How to Mitigate the risk of unavoidable Plastics.

To understand Plastics role, we need to look at the world statistics first. Plastics achieved prominence in the late 1950's and till date approximately 9200 million metric tons has been produced. The current global production is to the tune of 400 million metric tons. Plastics is omnipresent in our lives due to its lowest cost amongst competing materials, convenience and disposability, hence its use cannot be ruled out at-least in India.

42-45% is consumed by packaging, 19% by construction and industrial parts and 14% by textile fibres. Rest in various other industries.

The Indian Industry is about 27 million metric tons, only about 7% of world production, so there is huge potential to grow as we are 20% of the world population,

Of the 27 million metric tons:

i) Virgin polymer manufactured domestically – 15.5 million MT—57% (a)

ii) Virgin and regrind imports – 5.5 million MT---20% (b) •

iii) Recycled plastics – 5 to 6 million MT—23% (c)

There are 85000 processors, 90% of which are in the MSME sector contributing to 2.5% of the GDP or about 9 lakh crores.

• i) India has huge legacy waste stored in open or unregulated landfills all around the cities and tier 1, 2 & 3 towns. Infact, our mangroves (the life lungs for oxygen) are now filled with plastic blankets, footwear and other plastic wares.

• ii) India is currently generating nearly 9.5 million metric tonnes of plastic waste yearly based on extrapolation of per capita waste generation.

The recycling plastic industry also employees a huge amount of waste collectors and segregators; however since waste collection activity is not a formal employment, it is extremely difficult to quantify the employment figures and estimates vary from 1.5 million to 4 million rag pickers.

We need to understand how we progressed from Durability to Disposability in India and elsewhere, which is solely due to convenience and hence difficult to break.

Progressive results from restrictions--Bangladesh had already banned single-use bags in 2002; Kenya banned it in 2017, Uganda in 2007–09, Eritrea in 2005, and India in 2022. Ireland’s 2002 law levying a 15% charge reduced consumption by 90%, while China barred shops from providing free bags in 2008, resulting in a fall in consumption by 2/3rd.

Britain is the biggest success story. From 2021, the number of bags [with a charge of 30 pence fee] has seen a fall of 97% in consumption.

(a) Dept. of Chemicals & Petrochemicals, GOI

(b) DGFT

(c) CPCB

Chapter 1 – How Disposability preceded Plastic consumption.

Chapter 2 – The advent of Plastics and its growing utility in packaging.

Chapter 3 –Economic Benefits

Chapter 4 – How Plastic waste creates Risk

Chapter 5 – Microplastics, Nanoplastics and Human health

Chapter 6 – Why Recycling alone, even if done is not enough.

Chapter 7 – Extra Notes on USA (can be skipped)

Chapter 8 – Extra Notes on South East Asia and comparison to Tobacco

Chapter 9 – Solutions for India

Chapter 10 – Research and the Future.

Chapter 1

Disposability is the mantra, which preceded plastic packaging.

In India----How convenience led to replacing durability with disposability.

While travelling, metallic water accumulators (Lota or Surahi) were refilled at transit stations or even at riverbanks as journeys stretched for even days at that time. Scrubbing was necessary to keep it clean.

Bisleri, an Italian brand, was first introduced in the 1960's in single-use glass bottles – paying for water, something you could get otherwise for free.

Cotton napkins during functions replaced by paper tissues. Cotton handkerchiefs, carried by every urban workforce, has been completely replaced by paper-based tissue paper. Every car and every office now boasts of a tissue box. **(o)**

Cotton cloth pad used during menstrual period was replaced by sanitary napkins by the 1990's.

Paper plates replaced **sal-leaf** and **banana-leaf** at urban functions in Delhi and Chennai, sometimes made from dry areca and other palm leaves also. **(+)**

Tinplate biscuit and confectionery can were replaced by wax-paper outer wrap with cardboard inner divider for mass market biscuits. **( )**

Horlicks also transited from glass jar to cardboard refill pack (single use, what the consumer throws out). **(↑↓)**

Plywood tea chest were replaced by papercocks and Plywood Mango and other fruits chest were also replaced by cardboard.

The question is disposability v/s Re-use / Refill.

India, being rated as the poorest Asian country (in terms of number of poor people) was always used to refill.

However, convenience and adulteration of goods made buying in sealed packages logical. Also, sachets and small plastic packs had already made great inroads, but it is still possible to return to our earlier buying patterns.

(#) Hindustan Times – The Bisleri Bottle: Paying for Water- 14/8/2018

(o) Origami Tissues, CMD Manoj Pachisia.

(+) Down to Earth / Food / Feast on pattal.

(⟹) Brittania’s Wadia, Esh, India Lithography.

(↑↓) Business-standard.com: article: management 114100101279 Oct 2014

All over the world---**What disposability meant for Waste?**

1. Goods were sold in durable glass or metal containers which were returnable for replacement.
2. One-way packaging in aluminium or glass containers replaced the durable glass or metal containers due to their ease in carrying and the freedom it gave the retailers, wholesalers & the manufacturers from the hardship of collection, washing, removal of impurities and refilling, as the durable containers could be used multiple times.
3. Household waste due to single use, increased by two to three times and very soon one way packaging in aluminium, glass, wood or cardboard was replaced by plastics.
4. Even though one-way packaging was costly, convenience and non-availability of bulk packaging/ reusable packaging [manufacturers stopped supply] forced consumers to adopt one-way.

Entire world moves to disposability.

a. In 1958, twelve billion bottles were used/filled fifty-three billion times, ie used four times on an average
b. By 1966, the use had fallen to two times
c. By 1976, it was estimated to be used only once.

We often discard today what a generation ago we saved, pouring more and more public money into collection and disposal of whatever happens to be privately produced and discarded amounting to a public subsidy of waste ☉

The beer industry however, had already moved onto “One-way containers”. Anheuser-Busch and Miller were selling in steel cans.

Consumers were largely satisfied with returnable bottles and had not asked for one-way containers. The idea of disposability was dumped on the consumer, as for the manufacturer the returnable bottles were an obstacle, and limited the marketing area of a bottling plant as a truck could collect only so many empties. **(#)**

However, the additional packaging cost was pushed onto the buyers who reluctantly absorbed them.

Another beauty of the new system was that while companies saved on bottle collection, cleaning, trucking of used bottles and labour, Municipal sanitation departments were saddled with huge waste each day. Thus, it was the consumer, or citizen who paid the taxes to clean up the mess. Double whammy, pay extra for initial packaging and pay later for municipal waste. Coke was 30–40% more costly than in reusable packaging earlier. **(O)**

Despite pushing disposability to suit the companies balance sheets, industry kept on advertising that consumers had demanded the same.

☉ President Richard Nixon, 1970

(#) Bottler fights a trend, Pleads for returnable, New York Times 7/1/1972
Peter Chokola, President Wilkes-Barre Pennsylvania at senate hearing.

(O) Executive J. Lucian Smith, Hearing, Reports and Prints of the Senate Committee on the Judiciary, 1971 pg 164.

Case Studies--How reuse was dumped by industry step-by-step, creating disposability.

Packaging serves three major requirements:

1. **Protection**
2. **Information**
3. **Shelf Appeal**
4. For growing numbers of internet-first companies, the shelf is no longer a physical store but a screen. Consumers encounter product as thumbnails on a quick commerce app, as images on a marketplace listing or as part of a Instagram feed. For 11600 active D2C brands in India alone, packaging is the only physical touchpoint with the consumer. **(#)**
5. Since aesthetics have become core to how people see and present their lives, it is very important to get packaging right (in the shortest possible time).

Originally, the National Biscuit Company, controlling 50% of the US cracker and cookie business was shipping their biscuits locally in large barrels from which shopkeepers doled out portions to customers. The same pattern was followed for other edible goods. **(#)**

Later, to lengthen shelf life and permit centralized manufacturing and shipping long distances to reduce costs, barrels were replaced by layered waxed paper and cardboard into a cleverly folded carton. This packaging kept the biscuits crisp and hygienic and also enabled the company to brand the product, permitting specific advertising. Result, Nabisco was selling 10 million packages per month. Soon Quaker Oats followed and later the entire edible food industry. **(o)**

Companies had learned that packaging could be highly effective at "MOTIVATING SALES AND REPEAT SALES". **(>)**

Coco-Cola had a network of local bottlers, franchisees who distributed and recollected the glass bottles for cleaning and refill as customers returned the bottles for obtaining the deposit back. The soda bottle return rate was 96% and they were refilled 50-90 times. **(+)**

(#) Tracxn, 2026

(#) Uneeda Business History: The Nabisco Story, American Business History Center 12 September 2021.

