

Overview of Plastic Waste Management



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Chapter – 1: Annual Report (2011-12) on Implementation of PWM

Plastic products have become an integral part in our daily life as a basic need. It produced on a massive scale worldwide and its production crosses the 150 million tonnes per year globally. In India approximately 8 Million tonnes plastic products are consumed every year (2008) which is expected to rise 12 million tones by 2012. Its broad range of application is in packaging films, wrapping materials, shopping and garbage bags, fluid containers, clothing, toys, household and industrial products, and building materials. It is a fact that plastics will never degrade and remains on landscape for several years. The recycled plastics are more harmful to the environment than the virgin products due to mixing of colour, additives, stabilizers, flame retardants etc. Further, the recycling of a virgin plastic material can be done 2-3 time only, because, after every recycling, the strength of plastic material is reduced due to thermal degradation. It is to mention that no authentic estimation is available on total generation of plastic waste in the country however, considering 70% of total plastic consumption is discarded as waste, thus approximately 5.6 million tons per annum (TPA) of plastic waste is generated in country, which is about 15342 tons per day (TPD).

Environmental issues on disposal of Plastic Waste:

Indiscriminate littering of unskilled recycling/reprocessing and non-biodegradability of plastic waste raises the following environmental issues:

- During polymerization process fugitive emissions are released.
- During product manufacturing various types of gases are released.
- Indiscriminate dumping of plastic waste on land makes the land infertile due to its barrier properties.
- Burning of plastics generates toxic emissions such as Carbon Monoxide, Chlorine, Hydrochloric Acid, Dioxin, Furans, Amines, Nitrides, Styrene, Benzene, 1, 3-butadiene, CCl₄, and Acetaldehyde.

- Lead and Cadmium pigments, commonly used in LDPE, HDPE and PP as additives are toxic and are known to leach out.
- Non-recyclable plastic wastes such as multilayer, metalised pouches and other thermoset plastic poses disposal problems.
- Sub-standard plastic carry bags, packaging films (<40 μ) etc. pose problem in collection and recycling.
- Littered plastics give unaesthetic look in the city, choke the drain and may cause flood during monsoon .
- Garbage mixed with plastics interferes in waste processing facilities and also cause problems in landfill operations.
- Recycling industries operating in non-conforming areas are posing threat to environment to unsound recycling practices.

Salient Features of the PWM Rules, 2011:

- (i) The plastic carry bags used for the purpose of carrying or dispensing commodities but don't include these bags which are integral part of packaged products. The thickness of bag shall not be <40 μ ;
- (ii) Carry bags can also be made from compostable plastics conforming IS/ISO:17088:2008;
- (iii) Prescribed Authority for registration, manufacture & recycling shall be State Pollution Control Board (SPCB) or Pollution Control Committee (PCC). And for enforcement of Rules relating to use, collection, segregation, transportation & disposal of plastic waste, shall be concerned Municipal Authority;
- (iv) Multilayered pouches or sachets used for packaging of gutkha etc. shall not use plastic material in any form;
- (v) Every carry bags made from plastic shall bear a label or mark "recycled" as per IS:14534:1998. Each carry bag made from "Compostable Material" shall bear a label "Compostable" & shall conform to IS/ISO:17088:2008;

- (vi) No carry bag shall be made available free of cost by retailers to consumers. The concerned Municipal Authority may be notification determine the minimum price for carry bags in order to encourage re-use so as to minimize plastic waste generation;
- (vii) Each State Government shall for constitute a State Level Advisory (SLA) Body to monitor implementation of Rules. This body shall meet once in a year and may invite experts, if it considers necessary.
- (viii) **The Plastic Waste Management (PWM) shall be as under;**
- (a) recycling, recovery or disposal of plastic waste shall be carried out as per the rules, regulations and standards stipulated by the central government from time to time;
- (b) recycling of plastics shall be carried out in accordance with the Indian Standard IS 14534:1998 titled as Guidelines for Recycling of Plastics, as amended from time to time;
- (c) the Municipal Authority shall be responsible for setting up, operationalisation and co-ordination of the waste management system and for performing the associated functions, namely:- (i) to ensure safe collection, storage, segregation, transportation, processing and disposal of plastic waste; (ii) to ensure that no damage is caused to the environment during this process; (iii) to ensure setting up of collection centres for plastic waste involving manufacturers; (iv) to ensure its channelisation to recyclers; (v) to create awareness among all stakeholders about their responsibilities; (vi) to engage agencies or groups working in waste management including waste pickers, and (vii) to ensure that open burning of plastic waste is not permitted;
- (d) for setting up plastic waste collection centres, the Municipal Authority may ask the manufacturers, either collectively or individually in line with the principle of Extended Producer's Responsibility (EPR) to provide the required finance to establish such collection centre;

- (e) recyclers shall ensure that recycling facilities are in accordance with the Indian Standard: IS 14534:194 titled as Guidelines for Recycling of Plastics and in compliance with the rules under the Environment (Protection) Ad, 1986, as amended from time to time;
- (f) the concerned Municipal Authority shall ensure that the residues generated from recycling processes are disposed of in compliance with Schedule II (Management of Municipal Solid Wastes) and Schedule III (Specifications for Landfill Sites) of the Municipal Solid Wastes (Management and Handling) Rules, 2000 made under the Environment (Protection) Act, 1986, as amended from time to time;
- (g) the Municipal Authority shall incorporate the said rules in the Municipal Bye- laws of all the Urban Local Bodies;
- (h) the Municipal Authority shall encourage the use of plastic waste by adopting suitable technology such as in Road Construction, Co-incineration etc. The Municipal Authority or the operator intending to use such technology shall ensure the compliance with the prescribed standards including pollution norms prescribed by the Competent Authority in this regard.
- (ix) Each SPCB or PCC shall prepare and submit Annual Report to CPCB by **30th day of September** each year. The Central Pollution Control Board (CPCB) shall consolidate the report on use of plastic carry bags, sachets/pouches etc. and management of plastic waste. The consolidated report alongwith recommendations on implementation of the Plastic Waste (Management & Handling) (Amendment) Rules, 2011 will be submitted to MoEF by **30th Day of December**.

