The Plastics Conundrum
What is the Way Out?

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Introduction

It has been more than a decade since the debate on the feasibility of plastics started at the international level. The environmentalists and the plastics industry have slugged it out on whether plastics are good or bad and the debate has become extremely convoluted. Nevertheless, there are some points of agreement that have emerged from this debate. A significant segment of the anti-plastics movement has accepted the unavoidability of plastics and recognised their benefits to mankind. At the same time, the plastic industry has by and large agreed that there are certain ecological effects caused by plastics in various stages of its life cycle.

With such admissions and acknowledgements being made, the focus now shifts to how the banes of plastics should be addressed. It is this that forms the subject matter of our paper. Our paper examines the viability of the command-and-control approach and that of the market-based alternatives in addressing the environmental problems caused by plastics.

Structure

The methodology adopted in this paper is the following. First, the composition and the life cycle of plastics are briefly discussed. Second, the benefits from plastics are elucidated and their inevitability in India established. Third, the ecological harms and health hazards caused by plastics are elaborated. Fourth, the viability of command-and-control measures for addressing these harms and hazards is investigated. Finally, the competence of market-based solutions in this regard is examined.

The Basics

The carbon atom has the unique ability of combining with itself to form long chains. These chains can provide the base to which other atoms and functional groups can be attached to produce a large number of compounds. The scientists have used this to design new molecules and compounds of desired shape, size and properties. Plastics are an example of such compounds.[1]

Plastics are synthetic materials of high molecular weight manufactured by the polymerisation[2] of organic substances and can be molded into any desired form or shape. There are two types of plastics. Thermoplastics, which can be softened on heating and harden on cooling reversibly. In other words, they soften on heating and remain so as long as they are hot. On cooling, they regain their original rigidity and hardness. Repeated heating and cooling do not alter the chemical nature of these materials. These polymers consist of long chains without any cross linkages between the chains. Some examples of these are polythene, polypropylene, polyvinyl chloride, polystyrene.

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[1] Singh A K, Mishra N K, Verma H C and Saha L C, 1997. "Carbon and Its Compounds" *Foundation Science.* Bharati Bhavan. p 215.

[2] Polymer ("poly" meaning "many" and "mer" meaning "parts") is a compound of high molecular mass, which is made by the addition of a large number of small molecules called monomer ("mono" meaning "one"). The process of combining a large number of monomer molecules by subjecting them to heat and pressure in the presence of a catalyst to form a high molecular mass polymer is called polymerisation. (Source: Jain Malika & Jain Priyanka. "Carbon and Its Compounds" *Essentials of Science*, Dhanpat Rai Publishing Company (P) Ltd, Third Edition, pp 391)

Thermosetting plastics, on the other hand, are those that during the molding process get hardened and once they have solidified cannot be softened. Such plastics during molding acquire three-dimensional cross-linked structure with predominantly strong covalent bonds. These bonds retain their strength even on heating. Some examples of these are polyester, bakelite, araldite, melamine.[3]

The Lifecycle

The journey of plastics involves three stages: manufacturing in the first stage, usage in the second, and recycling and/or disposal in the third.

Manufacturing

The starting point in the production of plastics is the heating of hydrocarbons or the "cracking process." The process involves the conversion of natural gas or crude oil components into monomers like ethene, propene, butene and styrene in the presence of a catalyst. That is, larger molecules are broken down into smaller molecules. The yield of ethene is controlled by the cracking temperature and is more than 30% at 850°C. Products like styrene and vinyl chloride are produced in subsequent reactions. These monomers then act as the starting materials for several other types of plastics. They are chemically bonded into chains to form polymers. Each monomer yields a plastic resin with different properties and characteristics. When monomers are combined, copolymers with further property variations are produced. The resulting resins may be molded or formed to produce several different kinds of plastic products with application in many major markets. The variability of resin allows a compound to be tailored to a specific design or performance requirement. This is why certain plastics are best suited for some applications while others are best suited for entirely different applications.[4]

Usage

The utilisation of plastics ranges from toys to aircrafts, from hosepipes to dolls, from soft drink bottles to refrigerators, from gramophone records to television sets. A detailed and discreet discussion of the applications and benefits of plastics has been taken up later.

Recycling

The kind of recycling practiced in India is quite different from what is practiced in the rest of the world, in that state-of-the-art technologies are not employed here. The entire process of recycling is done on the basis of experience. The starting point is the sorting of plastic waste. This is done on the basis of colour, transparency, hardness, density and opacity of the scrap. The sorted waste is then sent to the granulators. The technology employed is mechanical with the traditional grinding and extrusion to obtain granules. The final stage is reprocessing. The reprocessing sector can be divided into the granulators and the converters. The granulators make granules from the plastic scrap and sell these granules to the converters. The converters use these to make plastic products. A majority of the units in the informal sector are the granulators that utilise their storage shed in the houses to carry out the grinding. Such units are often located in slums, and function with stolen power and single machine extruding units. Scrap storage is done in the backyards, and washing is done in open drums. Their activities are often termed as backyard recycling. Conversion units are small industrial units that process the granules into finished products. The technologies used in these industries are also old and local.[5] The rate of recycling in India is extremely high. About 40 percent of the total plastics manufactured are sorted, collected and recycled as opposed to only 10-15 percent in developed

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[3] Jain, Malika and Priyanka Jain, "Carbon and Its Compounds" (Third Edition), *Essentials of Science.* Dhanpat Rai Publishing Company (P) Ltd, p 391.

[4] http://www.plasticsresource.com/plastics_101/manufacture/how_plastics_are_made.html

[5] Narayan, Priya, 2001, "Analyzing Plastic Waste Management in India: Case study of Polybags and PET bottles" published by IIIEE, Lund University, Sweden, pp 24-25 accessed at http://www.iiiee.lu.se/information/library/publications/reports/2001/Priya-Narayan.pdf

countries. Of the types of plastics recycled in India, PVC (polyvinyl chloride) accounts for 45 percent, LDPE (low density polyethylene) for 25 percent, HDPE (high density polyethylene) for 20 percent, PP (polypropylene) for 7.6 percent and other polymers such as PS (polystyrene) for 2.4 percent. According to manufacturers, almost all these types of waste can be recycled up to four or five times. However, the quality of the recyclate deteriorates as additives and virgin material are added to give it strength.[6]

Disposal

The final stage in the life cycle of plastics is disposal. In India, there are three common ways of getting rid off plastics; by dumping them in landfills, by burning them in incinerators or by littering them. In the case of littering, plastic wastes fail to reach landfills or incinerators. It is the improper way of disposing plastics and is identified as the cause of manifold ecological problems. Incineration is a process in which plastic and other wastes are burnt and the energy produced, as a result, is tapped. In Sweden, 95 percent of the heat generated from incineration is used for district central heating thereby covering roughly ten per cent of the country's total need.[7] Policy makers in India too advocate it as a sound option. Several big cities like Mumbai and Chennai have entered into agreements for constructing waste to energy plants. In Chennai, for instance, a 14.85 MW waste to energy plant will be set up in the next two years where 6,000 tones per day of municipal solid waste would be converted to electricity.[8] Incineration of plastic wastes also significantly reduces the volume of waste requiring disposal. It is said that the volume reduction brought about by incineration ranges from 80 to 95%. It is also a suitable option for disposing waste that cannot be recycled further or is non-recyclable.[9]

Now coming to landfills, a major issue that needs to be addressed is safety. Various environmentalists claim that landfills are unsafe for disposing plastics since toxic chemicals leach out into the surrounding soil and groundwater depleting the fertility of soil and polluting nearby lakes and streams. This argument is based on the popular notion that a large amount of biodegradation takes place in the depths of landfills. This notion stands challenged. Certainly, some biodegradation does take place otherwise landfills would not produce methane and other gases that they do produce. However, the suggestion that some intense chemical and biological activity is going on in every landfill is extremely flawed. For some kinds of organic garbage, biodegradation goes on for a while and then slows to a virtual standstill. For other kinds, biodegradation never gets under way at all. A major Garbage Project Research Program undertaken in US involved the excavation of various landfills in the country and the estimation of the proportion of old organic material in the landfills. The overall volume of old organic material recovered largely intact from the landfills turned out to be astonishingly high. For example, at the Mallard North Landfill outside Chicago, organics represented 50.6% of the 10 to 15 year old garbage excavated. Some 40% of 25-year-old garbage at Sunnyvale Landfill near San Francisco was organic. The picture of biodegradation that emerges from the above discussion is the following. Under normal landfill conditions, in which garbage is covered with dirt after being dumped and the landfill is kept relatively dry, the only types of garbage that truly decompose are certain kinds of food and yard waste. And these items account for less than ten percent of the average landfill's contents. Even after two decades, around 33% to 50% of supposedly vulnerable organics remain in recognisable condition.[10]

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[6] Shah, Priya, "The Plastic Devil: Ecological Menace" accessed at http://www.makingindiagreen.org/plastic.htm

[7] "Swedish Waste Management 2000—Annual Publication of RVF" RVF - The Swedish Association of Waste Management, accessed at http://www.rvf.se/frame_rt.html

[8] "Waste Technology" *Waste to Energy Project in India,* Asian and Pacific Centre for Transfer of Technology, New Delhi, Volume 5, Number 44, 2001.

