50 states (Table 2), where surcharge is placed on plastic beverage bottles and the cash refund is returned when the consumer brings the container back to the intended facility (Schuyler et al., 2018). Among all states listed, Michigan successfully recorded the highest rate of containers redemption of 94%. In Germany, CDL was introduced in 2003 with 99% of plastic bottles are recycled (Damian, 2018).

- ***Industrial ecology / waste exchange***

One man's waste is another man's raw material. Trying to mimic the natural cycles of ecosystems, industrial ecology creates different alternatives of the materials and their wastes through reuse, repair, recycling and remanufacturing while increasing the recovery of components with the intent of preserving valuable resources and generating less pollution (Nakajima, 2000;

Table 2. Characteristics of CDL programs in several states in the US and Australia (Adapted from Schuyler et al., 2018).

State/Country	Start year	Deposit value (cents)	Redemption rate (%)
California, USA	1987	5	84
Connecticut, USA	1980	5	84
Hawaii, USA	2005	5	73
Iowa, USA	1978	5	86
Maine, USA	1978	5	90
Massachusetts, USA	1984	5	64
Michigan, USA	1976	10	94
New York, USA	1983	5	65
Oregon, USA	1972	10	65
Vermont, USA	1972	5	75
Northern Territory, Australia	2012	10	46
South Australia	1977	10	80

Smith et al., 2015). Industrial ecology promotes in such a system that optimize the utilization of materials and energy as well as minimize the effluents and waste generation to serve as raw material for another process. Industrial ecology can be on the basis of being paid for the waste, paying nothing for its removal and/or paying less than the cost for its disposal (NI Business Info, n.d.).

Example of plastic industrial ecology is carried out by Nampak Plastics Europe, a leader in the manufacture of High-Density Polyethylene (HDPE) bottles for dairy industry (Nampak Plastics, 2019). Hard plastic head waste, off-spec product and single use LDPE plastic wrapping material are produced during the manufacturing process. These materials are incompatible for onsite recycling due to strict quality specifications. Nevertheless, through industrial ecology, these materials are supplied to Waste Not Ireland, a company that provides a range of waste collection and recycling services for dry recyclable materials. Therefore, Waste Not Ireland was able to provide a local tailor-made recycling services for Nampak that reduces the volume of plastics going into landfill and incineration.

However, the main hindrance to the implementation of industrial ecology is the absence of an 'advocate' to bring the various industries together. Therefore, businesses need to work together to determine what unwanted by-products exist and what their potential applications are, in order to create by-product synergy through an exchanged, sold or passed free of charge between sites of materials and resources (International Institute for Sustainable Development, 2013).

Impacts of circular economy

- ***Valorization***

Circular economy has been adapted across countries ever since it was introduced by policy makers from China, Japan and the European Union (Murray et al., 2015; Huysman et al., 2017). Simply put, circular economy can be described as a system which is restorative and regenerative by intention and design, through superior design of materials, products, systems and business models (Kiser, 2016; Kaur et al., 2018). All of these to achieve high production efficiency, yield, and productivity, while supporting sustainability goals through improved raw materials availability and reduced environmental impacts (Pomponi & Moncaster, 2017; Cuadros Blázquez et al., 2018; Kalmykova et al., 2018).

Conventional plastic production is highly dependent on virgin fossil feedstocks (i.e. natural gas and oil) in which 4 to 8% of the global crude oil extraction are consumed for the yearly production of plastics, and is projected to increase to 20% by 2050, if current consumption patterns persist (Kreiger et al., 2014). Apart from that, roughly 185 L of water are required to manufacture a kilogram of plastic (Zygmunt, 2007), and these resources will slowly be diminished if plastics are disposed, instead of being recycled (European Commission, 2018).

Quality does affect plastic recyclability, and given the right design and technology innovations at the sorting and reprocessing of plastic components, closed-loop recycling can be improved. Current innovations strive to achieve that, by also looking at improved design and capture intervention, to maximize the recovery of plastic material and its embedded value such as bioplastics, production of polyvinyl alcohol, removable colored coatings, shrink sleeves to replace in-mould labels, and use of 'self-peeling' labels (Eriksen & Astrup, 2019).