Observations:

There is no prescribed format in the PWM (Amendment) Rules, 2011 for preparation of Annual Report, hence, a format was developed and sent to all SPCBs/PCCs, asking them to provide requisite information in the prescribed format for preparation of Annual Report.

Out of 34 SPCB/PCCs, only 20 SPCBs/PCCs have provided the requisite information, however, the remaining 14 SPCBs/PCC have not yet submitted any such information on implementation of the PWM Rules, 2011 for unknown regions. However, out of 20 SPCBs/PCCs, some States/UTs have not given complete information as per the provisions of the Rules, therefore, the implementation status of these Boards namely Andhra Pradesh, Chhattisgarh, Goa, Gujarat, Himachal Pradesh, Karnataka, U.P., Delhi, Puducherry etc. is incomplete. Further, based on available information as well as random inspections carried by CPCB team in reference of Hon'ble Supreme Court Compliance and matter for 'Committee of Assurance'. The State-wise implementation status of the PWM (Amendment) Rules, 2011 have been prepared and shown at **Annexure-I**. It has been further observed that most of the States & Union Territories have certain doubts about following points which may be one of the cause for not submitting the reports on time.

1. Definition of "Conventional Plastic" and Compostable Plastic or Material;
2. There is no logo or mark given in the Rules for Compostable material/film;
3. Under Rule 4 (a) which agency will execute the Enforcement on '**stock, distribute, use and sale of plastic carry bag or sachets or pouches**';
4. The SPCB/PCCs are not enforcing regulations on "**stock, distribute, use and sale of plastic carry bag or sachets or pouches**";
5. Under Rule 4 (b), the implementation on use of plastic waste (excluding use of plastic carry bag or sachets or pouches) is being implemented by Municipal Authority;
6. Some States like Punjab, Kerala, M.P. etc. are still maintaining thickness of carry bags **<40 μ** , however, as per PWM Rules, 2011, the thickness of carry bags shall not less than **40 μ** . Also some States like Maharashtra and Tamil Nadu has increased thickness 50 μ & 60 μ respectively.

Recommendations :

Disposal of plastic waste is a serious concern in India and such no technology has been validated, however, several experiments have been conducted on reuse of plastic waste in road construction, co-processing of plastic waste in cement kilns. Currently, Worldwide accepted technology used for the plastic disposal is incineration, however, due to poor maintenance of

incinerators, it releases several harmful gases including dioxins and furans in case of chlorinated and brominated plastic waste therefore, raising several environmental issues. In India, for safer disposal of plastic waste, various technologies have been experimented such as Utilization of plastic waste in road construction, Co-processing of Plastic waste in Cement Kilns. The key issues relating to non-implementation of PWM Rules, 2011 are mainly emerged as indiscriminate use of sub-standard plastic carry bags and littering in cities and towns and use of plastic sachets or pouches in packaging of gutkha, tobacco and pan masala .

Listing of key points based on interaction with representative of SPCBs/PCCs and other agencies may be considered for making suitable amendments in the Rule or issue an Office Memorandum for better PWM Rules, 2011 ;

- (i) Definition of Plastic (Petro-based) and Compostable Plastic or Material (Renewable) may be looked in the existing PWM Rules.
- (ii) The monitoring mechanism shall be strengthened so that sub-standard carry bags (<40µ) are not available in the market.
- (iii) Prescribed Authority for enforcement on use of plastic carry bags and sachets & pouches may be mentioned in the existing PWM Rules, 2011.
- (iv) The recommendations of **Biodegradable Committee** (under Director-General CIPET) may be examined by MoEF in the light of thickness and use of compostable plastic or material for food packagings.
- (v) Municipal Authority may be directed to submit Annual Report to SPCBs/PCCs on implementation of PWM Rules, 2011, as the same is not given in the Rules. Accordingly, suitable amendments be made in the Rules.
- (vi) SPCBs/PCCs may be asked to utilize plastic waste in road construction, co-processing of plastic waste in cement kilns, conversion of plastic waste into liquid fuel etc.
- (vii) SPCBs/PCCs should develop laboratory facility for testing of thickness of plastic carry bags and plastic material in the sachets/pouches.

- (viii) The thickness of plastic carry bags shall be uniform, as some States are still allowing to manufacture carry bags <40 μ such as Madhya Pradesh, Kerala etc.
- (ix) All Municipalities may be directed to submit Annual Report to concerned SPCBs/PCCs by **31st August of the year**. Subsequently SPCBs/PCCs may also be directed to submit Annual Report for 2012 by **September, 2012**.

This being the 1st year for submission of Annual Report on implementation of PWM Rules, 2011 therefore, the performance of SPCBs/PCCs in submission of Annual Report for the year 2011-12 is not very satisfactorily. Also it has been reported that, the implementation of various provisions of the Rules during 2011-12 is not adequate because a number of public complaints and RTIs have been received in CPCB in respect of use and sale of sub- standard (thin) plastic carry bags (< 40 μ) in the cities/towns. Besides, it is also been observed that thin carry bags are available with all hawkers, vendors, shopkeepers, open markets etc. in Delhi. Further, violations of Rule 5 (d) and (g) have also been reported from different States and Union Territories including Delhi during random inspections carried out by CPCB team.