[9] Tammemagi Hans, 1999, "The Waste Crisis: Landfills, Incinerators and the Search for a Sustainable Future" Oxford University Press, New York.

[10] http://www.plasticsresource.com/disposal/5_major_myths/garbage/myth2.html

Another issue of concern with respect to landfills is space. But some important findings have, to a large extent, dispelled this concern as well. While, in US, the number of individual plastic objects found in a deposit of garbage of a given size has more than doubled in the last 15 years, the proportion of landfill space taken up by those plastics has not changed. In fact, at some landfills the proportion of space taken up by plastics has actually come down in the 1980s as compared to the 1970s. This has happened because of light-weighting i.e. making objects in such a way that the object retains all the necessary functional characteristics but requires the use of less resin. In a study published by the Washington-based think-tank, Resources for the Future, economist A Clark Wiseman has calculated that at the current rate of waste generation, all of America's garbage for the next 1,000 years would fit into a single landfill space only 120 feet deep and 44 miles square. This proves that the total amount of space needed for landfill is not all that large.[11]

The Benefits

Having explicated the composition and lifecycle of plastics, the next step is to examine the principal benefits from plastics and their inevitability to India.

An Imperative Source of Wealth Generation

The virgin plastic industry in India is touted and advertised as the country's Sunrise Industry.[12] In 1999, it was valued at Rs 3,000 crore.[13] Over the years, the industry has registered a phenomenal expansion growing at an average annual rate of 17%, higher than for the plastic industry anywhere else in the world.[14] The industry has also exhibited a consistent export growth in the past. The following table indicates the exports of plastics in the past few years.[15]

Year	Value of Plastic Exports (in US m $)
1997-98	620.35
1998-99	514.48
1999-00	2570.00

Not only the virgin plastic industry but also the recycling industry is emerging as a principal force in India. The industry, as of now, encompasses more than 2500 recycling units that generate an average output of 350 tones per annum. These 2500 recycling units are responsible for the recycling of 60% of the plastic waste generated in the country. The turn over of this industry is estimated to be Rs 26 billion up to the granulation stage. In the post granulation stage, the turnover is estimated to be Rs 39 billion. The industry as a whole provides gainful employment to about 250,000 people.[16]

Hence, plastic is not just any other chemical substance in this country but the cornerstone of one of the most promising industries. It is a prominent source of income and livelihood for multitudes of people. This best reveals the inexorable character of plastics In India.

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[11] http://www.plasticsresource.com/disposal/5_major_myths/garbage/myth4.html
[12] http://www.indianplasticportal.com/plastic-statistics/
[13] Shah, Priya, "The Plastic Devil: Ecological Menace" accessed at http://www.makingindiagreen.org/plastic.htm
[14] The Report of the National Plastic Waste Management Task Force, Ministry Of Environment and Forests, Government of India, 1997.
[15] http://www.indianplasticportal.com/plastic-statistics/
[16] Narayan, Priya, "Analyzing Plastic Waste Management in India: Case study of Polybags and PET bottles" published by IIIEE, Lund University, Sweden in 2001, p 25 accessed at http://www.iiiee.lu.se/information/library/publications/reports/2001/Priya-Narayan.pdf

The Raw Material for Various Key Industries

Plastics, besides providing livelihood to many, are also an essential raw material for numerous critical industries. According to one estimate, in 1996, the highest users of plastics in India were industries related to infrastructure (30 percent), agriculture and water management (24 percent) and packaging (25 percent).[17] A brief outline of the degree of dependence of certain industries on plastics is presented below.

Building and Construction: The building and construction industry is the largest consumer of plastics in India and over the years plastics have built a reputation for durability, aesthetics, easy handling and high performance in this industry. The use of plastics in this sector abounds in plumbing fixtures, siding, flooring, insulation, panels, doors, windows, glazing, bathroom units, gratings, railings and a growing list of both structural and interior or decorative purposes. For instance, when used for pipes, valves and fittings, plastics offer superior corrosion resistance, and are lighter, easier to install, and cost effective. Impervious to chemicals and sulfur-bearing compounds, plastic piping safely transports everything from fresh water to salt water and from crude oil to laboratory waste. These qualities also have combined with plastics' high strength-to-weight ratio to produce materials for bridge construction, including tough reinforcement rods, nonskid surfacing and quickly installed replacement decking. Similarly, for commercial buildings that contain sensitive electronic equipment, plastics provide highly protective housing that does not interfere with radio frequency or magnetic waves.[18]

Electronics: This is the age of electronics. The ever-growing universe of electronic equipment, components and gadgets is improving our lives. The computers are powering the business world and teaching skills to toddlers. The communications systems are allowing us to reach the far corners of the earth in a few minutes. Painful and dangerous medical procedures are being eliminated. And our leisure hours are increasingly having more variety. But, without plastics, little of this would have existed. In almost all electrical and electronic uses, plastics are playing one role or the other and lending safety and cost effectiveness. Lightweight, durable, attractive and cost-effective plastics are used in nearly all the small appliances, including coffee makers, irons, mixers, can openers, hair dryers and shavers. Bigger appliances such as microwave ovens and food processors also use plastic components. Plastics with premium thermal and insulating properties are used to insulate nearly all house-wiring today and are used in electric switches, connectors and receptacles. All refrigerators today are insulated with thermal-efficient plastic foam, and their interiors are made of durable, easy-to-clean plastics. Similarly, sophisticated electronic toys, home computers, and smoke or fire detectors—all these amazing machines depend on plastic housings, circuit boards, components and packaging to bring their technological wonders to us.[19]

Packaging: Plastics are often the answer and sometimes the only answer to packaging problems. When it comes to packaging, plastics can perform tasks no other material can perform and provide consumers with products and services no other material can provide. They are capable of meeting all kinds of packaging needs. Plastics are available in different forms and each form offers different qualities. The manufacturers and consumers can choose the type of plastic that best suits their application. Rigid plastics can be chosen when protection is needed and flexible plastics can be chosen when convenience is paramount. Similarly, one can choose clear plastics or opaque plastics. Plastics can also be moulded into various shapes and sizes. They offer safety, quality, convenience and savings. In medical facilities, plastic packaging offers a superior ability to protect products against contamination and, consequently, patients against infection. The chemical resistance, transparency and toughness of plastics enhance safety and efficiency in both the laboratory and day-

[17] Shah, Priya, "The Plastic Devil: Ecological Menace" accessed at http://www.makingindiagreen.org/plastic.htm

[18] http://www.plasticsindustry.org/industry/2114.htm

[19] http://www.plasticsindustry.org/industry/2115.htm

to-day hospital use. Plastics, which can conform to any shape and guard against impurities, are the perfect materials for shipping and storing intricate medical instruments. And in uses such as see-through intravenous bags and break-resistant containers, plastic packaging has proven indispensable in modern medical care.[20]