In Europe, improved plastic product design can save 77 to 120 EUR for each tonne of plastic waste collected, attributable to more efficient plastic recycling processes (European Commission, 2018). Furthermore, £20 million fund, known as the Plastics and Research Innovation Fund (PRIF) has been launched in the United Kingdom, to explore new ideas and innovations that can possibly bring changes in the plastics manufacturing, as part of a move to a more circular economy and sustainable approaches to plastics (Waste Management World, 2018).

A better understanding of how quality changes during plastic packaging's lifecycle would enable better handling, sorting and reprocessing, in utilizing the recovered plastic resource in the production of new products (Hahladakis & Iacovidou, 2018). The set of rheological, mechanical and structural properties of plastic materials produced may vary widely depending on the type of plastic used to make them, as tabulated in Table 3 (Adapted from Hamad et al., 2013).

Table 3: Perspectives during recovery and reprocessing of plastic products.

Plastic Type	Mechanical Recycling	Results	References
PET	1) Blending with HDPE using the extrusion process	1) HDPE reduces the melt viscosity of the blend indicating good flow ability	Navarro et al. (2008)
	2) Adding small amounts of virgin PLA	2) Lowers the viscosity of the blend, and gives higher thermal sensitivity	La Mantia et al. (2012)
HDPE	1) Reprocessing	1) Mechanical properties remain almost unaltered	Vilaplana & Karlsson (2008)
	2) Blending with virgin polyamide	2) Improves the mechanical properties and thermal stability of the blend	Vallim et al. (2009)
PVC	1) Via triboelectro static technology	1) Recovers PVC from plastic composites (e.g. PVC/PET, PVC/PP, PVC/PE or PVC/PS). Recovery of 96–99% with the pure extract content in excess of 90%.	Lee & Shin (2002)
	2) Blending with wood fiber	2) Improves recyclability- composite properties remained stable for up to 5 processing cycles	Augier et al. (2007)
LDPE	Subjected to extensive extrusion cycles (up to 100 cycles).	Increases the viscosity with increasing number of extrusion cycle. Its processing ability is affected after the 40th extrusion cycle.	Jin et al. (2012)
PP	1) Reprocessing	1) Progressive diminution of the elastic modulus	Vilaplana & Karlsson (2008)
	2) Subjected to injection cycles	2) Decreases the viscosity, and leads to small losses in material strength	Aurrekoetxea et al. (2001)
PS	Reprocessing cycles on PS nano composites containing 5 wt% organophilic clay	Increases reprocessing ability compared to pure PS	Remili et al. (2011)

• ***Less plastic waste generation***

With successful implementation of circular economy, significant decrease in plastic container litter are evident in countries worldwide such as in the United States (40% lower), Hawaii (50% lower), and Australia (40% lower) (Schuyler et al., 2018). Apart from that, from an economical point of view, reduction in plastic waste generation decreases the cleaning costs incurred for the remedial action of mismanaged and illegal dumping of used plastics that are not recycled and recovered (Xanthos & Walker 2017). In 2014, UN Environment estimated the natural capital cost of plastics, from environmental degradation, climate change and health, to be about USD 75 billion to USD 139 billion annually (Lord, 2016). On top of that, effective execution of circular economy will eventually increase the aesthetic value of the surrounding environment due to less litter (Lavee, 2010).

Hence, the development of plastic circular economy offers opportunities to tackle the aforementioned problems, while creating an effective after-use plastic economy with high resource efficiency and waste generation to a minimum (Kaur et al., 2018). The World Economic Forum reported that by implementing the circular economy globally, savings of up to $1 trillion per year of material (technical and biological) cost could be achieved by 2025 (World Economic Forum, 2014).

Case studies

• ***Subsidies on plastic recycling – PET Recycling Company (PETCO) (Black, 2016)***

In 2004, PETCO was established as a means to address the significant waste associated with polyethylene terephthalate (PET) products across the value chain and to avoid impending government legislation. PETCO fills the role of a non-profit producer responsibility organization, managing the collection of voluntary levies from PET converters, based on raw materials purchased locally or imported, which are subsequently used to support PET recycling firms in South Africa through subsidies.