**Consolidated Annual Report for the year 2011 on Implementation of Plastic Waste
(Management & Handling) (Amendment) Rules, 2011**

Name of SPCB/PCC	Estimated Plastic Waste generation Tons Per Annum (TPA)	No. of registered Plastic Manufacturing/Recycling (including multilayer, compostable) units. (3)			No. of unregistered Plastic Manufacturing/recycling units. (4)	States/UTs Issued Separate Act/Notification (regarding thickness of carry bags etc)	Action Plan for Plastic Waste Management (PWM) e.g. Collection, segregation, disposal (co-processing & road construction etc).	Partial Ban on usages of Plastic Bags (Through Executive Order)	Complete Ban on use of plastics bags including multilayer sachets on Gutkha etc.	Recommendations of Status of State Level Advisory (SLA) Body (Clause 11)	No. of violations and action taken against manufacturing, stock and use of thin (<40µ) carry bags and sachets etc.	Compliance Status of Rules 5 (d) & 5 (g) of the PWM Rules 2011
		Plastic units	Compostable Plastic units	Multilayer Plastic units								
(1)	(2)				(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Andhra Pradesh	28,888	51	NIL	09	232	Not Avl.	Not Avl.	Not Avl.	Not Avl.	Not Avl.	06	Complying
A & N Island	Information not provided											
Arunachal Pradesh	Not Avl.	No such plastic manufacturing or recycling unit present.			NIL	No	NIL	The use of carry bags have been banned in 6 districts	NIL	SLA constituted	NIL	Satisfactory
Assam	31000	7	NIL	1	15	No	State PWD have been asked to use plastic waste for road	No	NIL	Not constituted	NIL	Complying

							construction etc.					
(1)	(2)	(3)			(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Bihar	Information not provided											
Chhattisgarh	Not Avl.	Not Avl.	Not Avl.	Not Avl.	23	NIL	Commissioner, Urban Admn. & Local Bodies asked to implement	NIL	NIL	Not Avl.	Not Avl.	Complying
Goa	Approx 415.00	25	NIL	NIL	25	Goa Non-Biodegradable Act	Plastic waste will be sent to according Wadi for co-processing	NIL	NIL	Not Avl.	Not Avl.	Complying
Gujarat	Not Available	76	NIL	4	14	NIL	Not Avl.	Not Avl.	In two district such as Kutch & Junagarh	Not Avl.	18 show-cause notices issued & 6 Directions	One unit is violating the provisions of Rule 5 (d) & 5 (g).
Haryana	Information not provided											
Himachal Pradesh	202.67	03	NIL	NIL			Plastic waste is utilized in road construction & co-incineration	Not Avl.	Not Avl.	Not Avl.	Not Avl.	Complying
J & K	Information not provided											

Jharkhand	16691.05	08	NIL	07	01	Yes	Under preparation	Yes	Yes	Yes	21	Board has not received any complaint in this regard
(1)	(2)	(3)			(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Karnataka	Not Avl.	263	NIL	NIL	Not Avl.	Not Avl.	Not Avl.	Not Avl.	Not Avl.	Not Avl.	NIL	Complying
Kerala	109500.00	698	NIL	03	145	NIL	Possibilities explored for utilizing plastic waste in road construction & co-processing	Ban on sale & use of carry bags near Sannidhan am, Nitakkal & Erumeli	Not Avl.	SLA Body is being constituted	NIL	Not Avl
Maharashtra	1045.24	491	NIL	33	NIL	Issued separate notification for increasing carry bags thicknesses to 50µ	MPCB issued directions to 233 local bodies, 23 MCs, 14 A class cities & 202 B&C class cities for preparation of Action Plan	NIL	Carry bags <50µ allowed. Plastic sachets for gutkha, banned	Constitution of SLA body is under formulation	23 directions issued for violating PWM Rules	Usage of plastic pouches & sachet is banned in the State.

M.P.	16196.51	67	NIL	02	34	Yes	Plastic waste is collected by Sarthak, (NGO) at Bhopal & sent to the cement industries for co-incineration.	The use of carry bag is banned in Gwalior	NIL	SLA Body has been constituted	NIL	NIL
Manipur	10	8	NIL	NIL	10	No	SPCB asked State PWD to use plastic waste in road construction	NIL	NIL	SLA body is under formulation.	20	Not Avl.
(1)	(2)	(3)			(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Meghalaya	Not Avl.	Not Avl.	NIL	01	3	Yes	Not Avl.	NIL	Use of plastic carry bags completely banned	Not yet formed	Action taken against one unit which is violating the Rules	Not applicable

Mizoram	Not Avl.	NIL	NIL	NIL	NIL	NIL	Deputy Commissioners issued orders for compliance of Rules	NIL	NIL	SLA Body formed	NIL	Complying
Nagaland	Not Avl.	04	NIL	NIL	01	Yes	NPCB made a road using plastic waste. Also, exploring possibilities for co-processing in cement kilns.	NIL	Use of carry bags banned w.e.f 1.01.2011	Not Avl.	Not Avl.	Complying
(1)	(2)		(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	
Odisha	Not Avl.	18	NIL	NIL	17	NIL	Few Urban Local Bodies are sending their plastic waste to M/s ACC Ltd., Bargarh	In pilgrimage centres use of carry bags have been banned	No such ban imposed except use of plastic material in gutkha pouch or sachets	SLA Body not constituted	One industry has been found manufacturing carry bags <40µ	Not Avl.

Punjab	31000	29	NIL	NIL	291	Yes (For carry bags <30 μ)	NIL	No	No	No	38 Traders, 195 users found violating PWM Rules. Action under the Rules has been initiated against 90 units	Complying
Rajasthan	Information not provided											
Sikkim	Information not provided											
Tamil Nadu	Information not provided											
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)		

Tripura	182.50	NIL	NIL	NIL	Not Avl.	No	State Government Director directed all concerned Departments to implement PWM Rules in their jurisdiction	Yes	Complete ban on use of plastic carry bags	SLA Body is being constituted	NIL	Complying
U.P.	Not Avl.	13	NIL	52	46	No	Not Avl.	Government of UP issued notification on complete ban on use of plastic carry bags within 02 km distance from mid-stream of Ganga River	No	No SLA Body constituted	No carry bags unit violating.. However, closure direction issued to 02 gutkha packaging units for violating the Rules	02 units are not complying the provisions of the Rule 5 (d) & 5 (g).
Delhi	Not Avl.	Not Avl.	Not Avl.	Not Avl.	Not Avl.	Yes	Not Avl.	NIL	Use of plastic carry bags is banned in designated places	Not Avl.	Not Avl.	Complying
Lakshadweep	Information not provided											
Puducherry	Not Avl.	129	NIL	NIL	NIL	Yes. Carry bags < 51 µ not allowed	Plastic waste is being utilized in road construction	Not Avl.	Not Avl.	Not Avl.	Not Avl.	No unit is manufacturing in packing of Gutkha, Pan Masala and Tobacco.
Uttarakhand	Information not provided											