(O) Uneeda Biscuits: The First Consumer Package, Journal of Macromarketing 17, No. 2 (1997) pg 82-88

(>) Proceedings: First National Conference on Packaging Wastes (SWM Office, US Environmental Protection Office, 1971) Eric Outwater.

(+) Citizen Coke: The Making of Coco-Cola Capitalism, Historian Bartow Elmore

Chapter 2 -----Advent of Plastics.

Plastic derives its name from the Greek word “**Plassein**” meaning “**to mold or shape**”.
The famous Bakelite was synthesized from ordinary chemicals, namely formaldehyde and phenol, by Belgian Leo Baekeland. They came to be known as polymers (of many parts referring to the long chain of chemicals that make them up). It is this length which gives it flexibility and strength. The exact placement in the chain and how the molecules are bound together determine the plastic’s type and characteristics.

After Celluloid discovered by John Wesley Hyatt in 1879, **(o)**

One of the most famous "mistake discoveries" in industrial chemistry 1937 - **England's county Cheshire** - scientists Reginald Gibson and Eric Fawcett started experimenting with the chemical Ethylene and later scientist Michael Perrin ran the same experiment to synthesize a new material at the Imperial Chemical Industries having long chain of fused-together ethylene molecule, using controlled release of oxygen/peroxide. **(#)**

Unlike the original inventors/ creators of plastics, the later scientists sought to fill a specific need, like John Wesley Hyatt or Leo Baekeland. These later scientists, fueled with immense financial strength from leading companies of the world and huge availability of by-products of coal, oil, and gas processing, started inventing material first and then figuring out useful applications later.

Dupont’s patented Nylon, used earlier in parachutes and ropes during the war, was another example of this paradigm shift brought about by the chemical companies. This has led to the relentless invention of new uses for the end products and its low prices. **(#)**

They named it polyethylene. When heated it could be molded in any shape desired and when mixed with xylene, it dissolved into a gel that could be spread thin to dry into a flexible film. It did not conduct electricity.

Its first military use (as the second world war had already erupted) was a pathbreaking success for the British. They had developed a sophisticated new form of radar, however the signals running through its wires escaped before they could be read. Polyethylene provided the high-quality insulation and because it was light enough the radar could be loaded onto planes. British planes could now

easily spot the Nazi bombers and submarines, destroying Nazi naval supremacy. **(>)**

(#) Kennedy, ICI, pp. 58–60

(o) Susan Freinkel, Plastic: A Toxic Love Story (Houghton Mifflin Harcourt, 2011)

(#) Polyethylene: Discovery and Growth, University of Torino, Jan 2005
and Carol Kennedy, ICI: The Company That Changed Our Lives.

(>) Kennedy, ICI, pg 74-75.

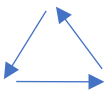
Growth of Plastic/ Plastic Packaging in million tonnes from fossil fuels with major products introduced during that period.
1 million tonnes = 10,00,000 tonnes.

Plastics include plastic fibres used in textiles, plastic resins converted to products and packaging and plastic additives.

i) 1950-60 – 3 million metric tonnes, used in Tupperware containers.

ii) 1960-70 – 6 million metric tonnes, used by toys manufacturers increased to 10 million tonnes after introduction of Styrofoam by Dow Chemicals.

iii) 1970-75 – 25 million tonnes produced after industry unveils logo to promote recycling, increasing its acceptability by the general public. 600 refineries and chemical plants. **(o)**



iv) 1976-1982 – 60 million metric tonnes – most commonly used material in the world.

v) 1983-1990 – Permanent Artificial heart introduced in medical history and other organs, appliances, amputee etc. 79 million metric tonnes.

vi) 1990-1997 – 194 million metric tonnes.

vii) 1998-2008 – 203 million metric tonnes, single serve coffee brewing pod introduced.

viii) 2009-2011 – 315 million metric tonnes. Plastic Composites introduced by Boeing in the airline industry with 50% of components and outer body.

ix) 2012-2020 – 343 million metric tonnes.

x) 2020 – 473 million metric tonnes.

(#) Estimated by Roland Geyer, professor at Bren School of Environmental Science and Management, University of California, Santa Barbara, USA.

(o) Chemical industry Overview 26/4/2021.

Chapter 3 – The Economic Benefits of Plastics and Plastic Packaging

Fastest Selling toy in history

Such was the properties of Silly Putty, which behaves partly like a liquid and partly like an elastic solid that in 1950's it became the fastest selling toy in US history (**#)**

Its main formulation is polydimethylsiloxane (PDMS) and boron containing compounds.
i) It can slowly flow and flatten like a liquid
ii) Bounce like rubber when struck quickly
iii) Stretch under gentle force
iv) Snap if pulled suddenly

Procter & Gamble introduced Pampers, the first disposable diapers in 1961, freeing parents, essentially mothers, from a burdensome chore, but creating a plastic mountain that would clog landfills with hundreds of billions of diapers.

Later, throwaway cups, plates, utensils, pens, cigarette lighters, toys, you name it and it was made from some form of plastics, many of those objects were of so little value as to encourage their displacement, their disposal, their quick and total consumption. **(o)**

However, in India, the story was completely different. It was the need to give India's poorest access to modern goods, which fuelled the actual growth of plastic sachet packaging, though the large companies were selling goods in plastic packaging for monthly consumption.

Container deposit laws are common in Europe.
a. for Scandinavians, returning your empty bottles to the store is a perfectly normal, everyday activity for everyone **(#)**
b. Germany gets 98% back as it levies 25 eurocents on plastic bottles **(o)**

(#) Fenichel, Plastic pg 260-61

(o) Historian Jeffrey Meikle, 1995, American Plastic pg 176

How popular plastic packaging compares to alternative materials.

Industry leader ExxonMobil estimates that plastic packaging costs upto 45% less than substitute materials, in the terms of value. Also, 20 times more bottles can be created with PET bottle is also lighter by 5 – 10 times, per kg than glass bottle and Plastic packaging is comparatively break-free, in relation to glass.

Supermarkets and even local grocery stores have stacks and stacks of goods packed in plastics, due to cost effectiveness in comparison to other packaging. In fact, by weight, 50% of entire packaging industry is now cornered by plastics. The balance 50% (by weight) is due to wholesale packaging in corrugated cartons, wooden pallets, metal drums (chemicals), steel strapping and glass, mainly for beverages.

The private sector economy of the world works on Profitability and accessibility. Plastic packaging as well as products guarantee both in comparison to other products like glass, metals, wood, paper etc.etc.

a. Plastics are Versatile/most malleable. It can be converted into any size or shape using minimum energy in comparison to other materials like wood, paper, glass or metal. Additives are used to get desired elasticity and colour.

b. Plastics are light weight. Pet bottles are at least 5 to 10 times lighter than glass bottles. It saves transport costs at every stage of the supply chain from producer of virgin plastics to manufacturer of plastic packaging to user of plastic packaging to warehouse .

Product category growth captured.

1. Plastics are manufactured from by-product of fossil fuels during extraction and hence are the cheapest.

2. 1980’S FMCG market was only 2-3 trillion USD (HUL, P & G, Colgate, Dabur etc). Glass / Metal containers being replaced by plastic packaging. PET bottles which enabled single-serve beverages to replace multi-serve glass bottles.

Also supermarket shelves size enabled self-service retail to attain scale. Shrink wrapping of palletized cargo commenced.

3. 1990’S - 2010 Flexible pouches, cosmetics, etc. became mainstream, also resin prices fell aiding consumption.