These projects are termed as PETCO's Category A projects. PETCO's recycling subsidies are planned to stabilize the price of post-consumer PET, ensuring constant supply of post-consumer PET to recyclers, and that operators across the PET recycling value chain to remain viable through adverse economic conditions. The subsidies are administered per kg of post-consumer PET inputs. The subsidies are administered as combinations of flat rates, fixed additional rates and variable additional rates, where the total subsidy for each recycled PET value chain accounts for between 11% and 14% of postconsumer PET input costs for recycling firms.

Ever since the inception of PETCO, physical recycling of PET in South Africa has increased from 16% (9 840 tonnes) of post-consumer PET in 2005, up to 48.55% (64 053 tonnes) of post-consumer PET in 2014. The awareness on recyclability of PET from both consumer and brand-owners' perspective has also been improved.

- ***Deposit-refund schemes (DRS) for one-way beverage packaging in the Netherlands (Deprez, 2016)***

The Netherlands, with a land area of 42,508 km2, comprised of approximately two-thirds of rural land area and a third of urban land area. 12% of the total population lives in rural land area while 88% of the total population lives in urban land area. The DRS of the Netherlands entered into force on 1 January 2006, covers one-way beverage packaging of PET-bottles with a deposit and refund of 0.25 euros charged for each purchased bottle. Figure 3 illustrates the packaging waste statistics of the Netherlands, showing the annual amount of packaging waste generated and how much of this amount is recovered and recycled.

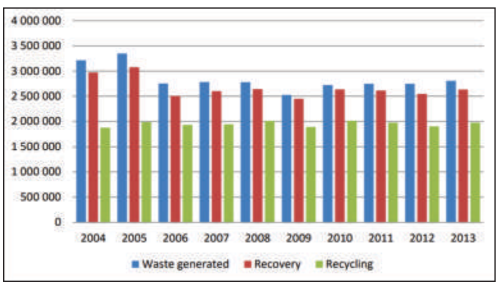

Figure 3: Packaging waste (in tonnes) in the Netherlands (2004-2013).

Based on Figure 3, the total amount of packaging waste generated has dropped since 2006, which coincides with DRS implementation. The implementation of DRS costs approximately 40 million euros per year, however only 34 million euros per year is benefited from the energy that is saved from DRS implementation, denoting that it is not cost-effective. Nonetheless, these numbers do not take into account the supplier costs, consumer costs and litter benefits which in reality more benefits can be visualized if they are to be considered.

Conclusion

The shift towards a circular economy is still very much in its infancy. Industries are continuously investing in R&D activities and innovation to develop new technologies that can support and maximize the recovery of plastic material and its embedded value. Manufacturers and retailers may have to stop thinking of themselves as purely product makers and sellers, and instead defining themselves as collaborators and deliverers of sustainable-related performance. One of the apparent barriers in achieving businesses circularity is the lack of product take back schemes and industrial infrastructure to reuse by-products. The aforementioned challenges require reconsideration in the current economic models that focuses not only into business model redefinition, but also system reorganization. Apart from that, one of the enabling tools that will help bring about a circular, restorative economy is a change in mindset which comes from education that will promote a shift away from traditional open, linear systems towards closed loops and inter-dependent relationships of the economy.

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Combining Food Waste and Sewage Sludge for Improving STP Economic Feasibility

- Examples from Scandinavia and Asian Cities

Currently only about 30% of India's population is connected to a sewage network and there are huge infrastructure projects planned, this is a great opportunity to leap frog in terms of adopting the Best Available Technologies (BAT) and strategizing based on different wastes with similar organic properties that are produced locally.

Dr. Ashish K Sahu *(PhD, MBA), Marketing Manager, Cambi Group AS, Asker, Norway*

Introduction

India annually generates about 62 million tons of solid waste, with a 4% growth, out of which 15% is currently treated. About 60% (37 million metric tons) of solid waste is organic waste, which is a huge potential for revenue generation in terms of bioenergy/electricity production, fertilizer production, in addition to gate fees if managed and handled in a sustainable way. Reduction in carbon footprint is achieved at the same time, contributing to sustainability goals. Currently only about 30% of India's population is connected to a sewage network and there are huge infrastructure projects planned, this is a great opportunity to leap frog in terms of adopting the Best Available Technologies (BAT) and strategizing based on different wastes with similar organic properties that are produced locally. Such mega projects are designed with over 25-30 year life span and comes with a heavy infrastructure costs and this article highlights on selection of sustainable BAT to address municipal organic solid waste and sewage waste (sludge) for future growth for Indian cities. Several Asian cities like Anyang in South Korea and Chongqing in China have adopted this strategy on co-digestion of food waste and sewage sludge with disruptive technology like CambiTHP® (Cambi Thermal Hydrolysis Process), the benefits are highlighted in this article.