West Bengal	Approx. 550 MT/day	46 units obtained registrations. i) Recycling units -32 ii) Carry bag manufacturing units - 14			i) Recycling units - 378 ii) Carry bag manufacturing unit -116							GoWB banning the use of plastic as packaging material for Gutkha, Tobacco, Pan Masala etc.
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	
Chandigarh	5548.0	NIL	NIL	NIL	Manufacturing of carry bags banned	Yes	Not Avl.	Use, sale and manufacturing of plastic carry bags banned	Use, sale and manufacturing of plastic carry bags banned	No SLA Body constituted	No violations reported	Not Avl.
Daman, Diu & Dadra Nagar Haveli	Information not provided											

(Updated on 08.05.2013)

- Abbreviations : i) SLA = State Level Advisory
ii) Not Avl. = SPCBs/PCCs not submitted information
iii) NIL = Information is Zero

Chapter – 2: Indicative Guideline for Plastic Waste Management (PWM)

Introduction:

Plastics are non-biodegradable, synthetic polymers derived primarily from petro-fossil feedstock and made-up of long chain hydrocarbons with additives and can be moulded into finished products excluding compostable plastic or polymer confirming IS/ISO 17088:2008. These polymers are broken in presence of suitable catalyst, into monomers such as ethylene, propylene, vinyl, styrene and benzene. These monomers are then chemically polymerized into different categories of plastics.








Categories of plastics

The main category of plastics include ;

A. Recyclable Plastics (Thermoplastics): PET, HDPE, LDPE, PP, PVC, PS, etc.

B. Non-Recyclable Plastics (Thermoset & others): Multilayer & Laminated Plastics, PUF, Bakelite, Polycarbonate, Melamine, Nylon etc.

1) As per BIS Codification as notified in Rule 8 (b) of the Plastic Waste (Management and Handling) (Amendment) Rules, 2011, there are seven categories of plastics:

Symbol	Short Name	Scientific Name	Used In
	PET	Polyethylene Terephthalate	Water bottles, PET Bottles , etc.
	HDPE	High Density Polyethylene	Milk/detergent Bags, Carry bags, Container etc
	PVC	Polyvinyl Chloride	Cables, Pipes, Floorings etc
	LDPE	Low Density Polyethylene	Carry bags , films
	PP	Polypropylene	Medicine bottles, cereal liners , Packaing films etc
	PS	Polystyrene	Foam Packaing, Tea Cups , ice cream cups, etc
	0	Others	Thermoset plastics, Multilayer & Laminated Plastics, PUF, Bakelite, Polycarbonate, Melamine, Nylon etc.

Note : Others means all other resins and multi-materials like ABS (Acrylonitrile butadiene styrene), PPO (Polyphenylene oxide), PC (Polycarbonate), PBT (Poly butylenes Terephthalate) etc.

Usage of Plastics and Waste:

Plastic products have become an integral part in everybody's daily life. Its production crosses the 150 million tonnes per year globally and in India, approximately 8 Million tonnes plastic products are consumed every year (2008)¹. It has broad range of application in films, wrapping materials, shopping and garbage bags, fluid containers, clothing, toys, household and industrial products, and building materials. Once plastic is discarded after its utility is over, it is known as plastic waste. It is a fact that plastics waste never degrades, and remain on landscape for several years. Mostly, plastic waste are recyclable but, recycled products are more harmful to the environment as thus contains additives and colours . The recycling of a virgin plastic material can be done 2-3 times only, because after every recycling, the plastic material deteriorates due to thermal pressure and its life span is reduced. Hence recycling is not a safer and permanent solution for plastic waste disposal. It is estimated that approximately 70% of plastic packaging products are converted into plastic waste in a short span. Approximately 5.6 million tons per annum (TPA) plastic waste is generated in country, which amounts to 15342 tons per day (TPD)².

¹ CIPET REPORT

² CPCBs ESTIMATION

Issues on disposal of Plastic Waste:

Indiscriminate littering and unorganized recycling/reprocessing and non-biodegradability of plastic waste raises the several environmental issues, these are as under;

- Release of fugitive emissions during polymerization process.
- Release of harmful gases such as Carbon Monoxide, Formaldehyde etc. during product manufacturing.
- Land become infertile due to indiscriminate plastic waste disposal.
- Release of toxic emissions such as Carbon Monoxide, Chlorine, Hydrochloric Acid, Dioxin, Furans, Amines, Nitrides, Styrene, Benzene, 1, 3- butadiene, CCl₄, and Acetaldehyde on burning of plastics waste including polyvinyl chloride (PVC).

- Leaching of toxic metals into underground water such as Lead and Cadmium pigments due to indiscriminate dumping of plastic waste on land.
- Multilayer, metalised pouches and other thermoset plastic pose disposal problems.
- Sub-standard plastic carry bags, thin packaging films etc. pose problem in collection and recycling and reuse.
- Indiscriminate and littered plastic waste pose unaesthetic look and choke the drain.
- Soiled and mixed plastics waste interferes its beneficial utilisation.
- Unsound of plastic waste and running of recycling industries in non-conforming areas releases fugitive emissions.