4.2011 onwards--Big consumer of plastic packaging in poly mailers form was the e-commerce market. There was a huge demand for plastic envelopes for clothing, accessories and non-fragile items being handled by the Amazons / Alibabas and Flipkarts of the e-commerce industry. A polymailer weighs only 15 – 45 grams for similar goods packed in corrugated box of 150 – 300 grams, beading to huge transport cost savings.

Nearly 50% of entire packaging market has been captured in weight terms by plastics.

In the Indian context, plastics including plastics packaging has been the fastest growing industrial segment in the economy for the past 3 decades.

India – Poverty breeds unusual practices:

In Rural India, in the 70's, it was common for rural shopkeepers to carve a single bar soap into half-a-dozen pieces. Chinni Krishnan in Tamil Nadu seeing children hair matted, vowed to make hair shampoo affordable in such small packs, that every child would be able to purchase it. Velvette shampoo was born and later hair oil and honey in sealed, little plastic packets for the first time. Later, Chic shampoo was sold in sachets for as low as three quarters of a rupee i.e. 75 paise. **(O)**

Because of its low value, consumers were enticed to give shampoo a trial. This was followed by detergents, cooking sauces and other products in single servings, too. HUL, P&G and Nestle jumped into the bandwagon in the 1980's selling 70% of their shampoo and some other products in sachets. **(#)**

Sachet revolution started in India, Southeast Asia and Africa. Some 300+ million consumers at the bottom of the pyramid, i.e. those who could not afford to buy previously, could now buy because plastic made it possible to pack, transport and sell goods at Rs 1–5 for daily use. Even baby & pet food, bottled water started coming in single and multi-

use packs, in addition to hundreds of other daily use goods like cheese, butter, bread, etc.

This phenomenon, also coined as the bottom of the pyramid (>), exploded throughout Southeast Asia with Philippines consuming 16 Crore sachets per day "or 600 sachets per person per year". *

The sachets market is estimated at USD 12 billion a year, today.

Sachets contain different kinds of plastic including aluminium in many cases and are worthless on recycling markets, leaving little incentive for informal sorters to collect them, so they accumulate in dumps, litter landscapes and clog rivers or are burned.

When plastic packaging is so supportive in improving the standard of living of the estimated 500+ million people at the bottom of the pyramid i.e. poor and middle income in India by satisfying their aspirational needs,(o) giving huge employment to people employed in the manufacture of plastic packaging (mostly MSME hence employing more people due to lower automation) and also people who are employed in accumulation, sorting, storage and recycling, why is plastic packaging considered a threat to the future generation?

(O) Asia Case Research Journal 12, No. 1 (2008)
(#) Unilever's Plastic Playbook, June 22, 2022.

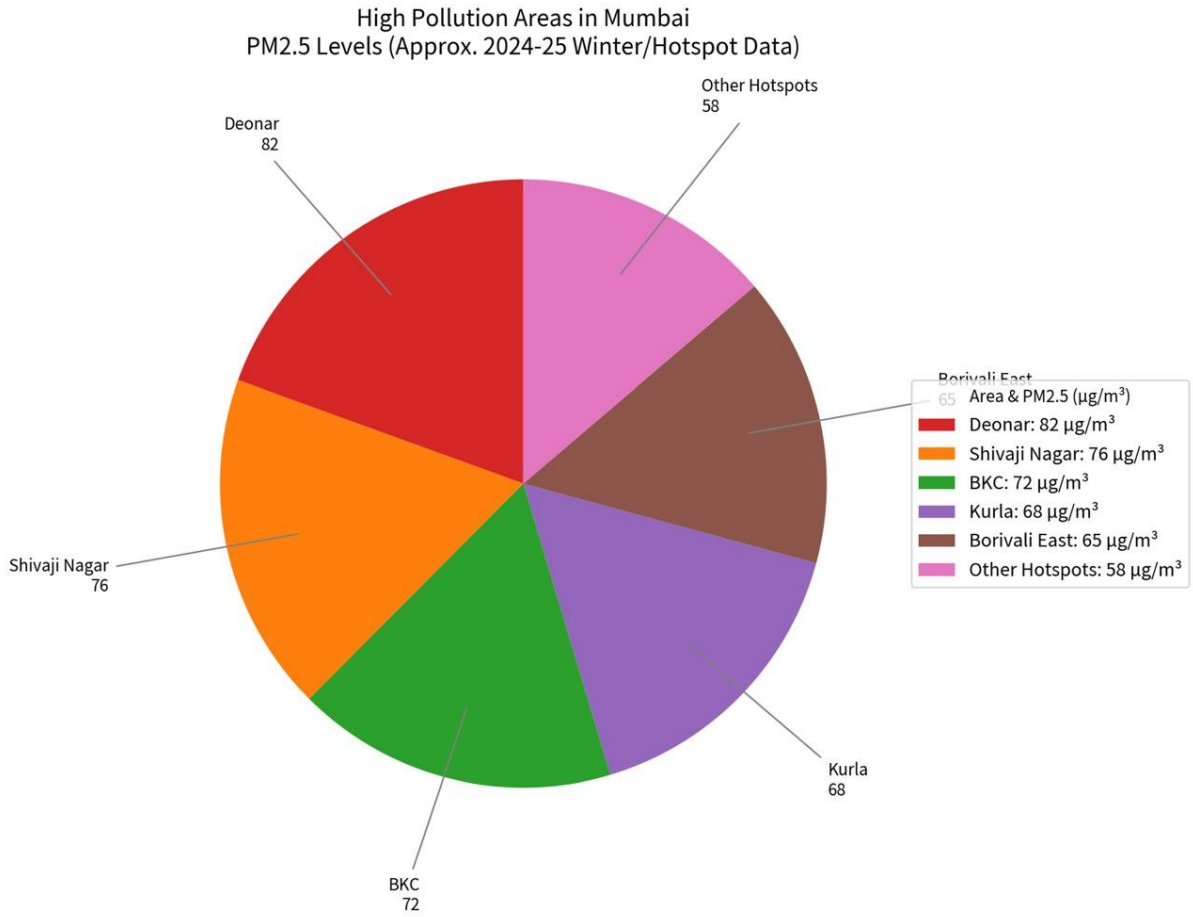
***** Sachet economy: Big problems in small packets July, 2020

(>) the bottom of the pyramid, C K Prahalad 2010.

Chapter 4 – How waste creates risk

Plastic once it enters any living matter does not decompose naturally, only accumulates.

India has two of the world's largest methane-emitting landfill sites out of total 25 in 2025. One in Secunderabad, Telangana and other in Kanjurmarg East, Mumbai.



Nearly 1.5 to 4 million informal waste pickers are employed, unfortunately they normally work without contracts, gloves, masks or insurance, earning only 10000 to 15000 per month. **(o)**

These waste rag pickers sift through household waste, collect waste which can be recycled and sell it to kabbadiwalas. Thereafter aggregators collect from various kabbadiwalas and crush and grind them to be recycled into granules and later new products. **(→)**

Methods of current disposal and recycling of plastic packaging in a regulated manner plus future upgradation. Sanitary Landfill or regulated landfill is an engineered facility designed to protect human health and the environment. (o)

i) Impermeable base through excavation, levelling and compaction of the loose soil. Installation of low permeability bottom liner containing compacted clay, geomembrane etc and leachate collection in cells created to prevent contamination of underlying soil and groundwater. The leachate drainage system conveys the collected to leachate treatment facility. Landfill gas captured from disposal cells are managed through controlled flaring or energy recovery systems. Upon closure, longterm monitoring of groundwater, surface water, air quality, leachate

and landfill gas is necessary to prevent explosion from leakage of gas due to decomposition. [o]

1. Enzyme deployment in water system supported by AI models like Alphafold 2, Rosettafold etc. There are 45+ polymer types found in waste water, AI and Machine Learning can design enzyme cocktails (mixture of various types of enzyme) permitting testing of the cocktail instead of individual enzyme optimizing substrate coverage, operational compatibility and functional diversity simultaneously at a ambient Indian temperature (25 – 40o C) at a low cost enough for municipal deployment. [o]

2. Charge Neutralization for NP already in the human body. We need to design molecules that bind to NP surfaces and neutralize their charge, rendering them biological inert, even if they cannot be removed from the human body.Chelation therapy does not remove metal from the body, just make it harmless. AI can cross these multidisciplinary interactions between material science, pharmacology and environmental science, supporting a research group.