Transportation: On land, on sea, in the air and in space, plastics are on the move. Plastics are used in everything from automobiles and light trucks to trailers and motorcycles, from marine craft and canoes to minesweepers and trains, from buses and airplanes to space shuttles. Automakers prefer plastic parts for their durability, corrosion resistance, ease of coloring and finishing, light weight, design flexibility and fuel savings. It was during the oil crisis of the 1970s that the automakers first discovered that plastics could make cars more energy efficient by reducing their weight. With that discovery, plastics found their way into automobile components such as bumpers, fenders, doors, safety and rear-quarter windows, headlight and side view mirror housings, trunk lids, hoods, grilles and wheel covers. The use of plastics was able to reduce the weight of an average passenger car built in 1988 by 145 pounds. This saved millions of gallons of gas annually and the energy equivalent of 21 million barrels of oil over the average lifetime of those cars. By the 1993 model year, over 250 pounds of plastics were being used in an average vehicle.[21]

Aeronautics: Many of the reasons that make plastics the materials of choice in other applications also make them the right stuff in aeronautics. During the past 50 years the aeronautics technology has soared and plastics have played a major role in this. They are used in everything from interior trim in airplanes to nose cones for missiles. The solid fuel boosters on rockets and the ablative shields for reentry too rely on them. By finding use in aircrafts, missiles, satellites and shuttles, plastics and plastic materials have enhanced and sped significant developments in civilian air travel, military air power and space exploration. It was World War II that accelerated the entry of plastics into aerospace both because other materials were scarce and because the possibilities for the materials' use were already being envisioned. During the war years, vinyl resins became a major substitute for rubber in fuel-tank linings and fliers' boots. Slowly, plastics became recognised as materials of first choice in various aeronautical applications. For instance, plastics started being used in radomes that housed radar installations. Plastic was virtually transparent to electromagnetic waves and allowed the waves to pass through with minimal loss and maximum transmission to night-flying bombers. Its introduction in this area was hailed as having significantly advanced the technology of airborne radar. The development of plastics that could "take the heat" associated with many aerospace applications further spurred interest and research in plastics for flight. [22]

Extensive Application in Households: It is not as if only large industries depend on plastics for their sustenance, small homes too extensively use plastic materials. Plastics help many domestic households save energy and thereby economise on their heating and cooling bills. In US, the use of plastic parts and plastic insulation in appliances like refrigerators and air conditioners has improved the energy efficiency of the same by 30 to 50 percent since the early 1970s. Similarly, vinyl siding and windows have enabled reduction in energy consumption. The US Department of Energy estimates that the use of plastic foam insulation instead of other kinds of insulation in American homes and buildings will ultimately save close to 60 million barrels of oil annually.[23]

In addition, modern forms of packaging enabled by plastics like heat-sealed plastic pouches and wraps help keep food fresh and free of contamination. Hence, the resources that went into producing the food are not wasted. Even in homes, plastic wraps and resalable containers keep the leftovers protected. According to packaging experts, each pound of plastic packaging can reduce food waste

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[20] http://www.plasticsindustry.org/industry/2117.htm
[21] http://www.plasticsindustry.org/industry/2118.htm
[22] http://www.plasticsindustry.org/industry/2113.htm
[23] http://www.plasticsresource.com/plastics_101/uses/uses.html

by up to 1.7 pounds. Plastics also help households bring home more products with less packaging. For example, just two pounds of plastic are needed to deliver roughly eight gallons of a beverage such as juice, soda or water. On the contrary, for the same amount of beverage, three pounds of aluminum or eight pounds of steel or 27 pounds of glass will be needed.[24]
Plastics also help maximise value from various big-ticket items. It is the use of plastics in portable phones and computers that make them really portable. Similarly, plastics help make major appliances like refrigerators, dishwashers etc. corrosion resistant, long lasting and efficient in operation.[25]

The ability of plastics to economically satisfy the rising needs of the Indian middle class has translated into a momentous surge in the consumption of plastics in the last few years. The consumption trends for key commodity plastics can be seen in the table below.[26]

Polymer	1995-1996	2001-2002	2006-2007
Polyethylene (PE)	823	1835	3267
Polypropylene (PP)	340	885	1790
Polyvinyl chloride (PVC)	489	867	1287
Polyethyleneterephthalate (PET)	34	140	289
Others	203	647	1415
Total	1889	4374	8054
Plastics in Packaging	976	2272	4037
% of Plastics in Packaging	52%	52%	50%

Source: National Plastic Waste Management task force report (1997). The above figure presents the total predicted increase in consumption of resins. (Figures in thousand tonnes)

Non-substitutable

There is no material on earth that can boast of as diverse and as exceptional benefits as plastics can. Inimitable properties, energy saving ability, resource conserving capacity, waste reducing capability—all make plastics a non-substitutable item.
Unique Properties and Characteristics: It is the uniqueness and distinctiveness in the properties and characteristics of plastics that spurs their use in various fields. For instance, the automotive industry chooses plastics for their durability, corrosion resistance, ease of coloring and finishing, resilience, energy efficiency and lightweight. The manufacturers of major appliances use plastics because they are easy to fabricate and have outstanding thermal insulation. The construction industry employs vinyl siding in homes because of its appearance, durability, ease of installation and energy efficiency.[27]

Energy Conservation: The use of plastics allows economisation in the consumption of energy and thereby provides substantial saving in production costs. The following statistical data as regards US will make this clear:

[24] http://www.plasticsresource.com/plastics_101/uses/uses.html
[25] Ibid.
[26] Narayan, Priya, "Analyzing Plastic Waste Management in India: Case study of Polybags and PET bottles," published by IIIEE, Lund University, Sweden in 2001, pp 16-17 accessed at http://www.iiiee.lu.se/information/library/publications/reports/2001/Priya-Narayan.pdf

[27] http://www.plasticsindustry.org/industry/

- By using plastics in packaging, product manufacturers save enough energy each year to power a city of one million homes for three and a half years.
- For every seven trucks needed to deliver paper grocery bags to the store, only one truck is needed to carry the same number of plastic grocery bags.
- Foam polystyrene containers take 30 percent less energy to make than paperboard containers.
- The manufacture of 1000 one liter plastic bottles requires 57 percent less fuel than is required by the same number of glass bottles and the manufacture of 1000 plastic bags requires 32 percent less fuel than is required by the same number of paper bags.[28]

Waste Reduction & Resource Conservation: The employment of plastics for various purposes brings about considerable waste diminution and resource saving.

- Plastics tend to be lighter than other alternative materials. This enables the use of lesser plastics as compared to other materials in packages and thereby reduces waste. For instance, the use of plastic grocery bags as against paper sacks reduces waste by 80 percent. Similarly, resource are conserved when more than 2.8 million plastic grocery bags can be delivered in one truck as compared to only 500,000 paper grocery bags.
- Plastics also have physical properties that allow their repeated use and use in multiple applications. For example, some laundry products are packaged in reusable plastic bottles and small packages of concentrated product are used to refill the original bottles. This helps reduce total packaging waste.
- Plastics generally exhibit superior resistance to breakage and denting. This results in fewer container breaches and less product loss on the packaging line and safer handling in the home.
- Plastics allow highly efficient manufacturing processes (up to 99 percent efficiency) that increase productivity by 20 to 30 percent and reduce capital expenditures by as much as 50 percent.
- Plastics help appliances and other durable goods last longer and thereby stay out of the waste stream. Without plastics' resistance to corrosion, the product life of some major appliances would be reduced by nearly 40 percent.[29]

Notwithstanding the sundry important benefits from the application of plastics, there are certain environmental side effects and health risks caused by them during manufacture, recycling and disposal. We list below some of the banes on which large-scale consensus has emerged.

The Ecological Impact

Manufacture

It is believed that toxic gases and chemicals are emitted into the air or discharged into the water in the process of producing plastics, which eventually generate negative environmental and human health effects. The kind of emissions or effluents generated and their toxicity varies depending on the type of plastic being made. Nevertheless, the toxic chemicals that are most frequently released during the production of plastics include tri-chloroethane, acetone, methylene chloride, methyl ethyl ketone, styrene, toluene, benzene. Other major emissions include sulfur oxides, nitrous oxides, methanol, ethylene oxide, and volatile organic compounds. Benzene is believed to cause cancer, styrene has been ranked in the US as "extremely toxic," sulfur oxides are known to harm the respiratory system, nitrous oxides adversely affect the nervous system and child behavioral development and ethylene oxides harm the male and female reproductive capacity. The production of a 16 ounce PET bottle produces nearly 100 times the air pollutants that a 16 ounce glass bottle.[30]

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[28] http://www.plasticsresource.com/plastics_101/basics/facts.html

[29] http://americanplasticscouncil.org/apcorg/classroom/perspective/waste_reduction.html

[30] The source of this information is the letter written by Tim Krupnik of the Berkeley Ecology Center to Dr A N Bhat of ICPE supporting the attempt to ban disposable plastics in India. Bharati Chaturvedi, Director, Chintan Environmental Organisation in New Delhi, made this letter available to us.