Technologies for Plastic Waste Management (PWM):

It has been observed that disposal of plastic waste is a serious concern due to improper collection and segregation system. However, a few technologies have been developed to minimize its adverse effect on the environment. Currently Worldwide accepted technology used for the plastic disposal is incineration, though it is not preferred option in India because it releases toxic gases like chlorinated dioxins and furans, raising several environmental issues. CPCB put efforts to consolidate innovative technical options for safer disposal of plastic waste, these are described in the following paragraphs. It is worth to note that before adopting any technology, it is necessary to segregate plastic waste from municipal and others solid waste. The descriptions of technologies are mentioned below;

Utilization of Plastic Waste in Road Construction:

Description of road laying process;

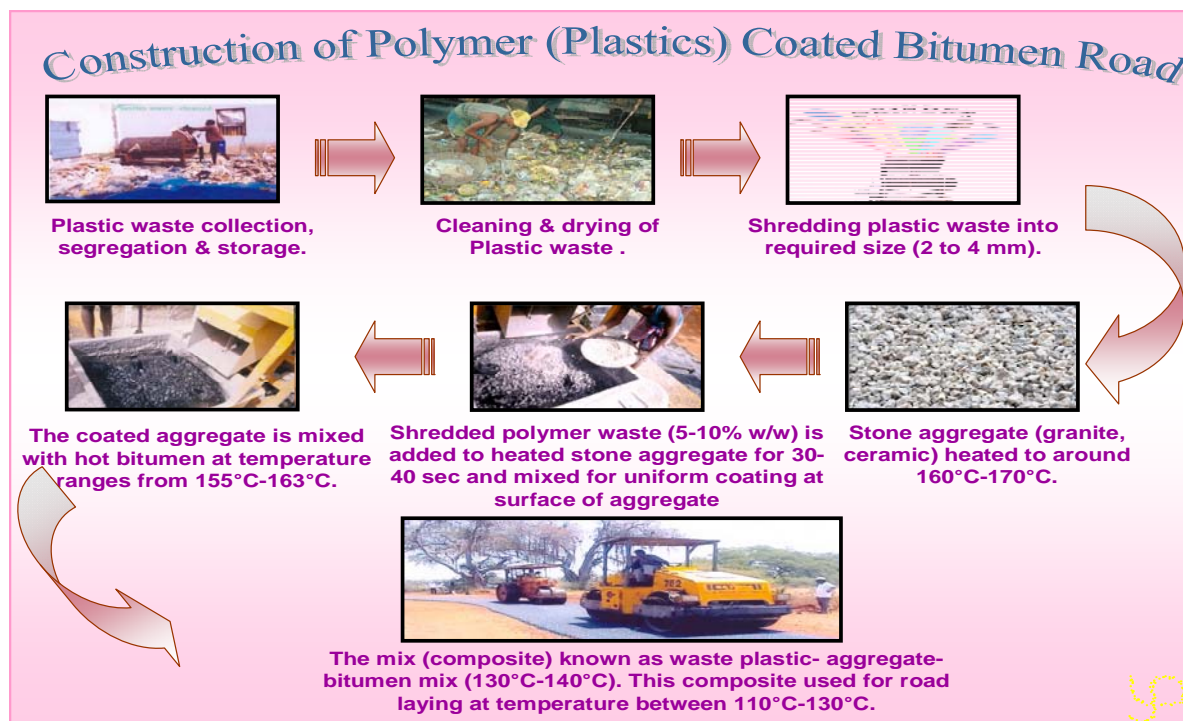
The process of road laying using waste plastics is designed and the technique is being implemented successfully for the construction of flexible roads at various places in India. A brief description of the process mentioned in the **Table 1** below and schematic flow diagram is shown at **Figure 1**.

Table 1 : Protocol for description of road laying process

Sr. No.	Description	Executing Agency
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1.	Collection and segregation of plastic waste (Except chlorinated/brominated plastic waste)	Municipal Corporation, Nagar Nigam, Nagar Parishad & Nagar and Gram Panchayat
2.	Transportation and storage of plastic waste	Municipal Corporation, Nagar Nigam, Nagar Parishad & Nagar and Gram Panchayat
3.	Cleaning and sun drying of plastic waste	Municipal Body or PWD
Sr. No.	Description	Executing Agency
4.	Shredding of plastic waste (2 to 4 MM size)	Municipal Body or PWD
5.	Heating of stone aggregate (160 ^o C -170 ^o C)	Municipal Body or PWD
6.	Adding of shredded plastic waste (5 to 10% w/w for 30 to 40 seconds)	Municipal Body or PWD
7.	Coated aggregate is mixed with hot bitumen (Temp 155 ^o C to 163 ^o C)	Municipal Body or PWD
8.	The mix-plastic aggregate bitumen mix (130-140 ^o C) The mix can be used for road laying	Municipal Body or PWD

Figure 1 : Schematic flow diagram of plastic coated bitumen road construction



Advantages of Polymer-Bitumen Roads:

- **Stripping and pothole formation:** Bitumen film is often stripped off the aggregates because of the penetration of water, which results in pothole formation. This is accelerated during the movement of vehicle. When polymer is coated over aggregate, the coating reduces its affinity for water due to non-wetting nature of the polymer and this resists the penetration of water. Hence the penetration of water is reduced which resists stripping and hence no pothole formation takes place on these roads.
- **Leaching:** Polymer will not leach out of the bitumen layer, even after laying the road using waste plastics-bitumen-aggregate mix.
- **Effect of Bleeding:** Waste polymer-bitumen blend shows higher softening temperature. This increase will reduce the bleeding of bitumen during the summers.
- **Effect of Fly Ash:** Roads made from plastic-bitumen mix inhibits leaching of toxic compounds into soil.

Co-processing of plastic waste as Alternative Fuel and Raw Material (AFR) in cement kilns and power plants:

Co-processing refers to the use of waste materials in industry process such as cement and power stations or any other large combustion plants. Co-processing indicate substitution of primary fuel and raw material by waste, recovering industry and material from waste. Waste material such as plastic waste used for co-processing are referred to as alternative fuels and raw material (AFR). Co-processing of plastic waste offers advantages for cement industry as well as for the Municipal Authorities responsible for waste management. In other hand, cement producers or power plants can save fossil fuel and raw material consumption, contributing more eco-efficient production. In addition, one of the advantage recovery method used in existing facility, eliminating the need to invest on other plastic waste practices and to secure land filling. The schematic flow diagram of the

process is shown at **Figure 2** and Protocol for Co-processing of plastic waste is given at **Table 2** **Figure 2 : Schematic flow diagram of Co-processing of plastic waste in cement kilns**