Floating waste barrier

A 57 meter long, floating waste barrier was installed in the Mahul Nullah in Wadala (East) Mumbai to trap plastic and other debris before it reaches the coastline

Nearly 5000 metric tonnes of plastic waste is dumped in the Arabian Sea through 50 drains across Mumbai. BMC's Storm Water Drain has installed trash boom barrier nets at 21 locations already. The Mahul Trash Catch was launched jointly by BMC and the Bharat Clean Rivers Foundation (BCRF) **(#)**

Smart River survey - The Ocean Cleanup, Netherlands
The Indian Express 10/5/2026, journalist Nayanika Bose.

How does Plastic enter the food chain.

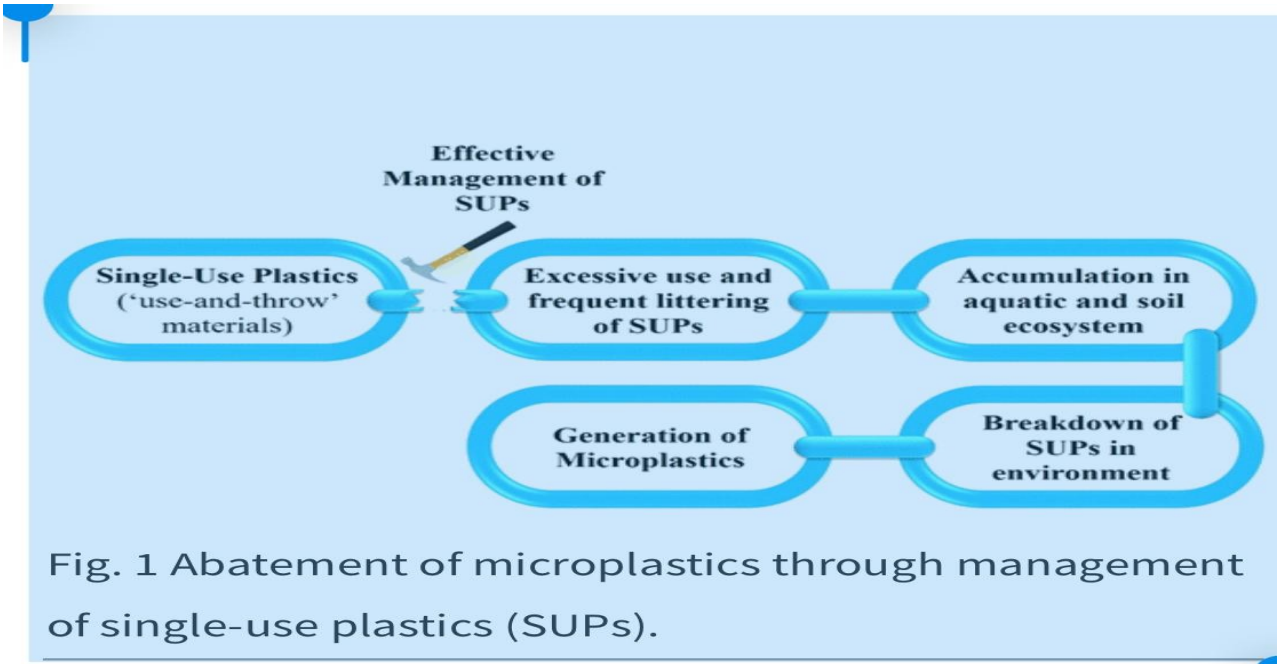


Fig. 1 Abatement of microplastics through management of single-use plastics (SUPs).

Microbeads are used in manufacture of cosmetics. These are not flushed out by waste water treatment plants and thus enter our rivers and sea. Micro plastics are eliminated but Nano plastics (NP) are impossible to eliminate even with the best water purification systems in the world (o)

What are these Nano plastics (NP). These are fragments from plastic waste which are smaller than 1 micrometre (one-thousandth of a millimetre). They are invisible to the human eye.

The uncollected, open dumpsite plastic waste, through wind and monsoon water runoff plus dumping by tourists, fishing nets discarded at sea enter the water, of which only 30% floats and is visible on beaches or in patches on the sea surface water. Balance 70% settle on sea bed.

e) Due to action of sunlight (photodegradation) and environmental impact of constant wave action, plastic waste fragments into microplastics and later into Nano plastics. Microorganisms mistake it for plankton and consume it. Small fishes big fishes very large fishes human which consumes seafood. Thus, it enters the food chain.

f) Even goats, cows and buffaloes consume food along with the plastic carry bag in which it is disposed off by households and the

nanoparticles of the waste enters the milk consumed by humans. Plastics do not decompose in any living being's body but accumulate.

(o)CPCB Guidelines for co-processing of plastic in cement kilns (May 2017).

- **(o) Nano plastics: Hidden connections and Emerging risks (EU conference)**
- **(0) Ingestion of microplastics by zooplankton 2013 Microplastics in fish and fishery products and risk to human health (L. Alberghini et al Journal: Foods.**

Chapter 5 – MP/NP and THE HUMAN IMPACT

Half a million microplastics were found by Researchers in every square meter of river sediment in North-Western England. Plastic is now a fundamental component of the air. **(#)**

In India, the Ganges River is estimated to dump three billion microplastics into the Bay of Bengal every day. **(o)** In Characterization and health risk assessment of airborne MP In Delhi NCR - Sachin Ghude pointed out extremely high levels likely endangering human health - 2025.

Dhaka has a recurrent monsoon flooding due to polyethylene bags and municipal plastic waste choking canals and storm water drains. Some incidences have been reported in Jakarta, Accra (Ghana), Lagos, Manila, Nairobi **(+)**

In 2024, Plaque samples from 258 patients in several Italian Hospitals, the research team found MP or nanoplastics in approx. 60%. They were monitored for 3 years and found that these patients were more than four times more likely to suffer a heart attack or stroke or die. **(-)**

Nano plastics also float in the air and humans may be regularly breathing them unknowingly. They have been also found in placenta, lung and whole blood.

Nano plastics have also been found in mother's milk, hence newborn babies are now found exposed to the horrors of plastic in human body (o)

There is a growing evidence of Nano plastics (NP) and Microplastics (MP) on mitochondrial health and function in the human body. Mitochondria are unique organelles which perform critical functions such as energy production, liquid oxidation, calcium homeostasis and steroid hormone synthesis in eukaryotic cells. MP/NP cross the blood-brain barrier after intravascular injection.

(#) A poison like no other: How microplastics corrupted our planet and our bodies, Matt Simon 2022 (Island Press)

(o) The abundance and characteristics of microplastics in surface water in the transboundary Ganges River Environmental Pollution (April 2021) pg 274.

(+) United Nations Environment programme GRID, Pollution: Phillipines.

