Toxics Link
for a toxics-free world

IPEN
for a toxics-free future

Refuse-Derived Fuel in India

About Toxics Link

Toxics Link is an Indian environmental research and advocacy organisation set up in 1996, engaged in disseminating information to help strengthen the campaign against toxics pollution, provide cleaner alternatives and bring together groups and people affected by these problems. Toxics Link has a unique expertise in areas of hazardous, plastic, medical and municipal wastes, international waste trade, and emerging issues of pesticides, Persistent Organic Pollutants (POPs), hazardous heavy metal contamination, etc. We have successfully implemented various best practices and have contributed to policy changes in the aforementioned areas apart from creating awareness among several stakeholder groups.

Toxics Link's Mission Statement - "Working together for environmental justice and freedom from toxics, we have taken upon ourselves to collect and share both information about the sources and the dangers of poisons in our environment and bodies, and information about clean and sustainable alternatives."

About IPEN

International Pollutants Elimination Network (IPEN) was founded in 1998 and registered in Sweden as a non-profit. It is a global network dedicated to creating a healthier world free from the harm of toxic chemicals. Comprising over 600 public interest NGOs in more than 120 countries, primarily in low- and middle-income nations, IPEN works to strengthen chemicals and waste policies, contribute to research, and foster a movement for a toxics-free future.

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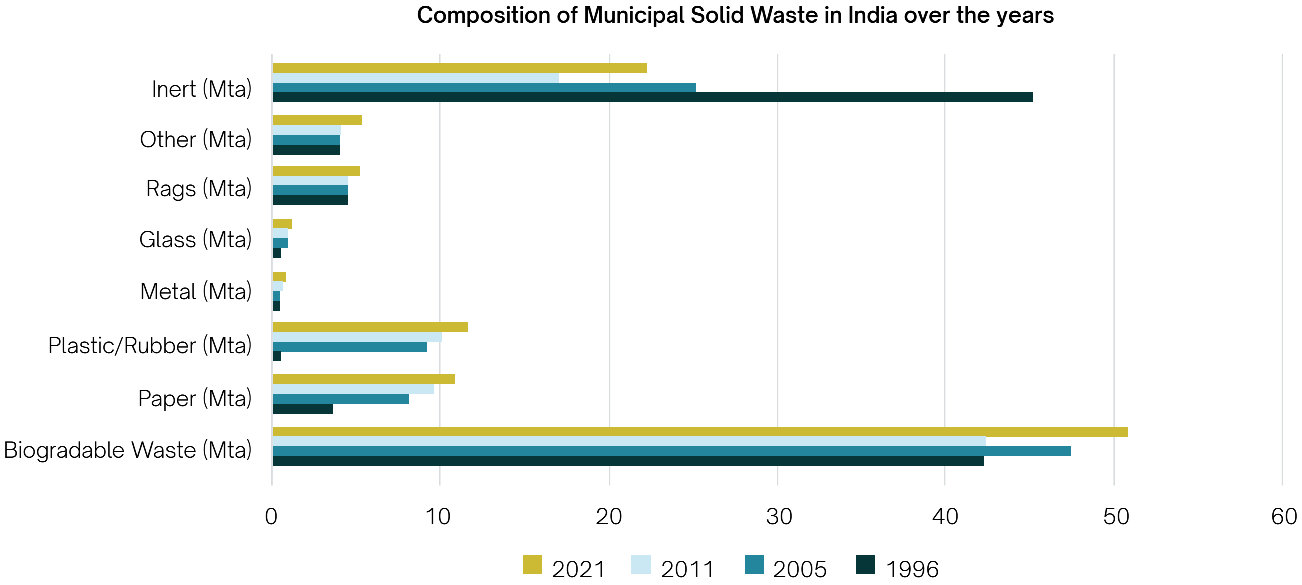
INTRODUCTION