[1]Swaminathan, M. (2018) How can India' waste problem see a systematic change. Economic & Political Weekly, 53(16).
[2]Press Information Bureau (2016)
[3]Gate fee (Tipping fee) https://en.wikipedia.org/wiki/Gate_fee

Definitions, Classification, and Treatment Processes

There are many ways of classifying waste depending on the origin of waste, type, and its state of matter, the definition and guidelines varies from different geographies and with regulations. While dealing with technologies for waste treatment, it is important to firstly understand the fundamental classification of waste and its definition for that particular region. Many a times there is no clear definition and there are several assumptions, which often lead to misunderstanding of technology and product applications.

Figure 1 describes the EU regulations of Classification of Waste in terms of the Risk Level & prescribed method of disposal.

In light of the same, this article focuses on treatment technology on wet-waste (food waste) and liquid waste (municipal wastewater).

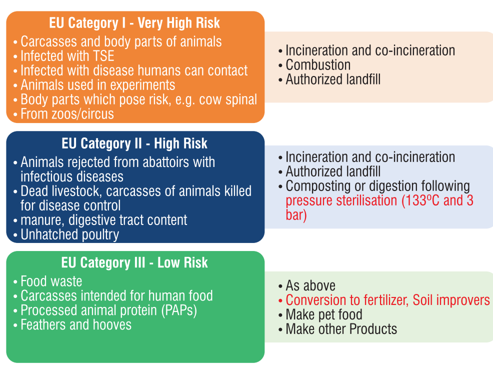

Figure 1. EU classification of wet waste
(Marked in red are advantages of thermal hydrolysis)

While liquid-waste (here referring to wastewater) comes from toilets, kitchen, washing (households/offices/restaurants) and is routed to a STP (sewage treatment plant) for further treatment and produce sewage sludge in solid state, the solid waste (wet-waste i.e. food waste) can be collected separately and can be further treated by anaerobic digestion, composting, landfill, or even incineration. There is an advantage of combining both this wet-waste into liquid-waste to be handled by a STP, as exhibited by several municipalities around the world. These projects can also fall under the umbrella on "Waste to Energy" which is a general terminology used in the solid waste industry[5]

The wastewater treatment (by physical, chemical and biological processes) in a conventional STP yields two by-products, treated (reclaimed) water (discharged to the environment based on regulations or is reused) and the solids generated (sludge) requires further treatment since most of the pathogens (harmful microorganisms) are present in the sludge. There are several ways of treating sludge from a STP, and this depends on quantities generated, regulations and selection of different technologies. The different technologies are lime stabilization, composting, anaerobic digestion, incineration, pyrolysis, and landfill. Anaerobic digestion is by far the most sustainable way of treating sludge since sludge can be transformed by microorganisms to bioenergy (biogas i.e. biomethane), which can be further used to produce electricity, or upgraded to fuel for buses; and the end product (biosolids) after digestion and dewatering can be used for agricultural purpose (depending on quality and regulations).

Co-digestion is anaerobic digestion of different substrates together in one system, so co-digestion is often used to treat sludge from STP and food waste (organics) from wet-waste. Co-digestion can be applied either for food waste digestion which receiving partially sewage sludge in addition or for sludge digestion, which receives partially food waste in addition, depending on local project financing and management conditions. The prime advantage of co-digestion is to improve both the STPs economic feasibility and organic waste management.

Benefits on Co-Digestion

Technology called "CambiTHP®", (Figure 2) is an advanced digestion process, comprising of several unit operations; viz. pre-dewatering, CambiTHP® thermal hydrolysis process, cooling, anaerobic digestion, post-dewatering. The Company Cambi has been a world leader in thermal hydrolysis process (CambiTHP®) and this process aids in anaerobic digestion as hydrolysis is a rate-limiting step in any anaerobic digestion process. So CambiTHP® speeds up the process and it has several advantag[7]. The process comprises of treating thickened and pre-dewatered sludge from STP, at high temperatures and pressure with steam and the end product is blended with food waste and is fed into the anaerobic digesters.