(-) The New England Journal of Medicine, Prattichizzo / Raffaele Marfella et al

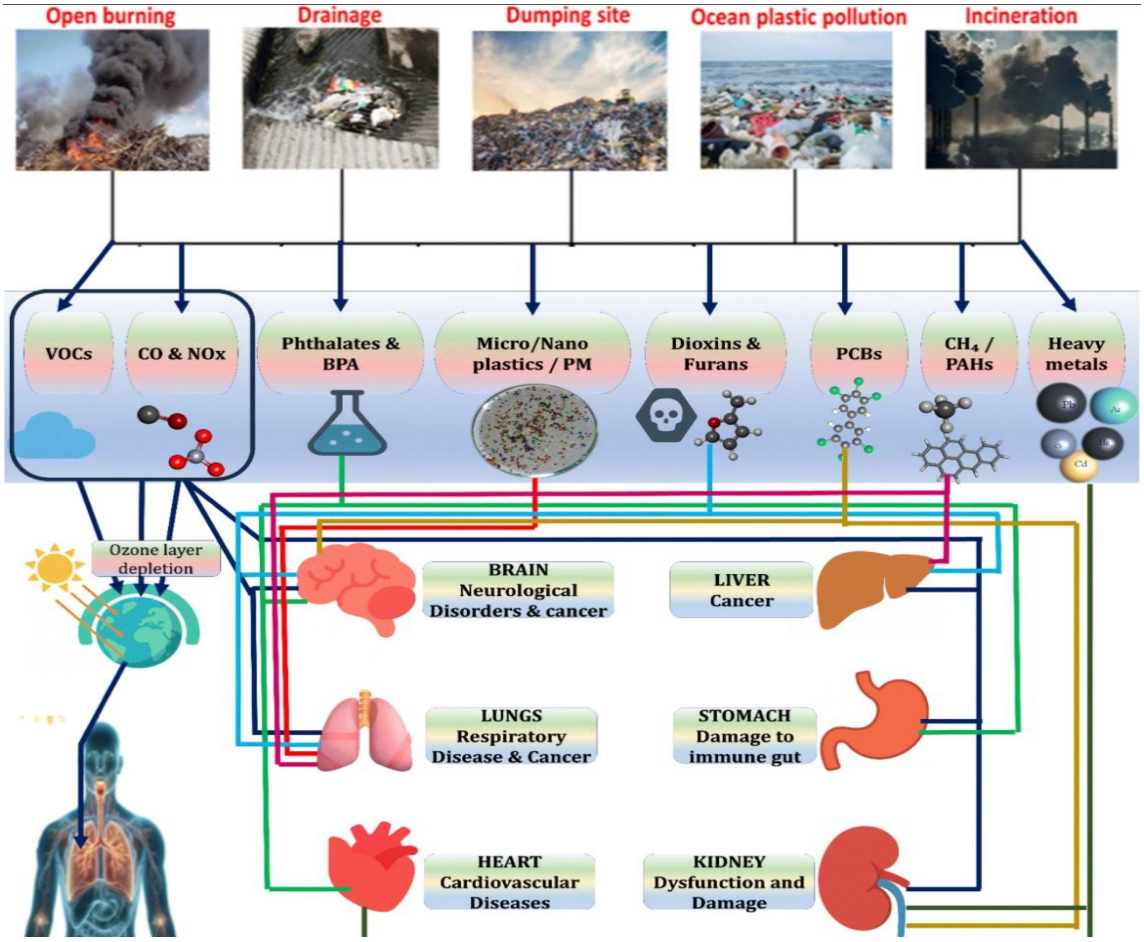
[o] Allatra Global Research Centre •

[o] Mintenig et al. 2017 •

(o) Deng et al 2021, Xu et al 2021, Prata et al 2020.

(o) Mitochondria as target of MP and NP toxicity — Fulya Dal Yontem et al 2024.

Inside the human being



Once inside the cell, MP/NP can disrupt mitochondria structure and may induce functional abnormalities and generate oxidative stress, damaging mitochondrial components and impair their energy production capacity by disruption of the electron transport chain. [o]

The increase in the cases of Diabetes coincides with the increase in plastic waste over the decades, yet extensive studies may be necessary to prove their connections. Ingesting plastics leads to internal blockages, starvation and death in seabirds and marine mammals. Plastic debris blocks vital sunlight on coral reefs, harbour pathogens and trigger disease outbreaks as plastic nurtures bacteria on its surface. [o]

Plastic waste clogs drainage and sewerage systems causing severe waterlogging and urban flooding when not collected and segregated. [o]

Endocrine disruptors are capable of interfering with hormonal networks in human beings. They are thugs on the biological information highway that sabotage vital communication, mug the messengers or impersonate them, jam signals, scramble message and sow misinformation. **(#)**

Elevated BPA levels are linked to premature ovarian failure and other fertility problems in women as well as early menopause
ii) women with highest phthalate level were 60% more likely to miscarry than those with lowest.
iii) Premature birth, decreased sperm counts and lower testosterone levels in adult men.
iv) 74% more chances of suffering heart attack from highest level of BPA.

PFAS — also known as Forever Chemicals are extensively used for their properties as additives, in addition to Bisphenol A and other phthalates. Common uses are in firefighting foams, cleaning products, tampons, cosmetics. These additives break away easily particularly when heated as they are not bound to the plastic's backbone molecules.

Burning plastic waste releases dioxins and furans which are potent carcinogens in addition to being most-toxic substances on earth. [o] Hence, it is utmost necessary to monitor and capture flue gases and process then before releasing such gases in the environment.

Heavy metal leaching due to mismanaged plastics into the soil and groundwater leading to contamination.

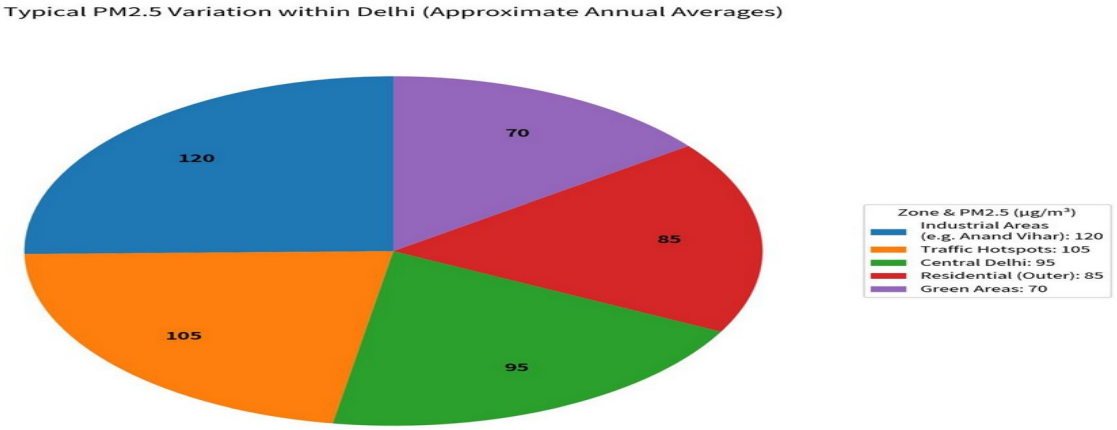
Some areas of Bhandup, a suburb in Greater Mumbai, was experiencing flooding every monsoon, resulting in sewage water entering homes.

The cause was plastic choking drains, trapping entire neighbourhood in filth and illness.

Till Shakti Yadav started serving meals to street garbage collectors against plastic garbage collected and deposited by them. Nearly 1 lakh plastic items

have been collected and 45000 meals served. Gathered plastic is sent to their own manufacturing plant, where it is upcycled into useful household articles. **(#)**

Across India, similar "**garbage cafes**" are taking root — Chattisgarh, where a kg can earn a full meal, Siliguri and parts of UP where essentials like food and sanitary pad are distributed in exchange of waste.



(#) Theo Colborn, John Peterson Myers and Dianne Dumanoski Our Stolen Future: Are we threatening our fertility, intelligence & survival? A scientific detective story (Little, Brown, 1996).

(o) Yang et al 2004. (o) Trevisan et al, 2019 .(o) Ocean Conservancy 2026 (o) Thorne et al, Lamb et al 2018. (o) Fulekar & Geeta 2008 (17) Sharma, Kumari & Kumar 2024, PMC/Cureus • (18) Manisalidis et al 2020, Frontiers in Public Health

Chapter 6---Why recycling alone is not enough.

Even multilayer plastics used in food industry - an aluminium layer inside to prevent plastics coming in contact with food prevents release of MP and NP to the food packed.

Aluminium foil itself cannot be heat sealed. The standard form-fill-seal machines, running at high speed on packaging lines require a PE or PP layer at the top , which melts and bonds under heat and pressure to create the hermetic seal. Also aluminium foil at 6-9 micron is brittle and prone to cracking. The inner polymer layer provides mechanical flexibility. • All single-serve sachets of shampoo, ketchup, pan masala, mouth freshener, tea premix, coffee retort pouches of snacks and ready-to-eat meals are mostly multilayer.

India has permitted plastic waste processors to offer IS certified recycled granules for mixing in packaging for the food industry upto 30%, to help recycling.