Several chemicals are used as plasticisers, antioxidants, colorants, flame-retardants, heat stabilisers, and barrier resins while producing plastics. These chemicals even while lending desirable performance properties to plastic products also cause negative effects. These effects include direct toxicity as in the case of lead, cadmium, and mercury or carcinogens as in the case of diethyl hexylphosphate (DEHP). Furthermore, the lead barriers and plasticisers are known Hormone Endocrine Disrupters (EDs) having the potential of causing serious health problems.[31]

Recycling

It is held that the recycling of plastics is not always green. Recycling usually results in the down cycling of plastics into lower-quality products that have higher and more leachable levels of toxic additives.[32] In addition, the incomplete combustion of PE during recycling releases carbon monoxide.

But a recycling plant generates the largest amounts of effluents during washing and cleaning. During recycling, the plastic scrap is cleaned to remove the dirt and foreign matter adhering to it. It is usually soap solution that is used for this purpose, and it is reused several times before it is finally disposed of into open drains. This way wastewater is generated. The quantity and the characteristics of wastewater generated cannot be generalised, and depends to a large extent on the contents of the plastic scrap. Nevertheless, this wastewater has high pollution load in terms of BOD, COD, and TSS. This water needs treatment before proper disposal into the drains. As of today, recycling units in the country release the wastewater into open drains without prior treatment.[33]

Disposal

As noted earlier, there are primarily three places plastics wastes can end up; in landfills, in incinerators or elsewhere. It was exhibited earlier that the dumping of plastic wastes in landfills is safe and that landfills do not require much space. The pollution that occurs in the disposal stage is largely during incineration and when plastic wastes fail to reach landfills or incinerators.

Given the limited re-cyclability of plastics, a large amount of plastic wastes is burnt in incinerators. Even in the villages in India plastic and other portions of the waste stream are frequently burned in "back-yard" fires. But the burning of these chlorine-containing substances releases toxic heavy metals and emits noxious gasses like dioxins and furans. The latter two are two of the most toxic and poisonous substances on earth and can cause a variety of health problems including damage to the reproductive and immune system, respiratory difficulties and cancer. In fact, dioxin has been shown to have hormonal activity and is an endocrine disruptor.[34]

It has been observed that due to an inefficient and faulty waste collection and transit system, a large amount of plastic waste fails to reach landfills or incinerators. Instead they are left behind to find their way into the soil, the sewage system and the water bodies. They choke the gutters and drains and during the monsoons flood streets causing severe health problems.[35] When plastic wastes get

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[31] Ibid.

[32] The source of this information is a press release of NoPE (No Plastics in the Environment) titled "Imports Versus Surplus: A Glut of Plastics in India Today," January 10, 2002. Bharati Chaturvedi, Director, Chintan Environmental Organisation in New Delhi, made this press release available to us through email correspondence.

[33] Narayan, Priya, "Analyzing Plastic Waste Management in India: Case study of Polybags and PET bottles" published by IIIEE, Lund University, Sweden in 2001, pp 25 accessed at http://www.iiiee.lu.se/information/library/publications/reports/2001/Priya-Narayan.pdf

[34] The source of this information is a press release of NoPE (No Plastics in the Environment) titled "Imports Versus Surplus: A Glut of Plastics in India Today," January 10, 2002. Bharati Chaturvedi, Director of Chintan Environmental Organisation in New Delhi, made this press release available to us.

[35] D'Mello, Pamela, "Plastic Bag Problem" *The Asian Age*. Accessed at

dispersed in urban fringes or in rural zones, they clog the soil preventing the free flow of water through it and depleting its fertility.[36] It is also said that when plastics reach the rivers, seas and oceans, they pose a serious threat to marine animals like sea turtles, seabirds and fish. If marine animals mistaking them to be authentic food consume plastic objects and pellets, they can clog their intestines leading to death out of starvation or malnutrition. This discomforting effect of plastics on marine life came to fore in the late 1970s when scientists from the National Marine Mammal Laboratory concluded that plastic entanglement was killing up to 40,000 seals a year. Annually, this amounted to a four to six percent drop in seal population beginning in 1976.[37]

Having established the inevitability of plastics in India and also having accepted the few environmental harms and health hazards caused by them, the question that has to be tackled now is this—how should the environmental problems caused by plastics be addressed, given that they cannot be completely done away with?

There are various policy instruments that can be employed for abating the pollution caused by plastics. We provide below a taxonomy of these instruments.[38]

Taxonomy of Policy Instruments to Reduce Pollution Due to Plastics

Policies	*Direct instruments*	*Indirect instruments*
Market-based incentives	Effluent charges; tradable permits; deposit refund systems	Input/output taxes and subsidies; subsidies for substitutes and abatement inputs
Command and control measures	Emission regulations (Source-specific, nontransferable quotas)	Regulation of equipment, processes, inputs, and outputs

It is clear from the above table that one way of dealing with the plastic pollution is to ask the government to step in and act as command and control regulator. Let us examine the feasibility of this option.

Government as Command and Control Regulator

The government's role as command and control regulator involves the promulgation and enforcement of rigid and uniform standards and the requirement of specific behavior from various

http://www.goacom.com/news/news98/jun/msg00043.html

36 The source of this information is the letter written by Tim Krupnik of The Berkeley Ecology Center to
Dr A N Bhat of ICPE supporting the attempt to ban disposable plastics in India. Bharati Chaturvedi, Director of Chintan Environmental Organisation in New Delhi, made this letter available to us through
email correspondence.

37 Amaral, Kimberly, "Plastics in Our Oceans" accessed at
http://www.umassd.edu/Public/People/Kamaral/thesis/plasticsarticle.html

38 Eskeland, Gunnar S and Emmanuel Jimenez, "Policy Instruments for Pollution Control in Developing
Countries" *The World Bank Research Observer*, Volume 7, Number 2, July 1992, pp 145-69.

parties. It formulates a set of "dos" and "don'ts" that are backed by penalties (fines and imprisonment).[39]

It was mentioned in an earlier section that the ecological problems attributed to plastics largely occur during its manufacture, recycling and disposal. Therefore, in the case of plastics, the government acting as regulator will mandate standards for the manufacture, recycle and disposal of plastics. For instance, plastic manufacturing can be asked to conform to a certain level of emissions or adopt certain kind of technology. Similarly, the operation of recyclers, incinerators and landfills can be ordered to be under specific parameters.

So, should command and control regulation by the government be accepted as the relevant policy instrument for lessening the ecological impact of plastics? The answer to this question will depend on how well command and control measures have fared around the world in addressing various environmental problems. Our analysis suggests that command and control measures have generally failed and often created trouble when used for environmental protection.

They impose an enormous burden on taxpayers

The entire course of promulgating and enforcing a command and control regulation involves massive expenditure by the government. The government begins by setting up a committee to analyse and recommend on an environmental problem. The government ponders over the committee report and tables a bill for consideration before the legislature. The legislature takes its own time and passes the bill. The bill receives executive consent and becomes an Act. Thereafter, agencies are set up and people recruited and equipped to ensure the enforcement of the Act. From cradle to grave, a command and control regulation requires heavy government expenditure and all of this is financed through the hard earned money of taxpayers.

In US, for instance, the private sector spent more than $668 billion annually (i.e. more than $6,000 per household) till 1994 to comply with federal regulations. Similarly, the cost of environmental regulation in US quadrupled between 1977 and 1994. US annually lost around $1.3 trillion of economic activity due to federal regulations till 1994. What is more, billions of dollars were spent by the government to study, produce and enforce regulations.[40]

They are highly cost-inefficient

Command and control regulations work by being uniformly applicable across all polluters. For instance, all polluters might be asked to achieve the same level of emissions or they might be asked to use the same pollution reduction technology irrespective of their pollution abatement cost structures. However, the homogenous imposition of a regulation on all polluters does not necessarily imply uniform costs for all of them. The cost of complying with the regulation might be low for some polluters and high for others. This way, rather than achieve maximum pollution reduction for the least possible cost, command-and-control regulations end up with higher costs per unit of reduction achieved.