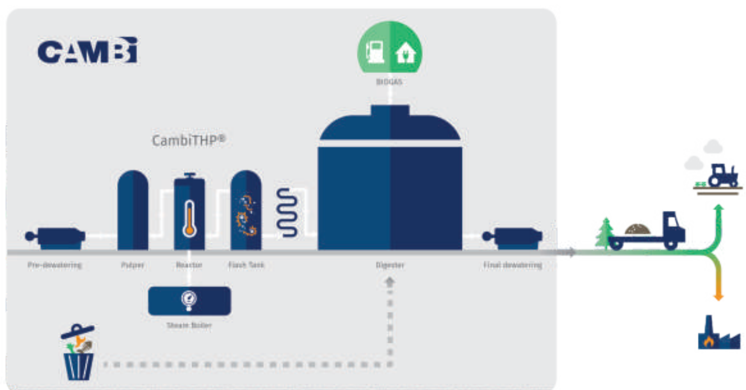

Figure 2. Cambi sludge line with anaerobic co-digestion

By integrating CambiTHP into co-digestion, the feed substrates are well balanced in carbon to nitrogen (C:N) ratio for stable digestion, and the performance is enhanced dramatically.

- First, the digester throughput is increased by up to three times, so the required volume is reduced down to one third, thus a huge saving in CAPEX investment and space need in digesters.
- Second, much higher biogas production is achieved depending on substrate composition, this number may be up to 50% more biogas.

[4]Regulation (EC) No 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) No 1774/2002 (Animal by-products Regulation) URL: https://eur-lex.europa.eu/eli/reg/2009/1069/oj
[5]Waste to Energy (WtE) https://en.wikipedia.org/wiki/Waste-to-energy
[6]Anaerobic digestion is collection of processes by which the microorganisms breakdown biodegradable materials in the absence of oxygen
[7]Barber, W.P.F. (2016) Thermal hydrolysis for sewage treatment: A critical review. Water Research. 104:53-71.

- Third, the bio-solids after bio-digestion are biologically safe for land application for plant growth due to total pathogen kill. Potential disruption of antibiotics can also be achieved for safe use.
- Fourth, the dewaterability of biosolids is significantly improved, therefore improve the quality of final products and reduction in biosolids cake amount to disposal and application.

The overall carbon footprint is largely reduced by more biogas energy production, biosolids and nutrient recovery to land application, and less construction materials (Figure 3). This shows the key benefits of co-digestion of sewage sludge and food waste where THP helps achieve these benefits.

Figure 3. Value creation on implementing a CambiTHP technology for anaerobic co-digestion

The reject water (after anaerobic digestion and dewatering) is rich in nutrients, can be used as soil conditioner or as a fertilizer.

Co-digestion examples by Cambi around the world

Since 2008, Cambi has delivered 6 co-digestion plants in Norway, Sweden, South Korea and China. The biggest is Luoqi project in Chongquing in China. Different ratios of raw sludge and organic waste (food waste) is mixed and co-digested. In Chongqing, China sewage sludge is first treated by CambiTHP® then combined into food waste co-digestion plant and in Anyang, South Korea pre-treated food waste is combined into co-digestion with CambiTHP® treated sludge in the STP plant. Table 1 gives the different types of plants delivered by Cambi. Cambi has delivered 65 THP plants in over 22 countries in 5 continents.

Table 1. Summary of the different Cambi plants capacities and percentage of raw sludge and organic waste for anaerobic co-digestion

Name of Plant	Location	Completed	Design capacity (t DS/day)	% Sewage sludge	% Organic Waste
Ecopro	Verdal, Norway	2008	24	60	40
Sundet	Vaxjo, Sweden	2014	26	70	30
Ivar	Stavanger, Norway	2014	36	35	65
Bakdal	Anyang, South Korea	2016	76	85	15
Mjøsanlegget	Lillehammer, Norway	2016	30	10	90
Luoqui	Chongqing, China	2019	297	15	85

Food for Thought

India is currently in the midst of planning on constructing and upgrading several STPs around several cities (Delhi, Mumbai, Bengaluru, etc), to name a few. Sustainable solutions like anaerobic digestion of sewage sludge has been adopted by several cities around the world, (e. g. Beijing, London, Oslo, Singapore, Washington DC etc.) , where they are converting sludge into wealth (e. g. bioenergy, fuels for buses for domestic transport & organic fertiliser). India too can adopt the same idea & adopt the state of the art technologies in the waste and wastewater sectors.