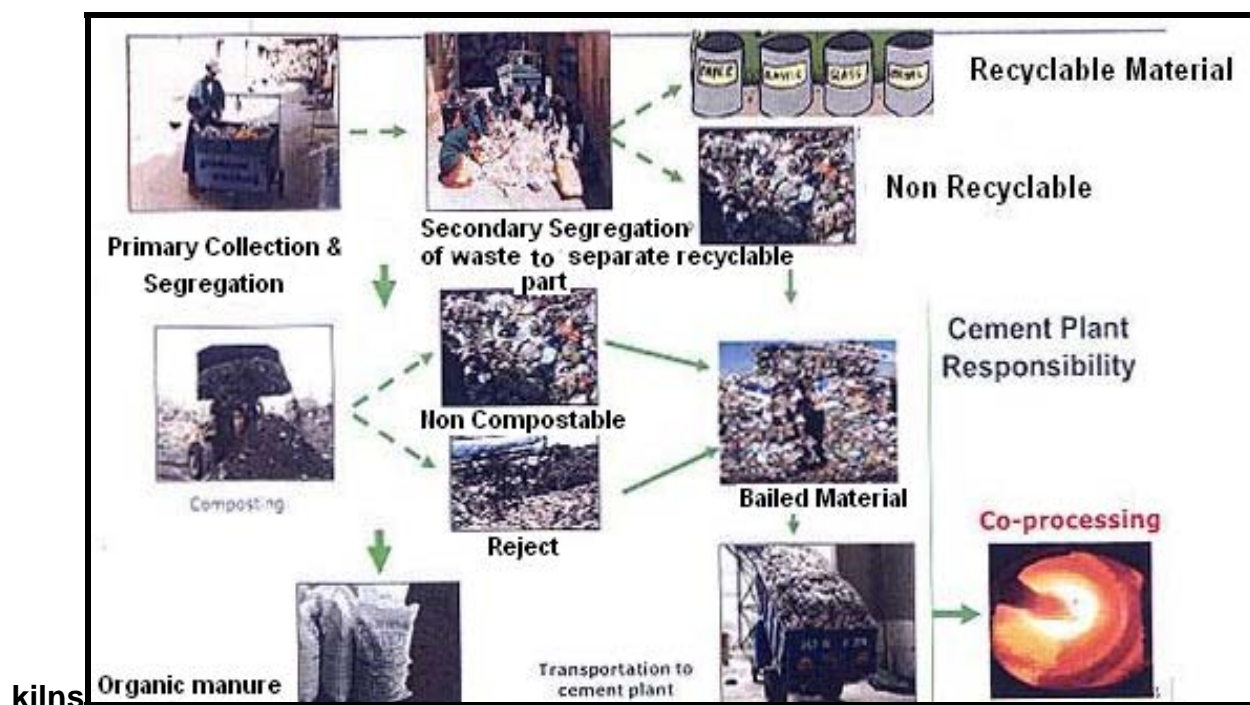


Table 2 : Protocol for Co-processing of plastics waste

Sr. No.	Item	Description	Action to be taken by
1	Collection of plastic waste	Concerned Municipal Authority should create a system for collection of plastics waste from Dustbins/Dhallaos through Public Private Partnership (PPP) mode on any other feasible method.	Municipal Corporation, Nagar Nigam, Nagar Parishad & Cantonment Boards
2	Segregation & Pre-processing of plastics waste	Collected plastics can be reprocessed/sorted for recyclable and non-recyclable. The Non-recyclable plastics waste will be transported to nearest cement kilns and power plant for co-processing by concerned Municipal Authority in consultation with concerned State Pollution Control Board (SPCB)/ Pollution Control Committee (PCC).	Municipal Corporation, Nagar Nigam, Nagar Parishad & Cantonment Boards
3	Identification of cement factory	Mapping of cement kilns and power plant for accepting co-processing of plastic waste in same State or neighboring State. An agreement shall be signed between Municipal Corporations and Cement kilns.	State Pollution Control Boards & Pollution Control

			Committees and Municipal Bodies
4	Modification for feeding plastic waste (PW) in cement kilns	Cement Industry/power plant to set-up storage facility, shredder, conveyor-belt, one hopper, one winch-machine and one double-flap damper.	Concerned Cement Industries/ power plant
5	Setting-up of laboratory for plastics waste analysis	Cement industry/power plant shall set-up a minimum lab facility to analyse plastics waste before sending for co-processing. The instrumentation include Thermo-Gravimetric Analyser, Bomb-Calorimeter and C, H, N & S Analyser.	Concerned Cement Industries/ power plant
6	Monitoring of emission by cement industry/ SPCBs	Cement Industry/power plant shall monitor the stack emission in respect of routine parameters and hazardous air pollutants (HAPs)	Concerned Cement Industry , Power Plant and SPCBs/PCCs
7	Forwarding progress Report to CPCB	Forwarding quarterly progress report of Co-processing of plastic waste to CPCB.	SPCBs/PCCs and Cement Industries/ Power Plant

Conversion of plastic waste into liquid RDF (Oil) :