Several economic analyses and empirical simulation studies have confirmed this. We cite here only the most famous of all. T H Tietenberg, a leading environmental economist, surveyed eleven empirical studies on air and water pollution control in the United States comparing the cost of complying with command-and-control regulations with the least-costly methods of achieving the

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[39] This section is largely based on the following reference unless otherwise mentioned: Bast Joseph L, Hill Peter J & Rue Richard C, "Eco-Sanity: A Common-Sense Guide to Environmentalism" The Heartland Institute, 1994, pp 206-210 accessed at http://www.heartland.org/pdf/23933b.pdf

[40] Burnett H Sterling. "Five Steps to Effective Regulatory Reform" National Center For Policy Analysis. Brief Analysis Number 202, April 24, 1996 accessed at http://www.ncpa.org/ba/ba202.html

same level of pollution reduction. For all the eleven cases it was found that the cost of complying with regulations exceeded the least-cost. The *potential cost savings* from using least cost methods rather than command and control (CAC) measures were shown as the ratio of costs under CAC to the lowest cost of meeting the same objective. The mean average ratio was found to be six and the median average ratio was found to be four implying that complying with federal regulations typically cost between four and six times as much as the least-costly means of reducing emissions by the same amount.

They discourage the usage and development of new pollution reduction technologies

Command and control environmental regulations work by imposing mandatory standards that are based on the best abatement technology available to the economy at the time of legislation. Regulations are inherently static and are not revised recurrently. As a result, with improvement in technological knowledge over time, these norms become outdated. The forced compliance of these norms prevents the use of new and better pollution reduction technologies by polluters. Also, the system of uniform emission or effluent standards fails to create incentives for polluters to innovate and develop new control technology for the cheapest and maximum abatement of pollution. Businesses know that even if they find a way to reduce emissions at one facility below the level required by current laws, regulations mandating the use of best available technology or (BAT) will require them to implement the same at every facility, regardless of cost considerations. As a result, no entrepreneur tries to use different or cleaner inputs, produce different or cleaner products, change the production process or invest in R&D for better pollution abatement technologies.

They are based on incomplete knowledge and information

Command and control regulations are promulgated and enforced without considering much of the important data and facts. The government officials are hardly aware of the procedures, opportunities, and costs—something the managers of factories and owners of resources are. Consequently, regulations result in the mandating of equipment and procedures that achieve less emission reduction and are more expensive. A case in this direction is the following.

In 1992, the Amoco Oil Company and the Environmental Protection Agency of US completed a study of an Amoco refinery in Yorktown, Virginia. Researchers compiled a comprehensive inventory of the facility's wastes, options for waste reduction, and the environmental regulations it was required to follow. They found that the best pollution reduction options for the plant *did not coincide with the existing regulatory requirements* and that *equivalent levels of protection could have been achieved at 25 percent of the cost of current regulatory programs*. In other words, allowing the plant's managers to apply their own ingenuity to the problem of reducing waste from the refinery would have achieved the same level of emission reduction at one-fourth the cost of complying with the regulations.

They tend to proliferate

This is not only a deduction of the potato-chip theory of regulation, but also an oft happening. Regulations are intrinsically incomplete and imperfect. One regulation might pave the way for another regulation because the former offered scope for misuse. Similarly, bureaucrats might spin a web of regulations in order to ensure compliance of a lone regulation. Likewise, more regulations may be formulated because one particular regulation was not interpretable.

There are several instances of this. We list here one of them. According to a report by Philip Abelson in the June 1993 issue of *Science*, local governments in US were required to comply with 419 "essential" environmental regulations and to monitor more than 130 chemicals in their water supplies. Not only were these environmental mandates costly, they were also difficult to interpret and implement. The result of all this was nothing but bureaucratic delays and expensive litigation.

Case Study: Mumbai's Experience with the Recycled Plastic Manufacture and Usage Rules, 1999

The Recycled Plastic Manufacture and Usage Rule of 1999 was the first central government rule on plastic waste. It was passed to control the packaging of food products in recycled plastics and to manage the littering problem. The objective of the Rule was supposedly to protect human health from the risk of colored plastic bags and to minimise the littering problem by encouraging reuse and recycling of polybags. The Rule was based on the recommendations of the Plastic Waste Management Task Force.[41]

There were three main specifications in the Rule:

- **The use of recycled and virgin colored polybags for non-food applications was allowed but for packaging food items was discouraged**
  The Rule allowed the use of colored virgin and recycled bags for non-food applications provided the dyes or pigments used in the manufacture of polybags were non-toxic and conformed to the specifications in the Food Adulterations Act. However, the use of colored polybags for food products was prohibited. The taskforce was of the view that the use of colored polybags for packing food items involved the risk of toxic pigments and dyes added during the manufacturing process leaching out into the food products. The Rule clearly specified that food products had to be packed only in virgin material of natural color without any pigments and dyes.

- **All carry bags of size less than 20 microns were banned**
  The ban was enforced with the intention of curbing the littering problem in the country. Prior to the formulation of this Rule, carry bags of size ranging between five and ten microns were used. The waste pickers had no incentive to pick these low-valued carry bags and a large part of plastic waste remained uncollected. As a result, unnecessary problems and nuisance like choking of soil, drains etc., were caused. The ban was supposed to be a panacea for all these problems. The rationale was the following. If the thickness of polybags increased, their value would increase and the waste pickers would have incentive to collect them for recycling. Increase in the thickness of carry bags also implied higher price for retailers, which would be passed to the consumers thereby initiating among the consumers a tendency of reuse.

- **The guidelines for the recycling of plastics were made mandatory**
  The Rule made recycling in accordance with the guidelines compulsory. The Ministry of Environment and Forest and the Bureau of Indian Standards with a view to bringing discipline to the recycling practices and to improve the quality of recycled plastic products had formulated the Guidelines for Recycling of Plastics. Standards were prescribed for the segregation and processing of plastic waste and manufacturers of plastic products were instructed to use marking on the finished product so as to facilitate the identification of the basic raw material. In respect of recycled plastic products, it was necessary to indicate the percentage of recycled content in the product.

Mumbai and the Rule: Two years ago, as is now, the provision of civic amenities and services in Mumbai was poor. This was largely because of the high population density in the city and due to 60% of Mumbai's population residing in slums. The city's waste management system was also in dumps. The average amount of waste generated in Mumbai was about 6,000 tones per day and this was expected to increase to about 14,000 tones per day by 2011. While waste was increasing, the collection of waste was inefficient and the landfill capacity was limited. The existing landfill sites

[41] This section is largely based on the following reference unless otherwise mentioned: Priya Narayan, "Analyzing Plastic Waste Management in India—Case study of Polybags and PET bottles" IIIEE Reports 2001, pp 37-49 accessed at http://www.iiiee.lu.se/information/library/publications/reports/2001/Priya-Narayan.pdf

were expected to last only for eight to ten years and there were no new sites available. Mumbai, as a result, had a major problem of disposal on hand. This contributed to littering. Plastic bags, a major component of the litter, had created several problems for the city like clogging the underground drainage system during monsoons. It was in the light of these problems that the municipality of Mumbai for the first time passed a resolution seeking complete ban on plastic carry bags. Then in March 1999, a law was passed banning thin plastic bags. It was a non-starter. The ill-equipped municipality encountered problems during implementation. Learning from past experience, the Mumbai Government decided to start afresh and accepted the Recycled Plastic Manufacture and Usage Rule banning plastic bags less than 20 microns and recycled plastics for food products.

The municipality of Mumbai ensured that strong administrative machinery was in place before the Rule was enforced. The Maharashtra Pollution Control Board was entrusted to take action against manufacturers of polybags, the civil corporations were made in charge of raiding and levying fines on the distributors and suppliers of these goods, the octroi department was supposed to check the entry of bags in concerned areas and the civil administration was made responsible of running awareness campaigns. Prior to enforcement, wide publicity was given to the Rule. After proper announcement and publicity, vendors, users, shopkeepers and manufacturers of plastic bags were raided for confiscating the banned plastic and fined heavily for using colored plastic bags. The Maharashtra Pollution Control Board took stringent action against the polybag manufacturers who violated the law. There was also cooperation from the licensing department, the pollution control board, citizens and NGOs. Follow-up was done every fortnight to shops by nuisance detectors to ensure compliance and non-usage of colored plastic bags by vendors.