Currently in Indian municipal bodies waste management & sewage are responsibilities of different departments with different set of regulations. To implement co-digestion strategy will require a different strategy. This article on co-digestion of food waste and sewage waste is just an example on the western approach of combining different waste for revenue generation. It has been adopted by several cities in Scandinavia, China and South Korea. However, this is an opportunity for India to think & act to achieve innovative waste management practice. ■

A Novel Approach Towards E-Waste Management – India

On the one hand e-waste contains valuable materials such as copper, silver, gold and platinum which could be processed for their recovery and on the other hand it also contains many hazardous constituents such as cadmium, lead, mercury, etc., that may adversely impact the environment and affect human health if not properly managed.

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Introduction

The electronics industry is one of the world's largest and fastest growing manufacturing industries. The increased production of electrical and electronic goods and the high rate of obsolescence of these products leads to the generation of huge amounts of Waste Electrical and Electronic Equipment (WEEE) or the Electrical and Electronic Waste or E-waste. According to the Global E-waste Monitor 44.7 million metric ton of E-waste was generated in 2016 of this 18.2 million metric tons is generated in Asia. According to the recent study India e-waste generation in India is about 2 million metric tons ranking it among the top five e-waste generating countries in the world. However, reuse and refurbishment of electrical and electronic products in India has enabled the growth of the secondary market there by extending the life of the product on the one hand and reducing the e-waste which are destined for recycling or disposal.

According to MAIT-GTZ study of 2007 95% of the e-waste generated in the country is recycled in the informal sector comprising of small and micro-enterprises. These units use highly polluting technologies leading to adverse effects on environment and health. However, the scenario is changing with the formal e-waste recyclers setting up recycling units. Presently, both the formal and informal e-waste recyclers are engaged in dismantling the e-waste to sell the dismantled parts/components for recycling locally and export the printed circuit boards to be recycled in the facilities set up in the developed nations. Only a few formal e-waste recycling facilities are engaged in recycling.

What is e-waste?

Electronic waste or e-waste comprises of old, electrical or electronics goods such as computers, servers, mainframes, monitors, laptops, TVs, DVD players, CDs, MP3 players, printers, scanners, copiers, calculators, fax machines, battery cells, cellular phones, transceivers, medical apparatus and electronic components, refrigerators and air-conditioners. MP3 players, etc., that are not fit for their originally intended use or in other words those that have reached their 'end-of-life'.

On the one hand e-waste contains valuable materials such as copper, silver, gold and platinum which could be processed for their recovery and on the other hand it also contains many hazardous constituents such as cadmium, lead, mercury, etc., that may adversely impact the environment and affect human health if not properly managed. Various organizations, bodies, and the governments in many countries have adopted and/or developed policies and strategies for environmentally sound management of e-waste in order to tackle the growing threat to the environment and human health due to improper recycling and disposal of e-waste.

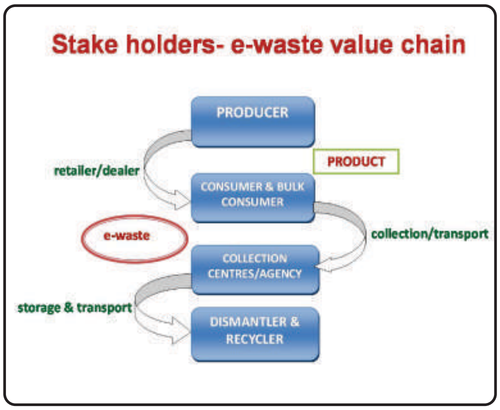
Environmental and health hazards of e-waste

E-waste is not hazardous per se, however, the hazardous constituents present in the e-waste render it hazardous when these are dismantled and processed. The harmful materials contained in electronics products, coupled with the improper recycling activities in the informal sector, pose a real danger to human health and environment if electronics products are not properly channelized for recycling and disposal.