• Blister pack of the entire pharmaceutical industry is multilayer and only 9% of multilayer is actually recycled, rest being sent to incineration or landfills. This is also because waste is too small, too contaminated and too dispersed. Multilayer is now • accounting for 17-

20% of all plastic packaging, creating huge recycling problems (PVC and aluminium). [o]

• Pyrolysis breaks down the plastic layer under heat in an oxygen-free environment, producing pyrolysis oil or syngas + Al. and is the most suitable disposal of plastic, if the flue gases are not permitted to enter the atmosphere.

Recycling can only extend the life of plastics, not eliminate MP or NP at end of life, which is solved by pyrolysis, if regulated stringently.
Industrial compositing use compostable plastics waste subjecting it to high temperature, moisture and aeration to trigger biological breakdown. Anaerobic Digestion yields biogas (Methane) to be captured for energy.

(#) The Better India, Journalist Nishita Kowrani 7/5/26

(o) ILO + Chintan Environment Research & Action group in collaboration with UNDP.

Chapter 7—Extra Notes on USA.

Marketing Wizards

The un-wanted by-products of the fossil fuel crude oil and gas industry serve as a raw material for manufacture of tons of polymers and are the reasons for their low prices. Hence you see large petrochemicals complexes adjoining to oil and gas refineries.

"The future of business" an advertising journal opined "lay in the ability to manufacture [consumers] as well as products."

Edward Bernays, described as the father of public relations, had said: A businessman cannot afford to wait until the public asks for its product; it must maintain constant touch, through advertising "excerpts from his classic book of 1928 - Propaganda. **1)** For Lucky Strike, he framed cigarettes as **"Torches of Freedom"** that empowered women.
2) For Dixie Cups sales, he formed a Committee for the Study and Promotion of the Sanitary Dispensity of Food and Drink to suggest reusable cups were unhygenic. **(>)**

An individual might want something "not for its intrinsic worth or usefulness, but he has unconsciously come to see in it a symbol of something else, the desire for which he is ashamed to admit to himself." With such buried motivations, the successful propagandist can swing emotional currents so as to make for purchaser demand.

By 2017, Industry had already pumped out 8.3 billion metric tonnes of plastic, out of which 6.3 billion tonnes is estimated to have become waste and 79% of which is estimated to have ended up in landfills. 42% used in packaging, 19% in construction and 14% in textiles. **(#)**

Scientists working for the biggest oil and gas companies, including but not limited to ExxonMobil [which came into being by splitting Standard Oil in 1911 under the antitrust law as it had become an illegal monopoly by buying out competitors, securing preferential railroad rates, controlling pipelines and refineries and following predatory pricing. Standard Oil (at one time was controlling 90% of US Oil refining.] clearly anticipated, at least as early as the 1960's that unchecked burning of fossil fuels would dangerously warm the atmosphere, cause heat, draught, storms and floods that could emperil humanity's future.

Yet they aggressively discredited anyone speaking publicly about it. **(o)**

It came to be known as a scandal called "Exxon knew".

(#) Heather Rogers, Gone Tomorrow: The Hidden Life of Garbage (New Press, 2005)

(o) Edward Bernays, Propaganda (Ig Publishing, 2004)

(>) The Manipulation of the American Mind: The Conservation, July 9 2015, the birth of public relations.

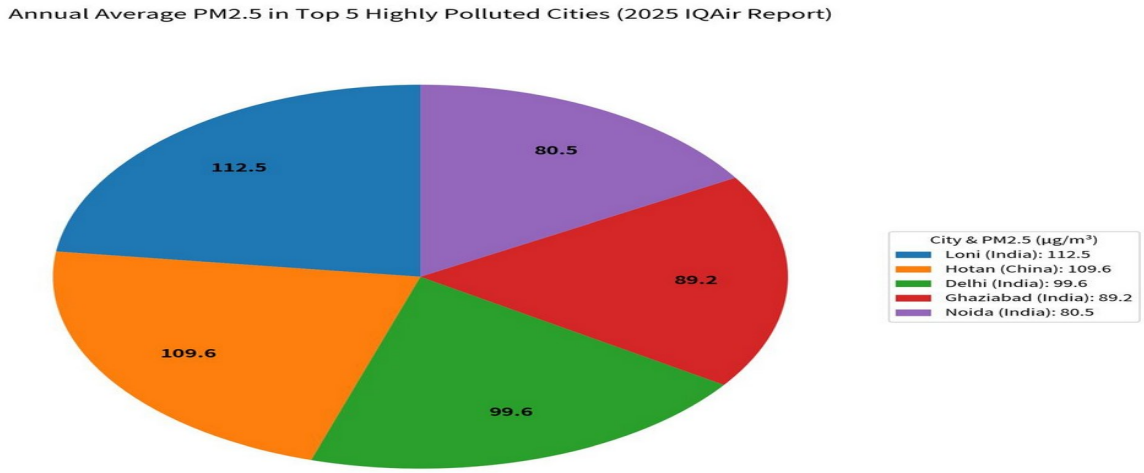
(#) Production, use and fate of All plastics ever made, 2017 Roland Geyer and et al.

- Carroll Muffet, Inside Climate News and the Los Angeles Times with other journalists.

The USA.----The Great Pacific Garbage Patch

The floating bottles and bags, and other plastic articles between Hawaii and California — The Great Pacific Garbage Patch, the largest of five offshore plastic accumulation zones — is spread over 1.6 million square kilometers.It weigh approximately 80000 tonnes and nearly 46% is abandoned fishing gear: nets, ropes, traps, and crates.

Scientists from the US and China have studied the behavior of the patch, only to know that it has fragmented into MP and NP, which become airborne due to winds, waves, and even typhoons lift particles into the air. If the airborne particles are colored, they darken as they age, absorb sunlight rather than scatter back into space as clear particles do. The net effect is climate warming.



False promises of recycling---Year – 1980. One of the highest-profile PR activity was the **National Polystyrene Recycling Company** - A joint venture of Chevron, Mobil, Amoco and many other makers of Styrofoam, i.e. disposable kitchenware.

- **Goal** → Recycle 110 million kg annually. Encourage municipalities to collect it and ship to the company. **PR** → Huge billboard ads and other media press releases.
- **Results** → a. Within 5 years plants starting shutting and staff laid off.
  b. Sold remaining plants to another company, which shut them.

Year 1990 - Council of Solid Waste Solution's PR

- **Goal** → By 1995, want to recycle a quarter of all discarded plastic bottles and rigid containers. **Result** → By 1995, the goal was effectively abandoned as only 10-15% of the goal was ever achieved, with PET bottles achieving a higher ratio.
- **Reason** → **1)** More money was spent on PR and stopping legislatures for bans than in recycling plants.
- **2)** Knowing recycling can cannibalize sales, no big corporation manufacturing plastic used for packaging wants something to come along that is going to replace the need of virgin plastic for conversion to packaging.

- **(>)(>)** How big oil misled the public, Sullivan Lavra 2020.

- How large corporations guard their turf.

1. Steven Englebright drafted a bill / ordinance to prohibit retailers from providing plastic shopping bags. Now plastic shopping bags are- but only one use of the entire plastic goods and plastic packaging industry or estimated 3-4%.

During the debate in Suffolk County, the Society of the Plastics Industry, oil and chemical companies sent their representatives to discuss with legislators. Just then, the MOBRO 4000, a barge loaded with 3000 tons of New York trash, wandered nearly ten thousand kilometers over five months, as all ports rejected its cargo.

Suffolk approved the bill in 1988, even though the industry giants labelled the shopping bag waste as

i) Harmless

ii) incinerating it reduced pollution by pushing burning temperature high enough to eliminate toxins from "other types of garbage also" **(+)**

iii) Bill would hurt local businesses

iv) Replacing plastic shopping bags would increase wastage

The ban unfortunately was put on hold for one year first in 1991 **(#)** and later repealed the law in 1994, even though the New York's highest court had allowed the ban to come into force. **( )**

Suffolk County's ban on plastics loses Allies, New York Times Dec 31, 1991.

(#) Suffolk Country's ban on plastic loses Allies, New York Times Dec 31, 1991.

(o) Suffolk votes a bill – New York Times,

( ) Suffolk weighs Plastic Delay – John Rather

New York Times 7/5/1989

( ) Appeal court upholds Suffolk Pioneering Plastic Ban NY Times.