This is in sharp contrast to the manifold difficulties experienced by other places in implementing this Rule. In Goa, the authorities were not well equipped to measure the thickness of the bags less than 20 microns. When they were finally equipped, the manufacturers of plastic bags found ways of deceiving enforcement authorities. They started making bags with bubbled or corrugated surfaces so as to cause the micrometer to read the thickness as greater than 20 microns. While many other states adopted this legislation, what makes Mumbai an interesting case study is the high level of enforcement that took place in the city.

The Scorecard: The performance of Mumbai in realising the objectives of the Rule can be evaluated on four fronts.

Effectiveness: Mumbai was largely ineffective in achieving the goals of the Rule. The only success that was achieved was in ousting colored plastic bags from the market. On all other fronts, the city administration bit the dust. The enforcement agencies in Mumbai were able to ensure that the food products were packed in virgin plastic bags of natural shade and colored bags were not used for non-food applications. But, the ban on thin carry bags (of size less than 20 microns) failed to realise its purpose. Mumbai had mandated the use of thicker bags. It was assumed that such a ban would encourage collection of carry bags by waste pickers for recycling and initiate the tendency of reuse of carry bags among customers, thereby, resulting in minimal littering. However, all of these assumptions failed. The collection of carry bags by waste pickers did not witness any significant rise. Even though the increase in thickness of carry bags meant more money for few bags collected, it did not generate enough incentive for the waste pickers to meticulously collect the bags. There were two reasons for this. First, the households tended to dispose their garbage in carry bags making it extremely difficult for the rag picker to collect these bags. Second, carry bags were highly unprofitable if found dirty. Dirty carry bags tended to be uneconomical for recycling and fetched a lower price. As a result, waste pickers preferred to collect other plastics like milk bags that fetched higher prices. The ban also failed to initiate a tendency of reuse of carry bags among consumers. The mandatory use of thicker carry bags did not impose much cost on shopkeepers. They still found it reasonable to hand out free bags to customers as a part of their service. Since people never paid for or valued the thicker bags, they never had the incentive to reuse them. In essence, despite the ban, littering in the city continued unabated. Drains continued to be choked and sewers continued to be clogged. But what is most astonishing is that the implementation of this ban increased the consumption of virgin plastic in the city. The use of recycled plastic bags for packaging foodstuffs and the use of thin bags in general had been completely banned. As a result, the consumption of virgin polybags in the food-packaging sector and the use of virgin plastic to manufacture bags of size greater than 20 microns rose. With the demand for virgin plastic mounting, its production increased too. The usage of recycled products tends to slow down the speed and volume at which finite resources are consumed. With the ban encouraging the use of virgin plastic instead of recycled plastic, the idea of resource conservation was lost.

Cost-efficiency: It is certainly not possible to determine the full cost of implementing the aforementioned Rule in Mumbai. Nevertheless, the cost incurred on the enforcement and promotion of the Rule can be examined. This cost can be segregated into four; the cost incurred on the salary of 97 nuisance detectors (the average salary of a nuisance detector was Rs 6000 per month implying an annual expenditure of Rs 69,84,000), the cost incurred on equipment (26 micrometers of Rs 2,000 each were purchased by the Mumbai Municipality implying an annual expenditure of Rs 52,000), and the cost incurred on carrying out awareness drives and campaigns (on the basis of information gathered from various contacts and from around Mumbai, the annual cost of awareness raising activities can be assumed to be Rs ten million). If the expenditure on micrometers (Rs 52,000), on the salary of nuisance detectors (Rs 69,84,000) and on awareness drives (Rs ten million) is added up, the total annual cost incurred on the Rule comes out to be in the order of Rs 17 million. As against an annual cost of Rs 17 million, the only benefit that accrued from the Rule was the ousting of colored plastic bags from the market. It is not possible to quantify this benefit into a comparable figure and therefore a discreet cost-benefit analysis cannot be done. However, on the surface, it is doubtful whether the benefits outweighed the costs.

Responsibility Sharing: It is a foregone conclusion that the management of litter problem is a joint responsibility. Consumers, recyclers, virgin plastic producers, and end users—all are responsible for the problem. It is therefore expected that any legislation that aims to curb the litter problem involves all the stakeholders and makes them share the responsibility. The implementation of the Recycled Plastic Manufacture and Usage Rule was in that sense flawed since it only targeted the recyclers. In fact, it came down heavily on them. The recycled bags were banned for packing foodstuffs and the virgin polybags substituted for them. Fines and penalties were imposed on shopkeepers for using recycled material and this made them switch to virgin material. The Recycle Traders' Association has confirmed that their business suffered due to the enforcement of this Rule. There is no doubt that recycled bags contribute to the littering problem. However, this is true only in a limited sense. The problems with polybags e.g., clogged sewers can be associated with both virgin and recycled material. If the aim of the policy was truly to alleviate the problem of littering, it should have targeted the virgin plastic industry as well. Instead, the virgin plastic industry, which was financially and technologically better placed than the recycling industry, was given no roles and obligations. On the contrary, the virgin plastic industry benefited from the policy despite being an equal if not greater contributor to the problem.

Feasibility of Enforcement: There is no doubt that Mumbai succeeded to a large extent in enforcing the Rule. However, given the regulatory capacity and technical capabilities of the city administration, there were some respects in which the Rule was unfeasible to enforce. The ban on bags less than 20 microns was impractical and unsatisfactory. It was an arduous task for the detectors to measure the thickness of bags used by all shopkeepers and vendors across the city. Similarly, the specification on disciplining the recycling practices was unworkable and was not enforced. The State Pollution Control Board admitted that the enforcement of such a specification in the informal sector was extremely difficult given the clandestine nature of operations in this sector.

Conclusion

The impact of the Recycling Rule on the city of Mumbai can be understood fully by examining the table below. The table presents the effectiveness of the Rule in handling key issues of concern of polybags. It is pretty evident that various critical were not be addressed by the Rule despite its effective enforcement.

Critical Issues	Has the Union legislation managed to address the following problems
Choked Drains	No
Choked Soil	No
Dying Animals	No
Decreased health risk to the citizens by dyes and pigments	Yes
Improve collection and disposal of polybags	No
Improve recycling practices	No
Encouraging substitutes to polybags	No
Increase awareness of the citizens	Yes to a limited extent to move from coloured plastic bags to colourless plastic bags
Increased reuse of the polybags by the citizens	No

The Mumbai case study reveals how even when the government enforces a highly comprehensive legislation with proactive administrative machinery and strong citizen support, it fails to address the problem at hand. In fact, in the case of Mumbai, the governmental regulation to a large extent compounded the problem.

The aforementioned reasons and the Mumbai case study suggest that a command and control approach for tackling pollution due to plastics should be avoided. Instead, market-based solutions should be attempted. It has been empirically validated and a number of simulation studies have demonstrated that market based solutions are in general more cost-effective in achieving a given target of pollution abatement than command and control. It is primarily for this reason that economists, for almost three decades now, have advocated the use of market based solutions for environmental problems.