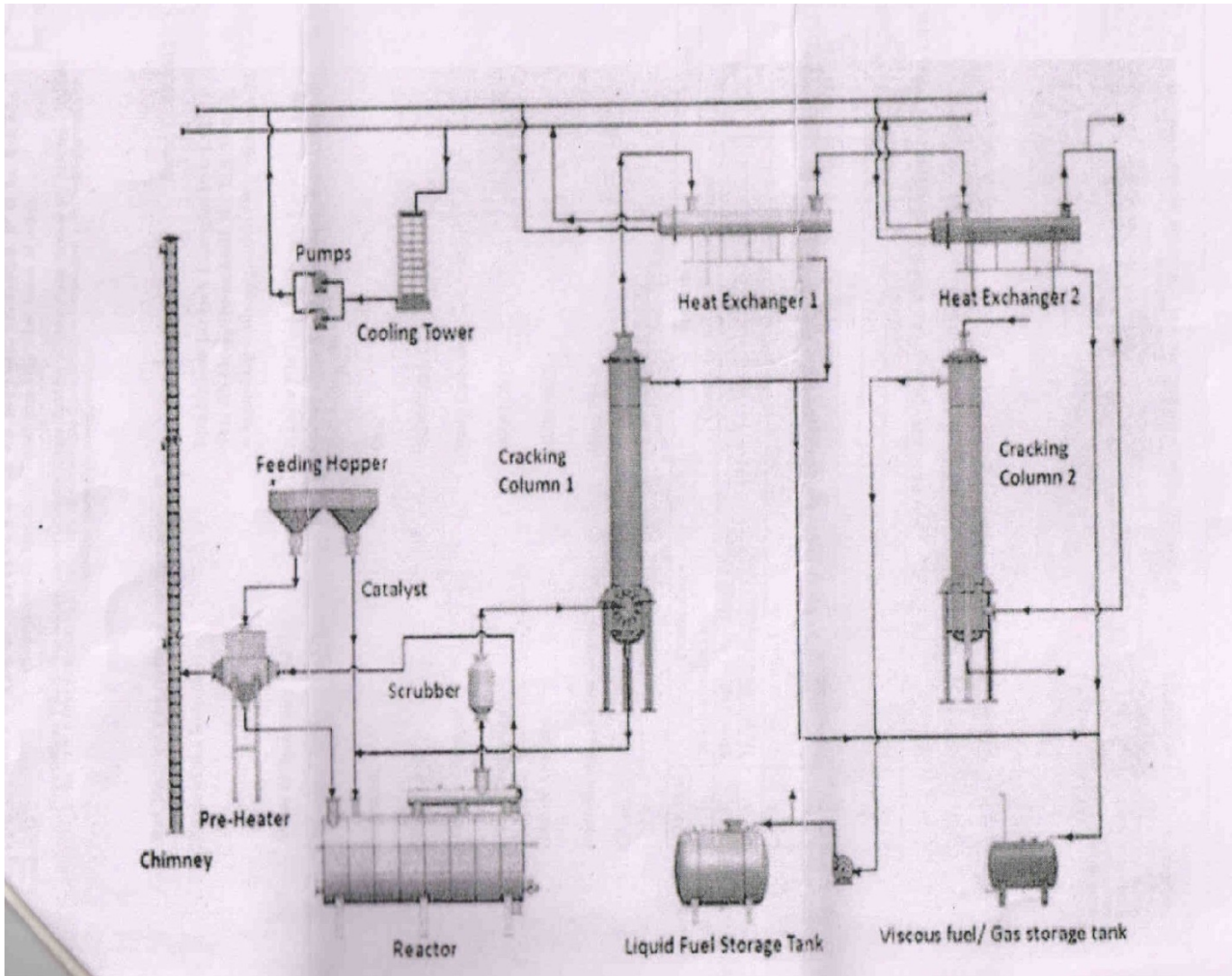
Firstly, plastic waste is segregated mechanically from municipal solid waste (MSW). This method is not full-proof, as alongwith plastic waste, other lighter material is also segregated. Therefore, the segregated plastic waste is again sent through conveyor belt fixed with optical segregation device for 100% source segregation of plastic waste. Then, the mixed plastic waste is converted into the more useable i.e. Liquid RDF through catalytic pyrolysis. The process is termed random De-polymerization as the degradation of bonds to break down into monomers occurs randomly. This process is utilized for the degradation of plastic to lower hydrocarbons. The random De-polymerization is carried out in a specially designed Reactor, in absence of oxygen and in the presence of certain catalytic additives. The maximum reaction temperature is 350°C. The entire feed material is converted into either of the products: Liquid RDF, gases and some sludge. There is no effluent generated in the process and the unused hot Air from the reactor is released through chimney. Steps involved in conversion of plastic waste into liquid fuel RDF (Fuel)

are given below :

- Mechanical segregation of plastic waste from mixed MSW dumpyard/storage;
- Transportation of segregated plastic waste through conveyor belt for optical segregation;
- Optical segregation of plastic waste (only HD, LD, PP and multilayer packagings except PVC);
- Shredding of plastic waste and dislodging dust and impurities;
- Transportation of segregated (100% plastic waste) into feeding hopper (reactor);
- Feeding of plastic waste into reactor for random depolymerization in presence of additives;
- Collection of liquid RDF (Fuel);
- Collection of rejects and solid waste (charcoal).

The schematic flow diagram is shown at **Figure 3** and process flow diagram is shown at **Annexure-II**.

Figure 3 : Schematic flow-diagram of conversion of plastic waste into liquid fuel (RDF)



Observations : The quantity of plastic waste from MSW is approximately 4% and varies depending on plastic waste content (quantity and concentration) in MSW sample. The catalyst is added whereby the pyrolysis requires less energy and results in the formation of more branched hydrocarbons. The products of the process include products in solid (Sludge), liquid RDF (Oil) and Gaseous State. The gas generated in the process is reused as fuel in the process thus making the process economically viable and also help in minimising air pollution. The Oil (liquid RDF) has properties similar to LDO and can be safely used as an alternative to LDO in industries thus conserving the already depleting natural resources. The by-products from the process like sludge and gas can be reused. The sludge can be reused as fuel in cement industries while the gas is reused in the system as a fuel.

Plasma Pyrolysis Technology (PPT)

Plasma Pyrolysis is a state of the art technology, which integrates the thermo-chemical properties of plasma with the pyrolysis process. The intense and versatile heat generation capabilities of Plasma Pyrolysis technology enable it to dispose of all types of plastic waste including polymeric, biomedical and hazardous waste in a safe and reliable manner. Pyrolysis is the thermal disintegration of carbonaceous material in oxygen-starved atmosphere. When optimized, the most likely compounds formed are methane, carbon monoxide, hydrogen carbon dioxide and water molecules. In Plasma Pyrolysis, firstly the plastics waste is fed into the primary chamber at 850⁰ C through a feeder. The waste material dissociates into carbon monoxide, hydrogen, methane, higher hydrocarbons etc. Induced draft fan drains the pyrolysis gases as well as plastics waste into the secondary chamber where these gases are combusted in the presence of excess air. The inflammable gases are ignited with high voltage spark. The secondary chamber temperature is maintained at 1050⁰ C. The hydrocarbon, CO and hydrogen are combusted into safe carbon dioxide and water. The process conditions are maintained such that it eliminates the possibility of formation of toxic dioxins and furans molecules (in case of chlorinated waste). The conversion of organic waste into non toxic gases (CO₂, H₂O) is more than 99%. The extreme conditions of plasma kill stable bacteria such as bacillus stereo-thermophilus and bacillus subtilis immediately. Segregation of the waste is not necessary, as the very high temperatures ensure treatment of all types of waste without discrimination.