In phoenix, USA the state government approved a law "prohibiting local governments from placing restrictions on disposable bags or containers of any kind." Since cities refused to honour the prohibition, and continued the fees or ban in some cases.

The state passed another law, allowing the state to withhold the shared tax from any city or town found to be violating the Arizona law, in 2017. So all of Arizona is now permitting single use plastic consumption.

The bill is commonly referred to, as a state "PRE-EMPTION" law.

American legislative exchange council or "ALEC" was founded in 1970. It's conferences provided interaction between industry and lawmakers (lawmakers had to pay only $100 per year to be a member) Lawmakers can also apply to ALEC for scholarship to offset the cost of attending the conferences.

It has policy task forces, jointly chaired by a public official and an industry representative. They vote as equals on model bills, which if approved by ALEC's board, lawmakers can introduce, word to word in their legislatures.

Nearly a quarter of all state lawmakers are members. Prominent are five members of Trump's Cabinet, seven sitting governors and a fifth of Congress.

Shopping bags accounted for twenty percent of the waste clogging Southern California's storm drains, which over 15 years cost the municipalities USD 1.7 billion to clean up.

In 2004, San Francisco's lawmakers were considering requiring stores to charge for single-use bags — both plastic and paper, typically between five and twenty cents — to reduce consumption while allowing flexibility for those who want a bag, and many people preferred such fees to an outright ban.

(1) The big corporations, now embolded with the success in stopping the Suffolk County's ban and other such bans and charges elsewhere, forced the state to bar local governments from requiring fees for single-use bags.

(2) Thus, in 2007, San Francisco became the first American city to enact law to plastic bags, and later all disposable sacks, not just plastic.In 2011, the Supreme Court's order helped 150 Californian municipalities enact bag bans and fees for paper bags. In 2014, California became the first state to ban single-use plastic bags.

Eventually, the pre-emption law cancelling all prohibition/ banning plastic bags or charging a fee for them was passed by 17 states. Plastic bags have lobbyists. They're winning — 2020.

Lately, in 2021, Maine became the first state to require companies to contribute towards recycling programs. **#**
California followed and added a USD 5 billion fund to mitigate plastic pollution's damage to human health and the environment. That's 40,000 crores. **(o)** or 4,000 crore per year.

(#) Maine Department of Environment Protection, known as stewardship programme, rules framed in 2024.
(o) CalRecycle.ca.gov — effective 1/1/2026 — SB 54 for 10 years.
(+) Nature Climate Change, Drew Shindell et al. (2026)

However, companies in the US have always protested them.

"It's the public, if you as a regular citizen haven't made the people who bring the products to you know that this is what you want (recycled plastic) then you are not doing your job" **(+)** William Carroll, Occidental Chemical Executive.

A decade-long, quarter-of-a-billion-dollar ad blitz touting plastic's virtues was unveiled by the alliance of the big companies, including using recycling as a "guilt eraser" **(□)**

Plastics companies, have been consistently unwilling to engage substantively with concerns about waste. Their response was always more PR and hype and advertising, then actually addressing the problem. First it was the Plastics recycling Foundation, then the council for Solid Waste Solutions which converted to American Plastics Council, and eventually American Chemistry Council. Just Rebranding of entities, fully financed by the major polluters.

Recycling has a valuable role to play. For Aluminium, cardboard, paper, glass, its both viable and important.but plastics has a limitation in recycling. It can be recycled only 5-6 times before it loses its primary characteristics. However, re-use is advisable as deposits ensure all containers are returned and refilled.

It is because many types of plastic cannot be effectively recycled, that the Chinese government banned the import of plastic scrap in 2018, in what is now known as Policy - National Sword.

However, except for Europe and Australia / Japan, most countries still ship plastic scrap to developing economies like Malaysia / Indonesia / Vietnam / Latin American countries and even to Africa.

Knowing recycling can cannibalize sales of new plastic, nobody wants something to come along that is going to replace it. # Dupont and the trash giant Waste Management had pulled out within 2 years of unveiling a joint venture to process used bottles.

An Oregon recycling facility sold for scrap a USD 1.5 million sorting machine it had received from the Plastics Council. ⇄ Dozen projects had failed within a few years, □ others announced but never built ⊙

⇄ Sullivan et al, Plastic Wars, Garten services in Salem, Oregon

How big oil misled the public, Sullivan Lavra, 2020

⊙ Kirschner: Recycling's Rough Adolescence

□ Dumanoski: Key events of 1996

(#) Finn Arne Jorgensen "A pocket history of Bottle Recycling" The Atlantic 27/2/2013.

(o) A look at Germany bottle deposit scheme, Deutsche Welle Irene Banos Ruiz and Jeanette Cwienk 17/11/2021.

(+) Plastics Recycling: Problems and possibilities, House of Representatives 102 Congress, second Session Washington DC 25/2/1991.

(□) Plastic Industry Association - Lee Freeman.

How industry fooled the public and fought back deposits and bans.

In 1954, Vermont, USA prohibited disposable beer cans. Some other counties followed slowly. Industry started blaming the individual for the litter of disposable cans by advertising "keeping America clean and beautiful is your job" and "packages do not litter, people do".

In 1971, a man with a craggy face, tasselled buckskin jacket and long braided paddles a canoe to a riverbank covered with trash, then walks on a side of a highway. When a bag of garbage thrown from a passing car land at his feet, he looks into the camera with a tear on his cheek.

"Some people have a deep, abiding respect for the natural beauty that was once this country, and some people don't. People start pollution. People can stop it."

This AD achieved one of the highest viewer-recognition rates in television history and aired for a few years, not to mention the many advertising awards it garnered over time. "The Crying Indian" had created an effective template for defusing and deflecting anger about waste — embracing and co-opting environmental concerns, then directing blame back onto the public.

By 1972, 350 state and local bills mandating deposits or otherwise restricting throwaway beverage containers had been introduced as landfills were fast filling up. The deposit laws, known as "Bottle bills" pushed the cost of dealing with used packaging, which companies had successfully dumped up to now on municipal corporations.

"Keep America Beautiful" an alliance formed to protect the manufacturers from public and government ire. If Americans can be persuaded that plastic was not at fault, if they were properly disposed of. Laws will not be enacted, government wouldn't interfere and production can continue to expend indefinitely ♡

The upfront costs of building new plants is massive, while operating costs are relatively low, so companies have a strong incentive to run plants at maximum capacity for as long as they can — making and selling as much plastic as possible, even though it leads to global warming.

Arsen Darnay, packaging consultant

♡ Gone Tomorrow: The Hidden Life of Garbage, Heather Rogers

Chapter 8 – Extra Notes on South East Asia.

Formosa, the Taiwanese giant, ranking 9th in the world in size settled lawsuits for USD 50 million i.e. 450 crores for damages to the environment **(#)**

Plastic pellets or nurdles keep on spilling during manufacture, storage, transportation and sometimes are even lost at sea. Some 1700 mt or seventy billion individual nurdles, sank in the Indian Ocean in 2021. Pellets washed up on hundred of kilometers of Sri Lanka's coastline, found clogging the mouth of washed-up fish and in bodies of dead dolphins, turtles and whales. **(o)**

Even today, Formosa continues to pay a penalty for every spill under the Clean Water Act to the Wilson Trust,USA.

In $4^{1/2}$ years, they have paid $ 25 million i.e. 225 crores. **(+)**

Yet, the size of the market and the profits of the petrochemical giants is so huge, no amount of fines, even create a minor dent in their ambitions. As per United Nations estimates, five trillion plastic bags alone are used annually, a million consumed every minute. **(↑↑)**

(↑↑) United Nations Environment Programme: Our planet is choking on plastic 2024

(#) US District Court, Southern District of Texas, Victoria Divn, 27/6/19.

(o) Chemical and Engineering News; Grappling with the biggest marine plastic spill in history. Katherine Bourzac, 22/1/2023

(+) Post-consent Decree violations and Environmental Mitigation Payment Records to the San Antonio Bay Estuarine Trust 3/2/2025

Why plastic packaging waste (untreated) is a threat to humanity equal to tobacco smoking?