Market Based Solutions

Tradable Emission Permits

Under a system of tradable pollution permits, the pollution control agency determines a target level of environmental quality and translates this into the total amount of allowable emission that can be discharged. The agency then allots or auctions the rights to discharge units of pollution to firms in the form of permits. These rights can be bought and sold subject to an overall ceiling of allowable discharges, which has been fixed a priori. Since this ceiling is usually less than the current aggregate level of discharges, there is a scarcity value to the permits and this puts an initial price on them. The price would increase over time as economic activity increases and more firms bid for the permits.[42]

[42] As part of its ongoing efforts to address the problem of industrial pollution, the Ministry of Environment and Forests (MoEF), Government of India (GOI), signed an agreement with the World Bank in December 1994 to implement the World Bank assisted Industrial Pollution Prevention

The system of tradable pollution permits allows more flexibility than the current pollution control regime does. For instance, polluters would be allowed to increase pollution at some location where water quality is high in return for reducing pollution in an area where it is low. It also improves overall efficiency. If a permit is held by a firm that is capable of reducing pollution at lower cost than other firms, then a high cost firm could purchase that right to pollute from the low cost firm. The low cost firm would then reduce the pollution level it had previously been allowed to discharge and still make a profit from the sale of the permit. Another value of this system is that the cost of achieving a given level of air and water quality is much lower in this system than in other systems.[43]

Tradable emission permit is a market-based instrument (MBI). An MBI works through the market and alters the behavior of economic agents (such as firms and households) by changing the nature of incentives or disincentives these agents face. The use of MBIs to address environmental problems has been endorsed by the international environmental community in the Rio Declaration on Environment and Development at the UNCED conference at Rio de Janeiro in 1992 and also by the Indian government in its Policy Statement for Abatement of Pollution.[44]

Tradable pollution permits and pollution charges are the two market-based instruments that have received maximum attention around the world. Between these two, tradeable pollution permits have been preferred for pollution abatement in theory as well as practice. There are three reasons for this:[45]

- Tradable permits allow the regulatory authority to control the quantity of emissions (determined by the desired ambient quality), whereas under a tax system the polluters determine the level of emissions.
- In a charge system, the regulatory authority needs to periodically adjust the fee to allow for inflation (if the fee is set in nominal terms), and for growth in the level of industrial activity. In the case of tradeable permits, however, the price of permits automatically adjusts to such changes (with growth in industrial activity the demand for pollution permits would increase and so would their price, as long as additional permits are not issued).
- When tradeable permits are "grandfathered" i.e. initially distributed free of cost to firms instead of being auctioned, they have the advantage of political acceptability over a pollution charge (Baumol and Oates 1988, pp. 178-179). While the pollution charge imposes a new tax bill on polluting firms, a grandfathered system of permits favors incumbent firms.

The permit system, however, is not bereft of flaws:

- In the case of grandfathering of permits, subsequent buying and selling of permits is required to achieve a cost-effective outcome, since the initial distribution, which did not reflect the marginal abatement costs of different polluters, is non-optimal. Further, by providing permits free to existing firms, regulators discriminate against new firms. New sources are made to face a greater financial burden than other identical existing sources. This bias against new sources can retard the introduction of new facilities with newer technologies embodying the latest innovations (Tietenberg 1991, p. 98).

Project. As part of this agreement the MoEF constituted the Task Force To Evaluate Market-based Instruments for Industrial Pollution Abatement on August 1, 1995 to carry out a study to evaluate market-based instruments (MBIs) for industrial pollution abatement. The explanation of the concept of tradable pollution permits is based on the Report Of this taskforce (pp 11) made available by Dr Shreekant Gupta through email correspondence.

[43] Anderson, Terry & Donald Leal, 1991, "Marketing Garbage: The Solution to Pollution" *Free Market Environmentalism,* Chapter 9, Pacific Research Institute.

[44] Report of the Task Force To Evaluate Market-based Instruments for Industrial Pollution Abatement, p 1.

[45] Report of Task Force To Evaluate Market-based Instruments for Industrial Pollution Abatement, pp 19-20.

- Although costs on the monitoring of emissions or effluents are incurred under both pollution taxes and tradeable permits, the latter has the additional cost of tracking the trades (sale and purchase of permits) in the market. In other words, the *de facto* allocation of pollution rights in the economy has to be monitored.
- Also, advantages of permits will not be realised if market imperfections prevent the permit market from functioning smoothly. For example, if the flow of information is imperfect, potential buyers and sellers of permits will not be able to engage in profitable trades. In the presence of this and other distortions in the permit market (e.g., large search costs, strategic behavior on part of the players), an emission tax system may be preferred.

There are quite a few countries that have attempted the system of tradeable emission permits. The table below and the discussion subsequent to it give information in this regard.[46]

Table 1
Number of Countries Using Tradable Emission Permits for Pollution Control

Economic Instrument	Developed Countries	Developing Countries	Remarks
Marketable emission Permit	5	1	US has made the most extensive use, with success in air pollution permits

Limited emissions' trading was introduced in the United States in 1974, and enhanced over the years to include more types of transactions (bubbles, banking, and offsets). The pollutants covered were VOCs, CO, SO2, NOx, and particulates. By 1986, 7,000-14,000 internal trades, and some 200 inter-firm trades had taken place: the abatement cost savings—$935-$12,435 million—was substantial. Trade in lead credits, to phase out lead in petrol in 1982-87, has had the best performance. The trading of lead credits gave petrol refiners flexibility in significantly reducing lead in the fuel during this period. Limited banking of permits was allowed three years after the programme was introduced, and this allowed firms to carry over the rights to the future. Inter-refinery trading did not discriminate between old and new sources, or between large and small ones. The level of trading in the lead credits market surpassed those observed in other permit markets. In 1985, more than half the refiners participated in credit trading, and about 15 percent of the total lead credits in use were traded. In terms of "creating a workable regulatory mechanism that induces cost savings" the lead credits programme is considered to be a success. The estimated cost savings range from about $1-13 billion.[47] However, there is a key lesson to be learnt from the US experience: even when the necessary institutional structure is present, the presence of regulatory restrictions and uncertainty can impede the efficient performance of the pollution permit market. In the United States, tradeable permits market have performed well only where the rules of the game were clear and there was no discrimination among the various pollution sources, as in the case of lead credits. Where an environment of regulatory uncertainty prevailed regarding the possibility of recouping abatement

[46] Guha, Aparna, "A Review of Market-Based Instruments for Pollution Control: Implications for India" National Institute of Public Finance and Policy, New Delhi, 1996.

[47] Hahn, Robert W, "Some Economic Prescriptions for Environmental Problems: How the Patient Followed the Doctor's Orders" Journal *of Economic Perspectives.* Volume 3, Number 2, spring 1989, pp 95-114.

costs and regarding the future rules, a thin permit market emerged, as in the case of sulphur dioxide permits of electric utilities during 1992-93.[48]

For all this discussion, there is no attempt to underestimate the practical problems involved in implementing an MBI like tradeable emission permit in India. However, we would like to direct the attention of the reader to the Report of the Task Force to Evaluate Market-based Instruments for Industrial Pollution Abatement set up by the Ministry of Environment and Forests in agreement with the World Bank. The task force stated that there is nothing that is so different about India from the rest of the world, which makes it impossible to try to replicate the experience of comparable countries. In this context, we note in particular the experience of China, Thailand, Malaysia, Indonesia, and other developing countries including the formerly planned economies of Europe. Many of these countries had until recently problems similar to those that are cited in the Indian context against the use of MBIs: imperfectly functioning markets, problems of monitoring and enforcing standards (due to a bloated and inefficient bureaucracy, shortage of resources, large number of micro and small-scale firms), and so on. While we do not belittle the importance of these difficulties, we also maintain that the Indian situation is amenable to the implementation of well-designed MBIs.

Contracting Out Waste Collection and Transit

Another way in which pollution owing to plastics can be checked is by ensuring a professional and competent waste collection and transit system. Contracting out of these services will achieve just that. But, before elucidating the proposed reform, it will be useful shedding light on the present system of waste collection and transit. In the current system, municipal workers sweep the streets and bring the waste to prefixed collection points, which could be unconfined open spaces or confined masonry enclosures. The waste so collected is then loaded manually or through front-end loaders into open body trucks or tipper trucks and taken away for disposal. Some cities have introduced mechanisation in collection and transport but the use of these equipments almost invariably remains non-optimum. In Delhi on an average 30-35 per cent of vehicles is off-road and in Calcutta only about 55 per cent of vehicles is available for use. It is estimated that the efficiency of collection of waste in the urban areas varies from 59-82 per cent. This shows that a substantial quantum of solid waste is left behind and remains uncollected. The cost of waste collection and transportation in cities is also very high. The Calcutta Municipal Corporation is incurring about Rs 800 and the Delhi Municipal Corporation is spending over Rs 1,000 for collecting and transporting a ton of waste. It is seen that 80-85 per cent of the budget is spent in collection of waste and 12-20 per cent on transportation. All these problems are attributable to weak infrastructure, poor financial status of municipal bodies, use of improper equipment for collection and transportation, heavy absenteeism of workers and vested interests, lack of political and bureaucratic will, waste of labor in re-handling of refuse and poor motivation of workers.