The electronic products such as computers, cell phones, TVs Cathode Ray Tube (CRT) Monitors etc contain heavy metals such as lead, cadmium, mercury, Brominated Flame retardant (BFR) etc., which are toxic and hazardous to environment and human health if they enter the water bodies or food chain and can cause irreversible damage to human health. Therefore it is essential to ensure that all e-waste recycling is carried out in an environmentally sound manner. The environmental and health hazards that are likely when such wastes are recycled in the informal sector using polluting technologies, the operations take place in unsafe environment without the use of personal protection equipment such as masks, gloves etc. which lead to irreversible damage to the environmental and health.

E-waste Value Chain & Stakeholders

The Key Stakeholders in e-waste Value chain & management systems include:



The main stakeholders in the e-waste value chain are the producers, consumers, collection centres/agencies and dismantlers and recyclers. Each one of them have a specific role in the environmentally sound management of e-waste. The mandatory provisions for handling e-waste have been given in the E-waste Management Rules, 2016 and the implementation guidelines published by the Ministry provides compliance procedures for each of the stake holders.

Policies & Regulations

The Ministry of Environment and Forests, Government of India has notified the E-waste Management Rules, 2016 under the Environment (Protection) Act, 1986. The main objective of the these rules is to put in place a mechanism to regulate the e-waste from generation to recycling and final disposal. These rules provide enabling policies and procedures that would be legally binding for all stake holders in the e-waste value chain such as manufacturers, producers, collection centers, dealers, refurbishers, consumers, dismantlers, recyclers, transporters etc., handling e-waste.

According to these rules the producers have to ensure that the e-waste is collected through the authorized collection agencies and channelized to authorized dismantler or recycler. In order to facilitate this, producers are required to provide information about such authorized collection agencies to their consumers and this information should be provided with the product and periodically updated. Environmentally sound management of e-waste necessitates proper handling at every stage such as, **collection, storage, transportation, recycling and safe disposal of final wastes.** In order to understand the implications of the various clauses under these rules and its compliance requirements the implementation guidelines have been provided.

The National Environmental Policy, 2006 (NEP) provides a focus on sustainable development and the need to facilitate the reuse/recovery/recycling of useful materials from waste, thereby, conserving the natural resources and reducing the wastes destined for final disposal and to ensure environmentally sound management of all wastes. The NEP also encourages giving legal recognition and strengthening of the informal sectors and their integration in the mainstream activities. Considering the high recycle potential of e-waste, such waste should be recycled to recover valuable natural resources using environmentally sound technologies.

Collection & Channelization of E-waste

E-waste is a post-consumer waste requiring a system for collection after the 'end-of-life'.

In order to ensure the return and channelization of used electrical and electronics equipment it is essential to provide information about the authorized collection centres to all consumers including the bulk consumers. Under the e-waste rules it has been made mandatory to provide detailed information about the authorized collection centre. It is also necessary to provide the helpline number so that the consumer can reach the nearest collection centre wherever he/she is located. This information can be provided along with the product in the product information booklet.

The collection of e-waste could be organized in any of the following manner:

- Through Dealers: The dealers/ distributers will be responsible for the collection of e-waste as part of the take-back/buy-back/exchange policy of the producers.
- Establishing Collection Points/Bins: The collection points or collection bins can be put up at several public places like malls, airport, offices, market places etc. and in other organizations and educational institutions to collect e-waste.
- Through Informal Sector: The informal recyclers could be engaged in e-waste collection should in turn have a tie-up with the formal for processing in the formal recycling units.
- Formal Recyclers: Formal recyclers can organize to collect the e-waste from the dealers/collection points/bins/informal recyclers as the case may be and take the responsibility for recycling of the e-waste.