Plastics materials and plastic packaging are mostly derived from fossil fuels. While consumption of fossil fuels converted to products like diesel, petrol and gasoline has either declined or is stagnant due to larger share of renewable energy in all parts of the world, its share of conversion to polymers has dramatically increased.

It generates pollutants right from beginning.

a. During exploration of fossil fuel i.e. crude oil.

In case of exploration by fracking, hundreds of chemicals are used, the 2005 Energy Policy Act and other Federal laws does not mandate full ingredient disclosure in USA. State Rules require disclosure but trade secret carve-outs allow companies to withhold proprietary mixtures. Under Safe Drinking Water Act, the underground injection of fracking fluid is largely exempt. Subtitle C of Resource Conservation and Recovery Act exempts drilling fluids, produced waters and other wastes associated with the exploration, development or production of crude oil, natural gas or geothermal energy.

Clean Air Act – Title V permit is not required because emissions are slightly below the Threshold prescribed.

Thus, fracking can continue unabated. However, studies by University of Yale, 2022 (Pennysylvania) indicate the following:

a. Children growing up within a mile of a natural gas well had 200% more chances of developing juvenile leukemia, including newborns had 300% more chances to be diagnosed with leukemia.

b. University of Pittsburgh, 2023 study found children living within the 1 mile radius having 500 to 700% more chances of developing lymphoma. Even in the US gulf, ethane and methane gas is released while exploration, it is converted to polymers like polyethylene & polypropylene to prevent them from harming the environment directly.

c. Hundreds of additives chiefly Bisphenol A (BPA as it is commonly known) are released in the air when plastic waste decomposes layer by layer. This additive are extremely hazardous to all human and other living beings.

(#) Communications Earth and Environment (TRODOS) Airplast report.

Even rocks are found to be containing plastics.

- **Plastiglomerates & Pyroplastics** – Plastic rock structures formed by human-induced burning of plastic. **(#)**
- **Plastistones** – Biogenic material, substances that originate from organisms like foraminifera which are single-celled organisms, deposit on plastic waste and slowly integrates to form a rock, due to UV exposure, high temperature and waves. **(o)**
- ALDFG – Abandoned, lost or discarded plastic gear (including plastic nets).

Chapter 9 --How can India mitigate the unavoidable risk of growth of plastic and plastic packaging.

Avoid multi-layer packaging, which are extremely difficult to recycle, instead use single polymer packaging. [o]

A. Upgradation: India has 800+ waste water treatment plants. Upgrading them with membrane bio reactors at very nominal costs can capture 99% MP, though NP will escape. Flue gas treatment should be upgraded to capture this NP.

B. Incineration is also considered Recycling as per PWM (amendment) Rules 2026 dt. 31/3/2026.

C. Setting up stoker Furnace plants: Japan has successfully commissioned 1100 municipal [o] waste incineration facilities. Waste is fed to a moving grate and burned at 850 - 1000oC, the heat generates steam which drive turbines for electricity and their emission controls permit them to be set up in urban residential proximity. They eliminate both MP and NP.

D. Setting up fluidized bed gasification: Waste is heated in sand bed with controlled oxygen producing syngas that's later converted to energy. No MP or NP residue. In both stoker furnace and fluidized bed, the emission control through bag filters, electrostatic precipitators, activated carbon injection for dioxin capture and selective catalytic reduction for NOX is very stringert. Also heat recovery rates are high, through carbon dioxide is released in the air and may hamper carbon neutrality targets.

In India, the Director General of Shipping has prohibited ocean going vessel, even transiting through any Indian port from stowing plastic nurdles on deck the ship. **(->)**

FOOD SAFETY AND STANDARD AUTHORITY OF INDIA (FSSAI) has effective 28/4/2026, also prohibited the use of any type of plastic including in multipack for packaging of any type of "PAN MASALA" **(>)**

Informal workers possess knowledge, and they knew their neighbourhood and source. However, replacing them with new contractors and machinery will not have sufficient impact on recycling rates, in fact lead to increased costs.

Pune's SWACH cooperative has 4000 waste pickers registered service providers under the PMC. They have access to protective gear, health check-ups, insurance and even child care. **( )**

( ) Down to Earth, Utkarsh Mishra 15/5/2026.

[o] Incineration Norms and Govt. Authority (Japan) (2025).

(→) Hasira Dalu, Bangalore, savings of municipality in transportation and sorting Rs 84 crores. 2025.

Chapter 10 - Future

Research continues to reduce cost, yet most technologies are still unviable, on a large scale. •

i) SAND FILTRATION – 97% exclusion of MP [microplastics], but inadequate for NP [nanoplastics]. •

ii) Membrane bioreactors – 97% for microplastics and Nano plastics, but membrane fouling reduces long-term effectiveness. •

iii) Advanced Oxidation Processes (AOP) is hampered by high energy consumption, need for specialized catalysts, and high operational costs. • iv) Bacterial Remediation – Pseudomonas aeruginosa used by Egyptian researchers noted 97% reduction in Nano plastics. Degradation however takes weeks to months and conditions must be carefully controlled for PH, temperature, and humidity plus costs. •

iv) Algal Remediation (Phyco-remediation) – marine microalgae, Picochlorum maculatum shows most effective degradation of LDPE within 45 days. •

v) Genetically modified microorganisms – Bioengineered Comamonas testosteroni CNB-1 is used to secrete Durapetase, achieving PET hydrolysis at room temperature and utilizing degradation intermediates for growth - moving towards complete mineralization.

vi) Photocatalytic Degradation – Under UV light, Tio2 nanoparticle films achieve 98.4% complete mineralization of 400-nm polystyrene microspheres within 12 hours.

viii) PET, considered the best recycling plastic, can be recycled only 3 to 4 times before it is rendered useless. This simply slows its journey of plastic to the landfill or incineration. •

Plasma systems can process mixed, contaminated or non-sortable plastic streams. The reaction conditions are mild in the sense of not requiring high pressure vessel or corrosive chemicals. [o]

Graphene and carbon nanotubes obtained command a good price in the market. They only solution is proper incineration for land plastic waste and electro-fenton and electrochemical oxidation for river, stp, RO reject water and sea waste. [o]

Incineration requires 300+ TDP municipal solid waste feed and heavy investment, so for hospital waste or lower volumes justify only plasma units or electrochemical reactors. [o]

[1] Neil Tangri, Science and Policy Director at GAIA Global. •

[#] Packaging optimization – ED Georgakoudis – MDPI 2025. •

[o] Packaging World: PepsiCo. [o⇩] Alliance and AIM European Brand Associations. •

[->] Journal of Applied Polymer Science (Wiley). •

[<-] Howarth et al. 2011, Wollin et al. 2020. –

A few Upcoming Investments worldwide:

1. Eastman in France plans to invest USD 1 billion in a material-to-material molecular recycling facility in France for 0.160 million MT.

3. Global negotiations for a legally binding treaty on plastic pollution. Plastic production was the biggest fault line in the last negotiations in Geneva in August 2025.

a. Redesigning led to reduction in bottle weight by 8%. [#]

. Design packaging without labels, embossed with signages mostly of polymer type which aids fast sorting. Labels are difficult to recycle particularly with the chemicals used for printing them. [o⇩]

4. d. MA-GPP or E-GMA can be used in mixed PE + PP streams to obtain 95% very pure polymer streams. [->]

5. e. Fossil fuel extraction releases methane and other volatile organic compounds into the atmosphere. [<-] •

o Tripathi et al. (2025) Strategies for remediation PMC 111856438 •
o Yuan et al. (2020) The phytoremediation PMC 11372594 •
o UNEP Intergovernmental Negotiating Committee on plastic pollution proceeding (2022 2026) •
o Thomas Maes, Sr. Scientist at GRID-Arendal, Norway NGO.
[o]Pinasseav et al 2018.
[o]Carbios, France industrial scale enzymatic PET recycling.
[o] PubMed Central (PMC) SJS Flora 2010.
[o] Science direct Yuan Ji volume 52 August 2025.

Disclaimer : This is for private circulation only.
Owner does not claim any copyright over the Information.
Many thanks are due to the publication of Plastic Inc. by author Beth Gardiner.