In India, municipal bodies in more than 98 per cent of the cities handle waste. But there is one metropolitan city—Calcutta—that has switched over to partial privatisation and this is the city to emulate. The Calcutta Municipal Corporation has been engaging private contractors for loading and transportation of waste for more than three years. They handle more than 40 per cent of waste. The waste is brought to prefixed collection points through handcarts and the same is offloaded on to ground by turning the handcarts up side down. The waste is loaded into the open body trucks by the contractors' labor by using hand shovels and the basket. This arrangement is an improvement over the earlier system. The removal of waste is regular and effective. Although, private operators in Calcutta load waste manually and transport it through open body trucks, their operating efficiency is around 90-95 per cent. This is largely because they are free from bureaucratic hurdles and upkeep of

[48] Cropper Maureen L & Oates Wallace E, "Environmental Economics: A Survey" *Journal of Economic Literature,* Volume 30, June 1992, pp 675-740.

their equipment is excellent. Good condition of vehicles and equipment not only ensures trouble free operation but also higher output and profitability for them. The present level of efficiency can only get better as private agencies adopt better methods of collection, efficient transportation, appropriate technology, better management practices and motivate workers.[49]

Private Operation of Landfills

A final way of limiting pollution due to plastics is to ensure their proper disposal in landfills. For this, landfills have to be managed and operated scrupulously.

Currently, landfills are owned and heavily mismanaged by the government. A large amount of waste that is collected fails to get disposed and safety norms are hardly followed. Even if one fine day the government started following environmentally acceptable practices and stipulated regulations to govern the operation of landfills, the cost it would have to incur on managing landfills would be extremely high. The annual regulatory cost of operating a “typical” landfill in US includes a cost of $100,000 to $300,000 per acre on landfill liners, $1 million to $2.5 million on leachate treatment and disposal, an operating cost of $50,000 to $90,000 on groundwater monitoring, a capital cost of $500,000 to $2 million and an operating cost of $100,000 to $200,000 on methane control and around $10 million to $12 million on post-closure funding.[50]

In the light of these facts, entrustment of landfill management to private parties even while retaining government ownership is a feasible way of guaranteeing meticulous waste disposal. Under a system of government-owned privately operated landfills, the local government will be contracting out the service of solid waste disposal. The government will continue to provide the service, but would not actually produce it. The government will have a role in the sense that it would maintain all assets, oversee the system, maintain or enforce regulatory authority, create the framework for running facilities, specify controls on the solid-waste stream and take advantage of competitive opportunities to save money and improve services. Besides this the government will maintain some liabilities, remain responsible for most capital needs and incur the costs of framing and monitoring contracts. Such a system will result in four main benefits.[51]

- **Increased Efficiency**
  We know that public officials are inefficient. Public management experts provide the rationale for this. Government executives play dual roles: as policy makers, they are buyers who think about the interests of the taxpayers and consumers; as service providers, they are sellers who think about internal organisational interests. The conflict between being a policy maker and a service provider results in a focus on process, with the consequence that the service "price" is determined by cost (or other political considerations that lead to decisions to subsidise service delivery). But cost itself is determined by process, and process is determined by political considerations rather than cost minimisation. For the private sector, the focus is on product and profit, with firms attempting to receive the highest attainable price for any given quantity of

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[49] The entire discussion on the contracting out of waste collection and transit services was based on the following reference: Bhatia MS & Gurnani PT, “Urban waste management privatisation” 22nd WEDC Conference: Discussion paper, New Delhi, 1996 accessed at www.lboro.ac.uk/departments/cv/wedc/ papers/22/groupg/bhatia.pdf

[50] "Calculating Landfill Costs: Background and Worksheet" Browning-Ferris Industries, Houston, Texas, 1992 accessed at www.bfi.com

[51] Segal Geoffrey F and Moore Adrian T. “Privatising Landfills: Market Solutions for Solid-waste Disposal” Reason Public Policy Institute. Policy Study Number 267, May 2000 accessed at http://www.rppi.org/privatisation/ps267.html

output. They then determine the lowest cost at which the desired output can be produced. This focus results in constant efforts to reduce costs.

The system of government-ownership cum private-operation will split the purchaser-provider functions. This way, policy and regulatory functions are separated from service delivery. Economist Charles Van Eaton notes "splitting policy functions from service delivery creates incentives for governments to become more discriminating consumers by also looking beyond government monopoly providers to a wide range of public and private providers." As government managers "shop around" for the best "price," the process focus and its attendant cost-plus consequences will be minimised.

- **Improved Accountability**
  Opponents of privatisation often fear loss of control or regulatory authority. However, these concerns can be addressed through contract provisions. The governments can set service standards and award contracts only to those producers that meet established goals. This way, governments, through the contractor-selection process, can "steer rather than row". Contractual power can enhance control in another important way. Through explicit and measurable performance standards tied to contractor payments, government managers can hold private providers accountable for their performance. If private firms fail to meet the standards, they can lose revenues or, ultimately, the contract. Such performance-based contracts in competitive markets give governments more control over a contractor than they may have over internal operations and employees. This system is, however, not foolproof. Contracts can result in poor outcomes if they are not structured well and here the government officials have a role. They must ensure that from the writing of the request for qualifications to the monitoring of performance, the contract incorporates best practices.

- **Enhanced Capital Availability and Superior Cost Savings**
  Another factor that makes this system desirable is the fact that the private sector, unlike the public sector, has access to capital.

  It has been empirically observed and verified that large disposal sites cost relatively less. Not only that, with large landfills multiple customers can be served. For these reasons, the construction of large landfills is preferable. However, these large landfills require huge up-front capital. Large capital investment is also needed for research and development and technical training. Similarly, expansion or closure of a facility or construction of a new one requires capital, new operations and new technologies.

  Such a great amount of capital is not available to local governments. It is therefore extremely difficult for local governments to construct mega landfills. They also have no incentive to innovate or indulge in R&D. Private firms, on the other hand, can easily borrow against future earnings and construct mega landfills. They also have the incentive for spending on R&D and undertaking effective innovations that bring immediate gains. This way the private sector through its capital availability will be able to provide safer and more-efficient landfills without causing any risk to taxpayers.

- **Unambiguous Allocation of Risk and Liability**
  Another factor in favor of this system is that through privatisation operational, environmental, and capital risks can be shifted to the private firm and other liabilities can be entrusted with the government. The operators of landfills can be asked to provide financial assurances to demonstrate that adequate funds will be readily available for meeting the costs of closure, post-closure care, and corrective action for environmental violations. There are several alternatives that operators can choose from to meet the requirements like Trust Fund, Letter of Credit,

Insurance, Corporate Financial Test, Corporate Guarantee etc. Monetary liability can also be shifted via contractual obligations. If contractors fail to perform, they can be fined and/or the contract can be terminated. But, if, lack of performance leads to environmental hazards or regulatory noncompliance, government officials will be held responsible.

In general, the privatisation of landfills in US is growing. The percentage of facilities owned by the public sector declined from 83% in 1984 to 73% in 1997 and to 64% in 1998. The aforementioned system, in particular, has been implemented by various local governments. About ten percent of the publicly owned landfills are managed or operated by private firms. One such case is the city of Chandler in Arizona. Chandler has only one landfill. The city officials competitively contracted out the operation of this landfill, hoping to extend its life expectancy. They anticipated that a private firm would have more expertise and greater access to innovative techniques. Chandler first entered into a contract with Laidlaw, which in 1996 was purchased by Allied Waste Industries (AWI). AWI has thereafter continued to win re-bids on the contract. The landfill's life expectancy has been extended by 40 percent, affirming the value to the city of the partnership with AWI. AWI realised this objective by initiating a sophisticated compaction system. Greater compaction allowed the intake of more waste and thereby extended the life expectancy of the landfill. Chandler's landfill has a compaction rate of 2,000 pounds per cubic yard as against the waste disposal average of 1,200 to 1,400 pounds per cubic yard. The city achieved this compaction rate by introducing an incentive structure for landfill operations. The compaction rate has led to great cost savings for citizens. The citizens are not supposed to meet the landfill expansion costs and have to pay lower tip fees.[52]

[52] Segal Geoffrey F and Moore Adrian T, "Privatising Landfills: Market Solutions for Solid-waste Disposal"
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