Extended Producer Responsibility (EPR)

The principle of '**Extended Producer Responsibility (EPR)**', was is global phenomena used for the management of e-waste and other wastes the world over. '**EPR**' makes the producers of the electrical and electronic equipment (EEE) responsible for the '**end of life**' management of their products beyond manufacturing until the post-consumer stage in order to ensure environmentally sound management of their products. E-waste being a post-consumer waste, the biggest challenge is the **collection and channelization** of such waste for environmentally sound recycling. The producer is entrusted with the responsibility to finance and organize a system to meet the costs involved in the management of the 'end of life' products such that these products do not cause any adverse effect to the environment and human health. It is also mandatory for the producer to facilitate in the collection and processing of the historical wastes generated from his products and also the historic waste. The producer has an option for establishing and managing a system for the collection of e-waste either individually or collectively. Under individual systems, financing the entire system is the responsibility of the producer concerned. In contrast, under collective systems, e-waste from all the producers may be collected and recycled together with the producers sharing the financial burden according to their market share.

The Extended Producer Responsibility (EPR) suggests that the producer (manufacturer or importer) of the product is responsible for the management of a product through the life cycle of the product including the end-of-life management of products. The shift of the responsibility incentivizes the producers to incorporate environmental considerations in the design of the products and to reduce the environmental risk in the end-of life management of the product. This could be done by means of reducing the use of toxic and hazardous substances, increase in the use of recycled constituents in the products, enhancing the ease of product disassembly and by considering other ways to reduce the overall environmental footprints of a product. The product's energy consumption during use and packaging for distribution and sale would also determine the environmental performance.

Extended Producer Responsibility (EPR)has been made mandatory under the e-waste rules, wherein the producer has been entrusted with the responsibility for collection and channelization of the 'end of life' products to authorized recyclers. The rules also make it mandatory to seek EPR authorization for organizing the system for environmentally sound management of end-of-life their product. It also makes it mandatory for the producer to facilitate in setting up the collection centre and creating awareness. Under these rues EPR can be implemented by the producers either individually or collectively. These are two distinct models that need to be designed and integrated to suit the Indian requirements which are acceptable and viable in the long run. Individual Producer Responsibility (IPR) means the responsibility of a producer for its products through the entire life cycle including the collection and 'end-of-life management'. Collective Producer Responsibility (CPR) implies that a consortium of producers takes responsibility for the end of life management of products of all the members of the consortium.

The producers have been entrusted the responsibility of establishing collections centres. However, this responsibility could be discharged individually or collectively. In the case of 'take-back' and 'exchange schemes' announced by the individual producers, the responsibility of collection of the end of life products is organized independently by the producer. The decision about the mechanism for collection is taken by the individual producer in accordance with the company policy.

Role of Informal Sector in e-waste management

The MAIT-GTZ study of 2007 revealed that about 95% of e-waste recycling takes place in the informal or the unorganized sector. The recycling in the informal sectors essentially involves dismantling and sometimes include the extraction of precious metals but these units use highly polluting technologies that pose extensive health hazard to all those involved in processing of e-waste. However, the scenario is changing with the authorized recycling units that are the formal recycling units carrying out an end to end recycling of e-waste to produce valuable resources in environmentally sound manner using the Best Available Technologies (BAT). Most of the IT manufacturing company and the users do not have any disposal policy therefore most of the e-waste was being disposed of to the scrap dealers which in turn were sold to the recyclers in the informal sector. The manufacturing and marketing units do not take the responsibility for safe disposal of e-waste. Therefore the informal systems thrive. The processing of e-waste in the informal sector especially the recovery of metals has adverse impacts on environment and health. The other aspect is developing the mechanism required to ensure that recycling activities are carried out without causing any adverse effects on environment and human health. Since most e-waste recycling takes place in the informal or unorganized sector, monitoring the **recycling activity** and making every recycler accountable is also a difficult.




E-waste Flow

E-waste being a post-consumer waste with a high recycle potential exhibits the following channelization for sound management.

Awareness & communication

An important aspect in the process of compliance of any rules is the creation of awareness among the stakeholders on the various aspects of the products, including the requirements for the environmentally sound management of the product at the end of life. The awareness creation can also be done through road shows and camps in education institutions, especially schools collages and other institutions. Awareness is also essential regarding the hazardous constituents present in the equipment as well as the safe handling and disposal of the product after its use. The producers should provide information on safe handling of the product to ensure its safe delivery and installation for use. In the same manner the producers should also provide information for safe handling of the end-of-life product.

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