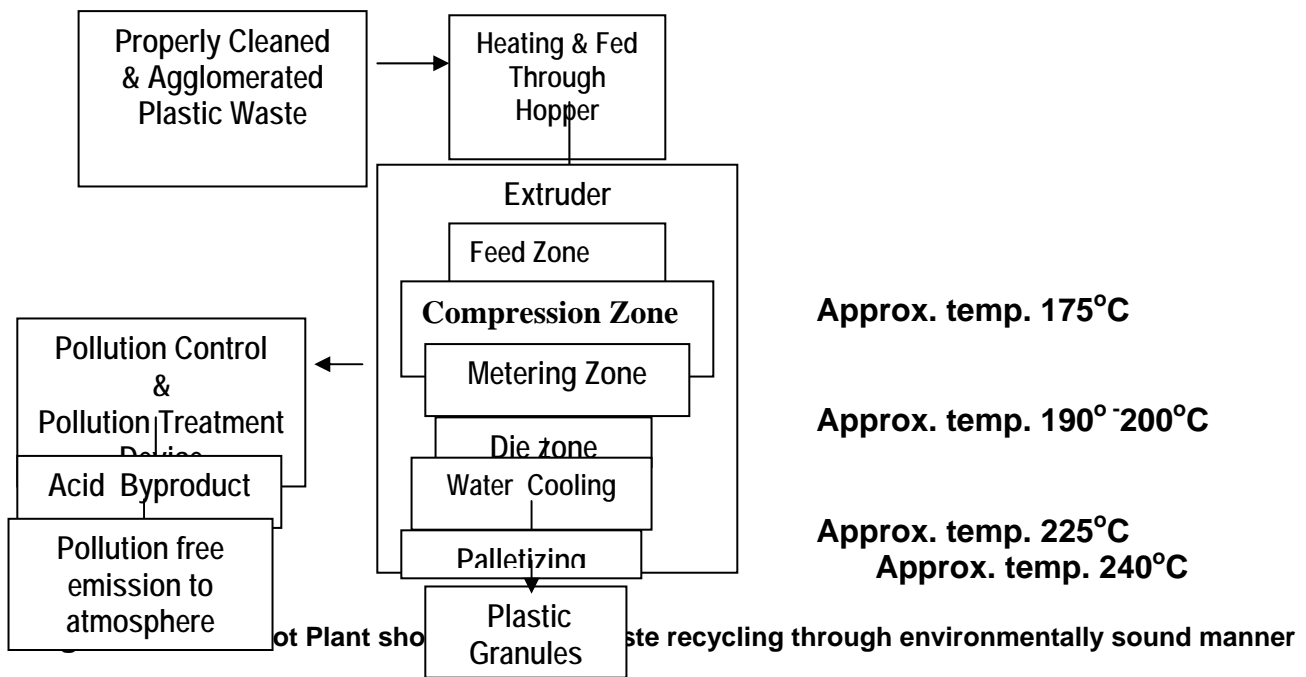
Environment Related Observations

Stack emission monitoring of different categories plastic waste such as (i) 100% Polyethylene Waste (ii) 80% Polyethylene + 20% PVC Waste was carried out by VIMTA Lab. It has been observed that the emission of toxic pollutants such as dioxins and furans from the plasma pyrolysis system developed by FCIPT is lower than the norms set for incinerator.

Recycling of plastics through environmentally sound manner:

The main goal for developing green recycling of waste plastic was to design an extruder, which would have “Zero Significant Adverse Environmental Impact”. This has been achieved by assigning right motor of minimum capacity, selecting optimum L/D ratio, heat sealing and right temperature for the processes and trapping all the emission in pollution control gadget and treating the pollutants to produce byproducts. The extrusion & palletization processes have been redesigned to make the pollution from the process to a minimum level and as a result to enhance the efficiency of the process (Figure: 4). The details of process Flow Chart is given below :

Process Flow-Chart of the “Green Recycling Process” – The Pilot Plant



Action Plan for PWM :

A time-bound action points as per the provisions of Rule 6 of Plastic Waste (Management & Handling) (Amendment) Rules. 2011 is mentioned at Table : 3 below :-

Table 3 : Time Bound Action Plan for PWM

Sr. No.	Action Points	Time Required	Infrastructure Requirement	Implementing Authority
1.	Setting-up of plastic waste system such as Safe, collection, storage, segregation	As soon as possible	Establishment of separate bin	Concerned Municipal Authority such as Municipal Cooperation, Municipal Council, Nagar or Gram Panchayat
2.	Safe, collection, storage, segregation	Immediate	Segregation of plastic waste from Municipal Solid Waste (MSW)	Concerned Municipal Authority such as Municipal Cooperation, Municipal Council, Nagar or Gram Panchayat
3.	Transportation, processing and disposal of plastic waste	Immediate	Transportation of segregated plastic waste to disposal site	Concerned Municipal Authority such as Municipal Cooperation, Municipal Council, Nagar or Gram Panchayat
4.	Create awareness among all stakeholders about their responsibilities including house holders or owners or occupiers	Immediate	<ul style="list-style-type: none">• Mobile vans• Newspapers ads• Television• FM Radio	Concerned Municipal Authority such as Municipal Cooperation, Municipal Council, Nagar or Gram Panchayat
5.	Engage agencies or groups working in waste management	As soon as possible	Visiting to successful waste management sites such as Kanpur, Gwalior, Surat, Rajkot etc.	Concerned Municipal Authority such as Municipal Cooperation, Municipal Council, Nagar or Gram Panchayat
6.	Ensure that open burning of plastic waste is not permitted	Immediate	Constitution of Vigilance Squad	Concerned Municipal Authority such as Municipal Cooperation, Municipal Council, Nagar or Gram Panchayat

Process flow diagram for production of Liquid RDF from waste plastic