Municipal Solid Waste (MSW) disposal is a major global issue, with over 2.1 billion tonnes generated each year. Only 16% of this waste is recycled, and 46% is disposed of unsustainably. By 2050, this amount is expected to rise to 3.4 billion tonnes[1]. Globally, plastics make up about 10-20% of MSW, and this percentage is steadily rising. This could be due to an increase in individual purchasing power, resulting in more plastic entering the supply chain. This surge contributes to climate change through emissions from production, incineration, decomposition, and transportation. India faces similar challenges with MSW. However, the composition of MSW in India has changed, as shown in figure 1, highlighting a massive 11% increase in the share of plastics since 1996. The major roadblock in plastic waste management is the prevalence of non-recyclable plastics, which originate from various sources. This is evident, as approximately 2.5 million tonnes of non-recyclable plastic waste are dumped in landfills annually. Key concerns arising from this situation include improper and inadequate waste management, resource conservation, and environmental pollution. To address these issues, MSW-based Refuse-Derived Fuel (RDF) has been identified as a promising alternative for co-processing with coal by government and industries, potentially reducing reliance on fossil fuels and mitigating waste problems.

Figure 1: Composition of municipal solid waste in India



Source: Planning Commission, 2014; CPCB, 2022; and MoHUA; 2022

In India, RDF is defined as a fuel produced from various types of waste, primarily MSW. The first official mention of RDF in India can be traced back to the Municipal Solid Waste (Management and Handling) Rules that came into force in 2000. The term "refuse-derived fuel" refers to fuel made from processed waste, which can be either loose or palletised and co-fired with other fuels like coal or burned alone[2]. In October 2017, the Union Ministry of Housing and Urban Affairs (MoHUA) established an Expert Committee to explore the potential of using MSW-based RDF[3&4]. The Government of India, cement industries, and various stakeholders are working to increase the use of RDF due to its perceived benefits in waste management, energy recovery, cost-effectiveness, reduced carbon emissions, resource conservation, and alignment with sustainability goals.

Despite these claims, the use of RDF remains controversial. Although it is marketed as a greener and safer fuel alternative, many environmental organisations[5] have raised concerns about its trade practices and potential health and environmental impacts. This highlights the urgent need for comprehensive waste management strategies that tackle both local and global environmental issues. This report aims to evaluate the current standards and government policies related to the use of RDF across India. It assesses health and environmental risks associated with RDF, analyses the dynamics of RDF imports and exports, and raises awareness about the critical issues surrounding its implementation.

The composition of municipal solid waste (MSW) in India has shifted (See Figure 1), reflecting a significant 11% increase in the proportion of plastics since 1996.

Objectives

The main objectives of the study are:

Assess RDF Import and Export Scale: Research databases and industry news to determine RDF import/export volumes and countries of origin.

Investigate Government Policy on RDF: Examine RDF approval status, classification, carbon credit eligibility, and national standards for RDF content.

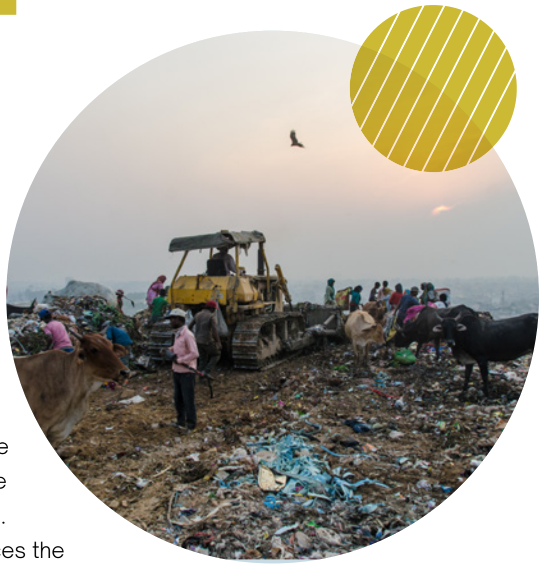
Identify RDF Utilisation Facilities: Determine types of facilities using RDF (cement kilns, incinerators, etc.).

Research and Map Domestic RDF Production: Investigate plans for domestic RDF production and use. Create a map of RDF-burning facilities and production sites.

Interview Industry Stakeholders: Interview cement kiln operators to find out RDF usage percentage and annual consumption.

Review Government Policies and Future Plans: Assess government initiatives to promote RDF production and usage.

NAVIGATING RDF PRODUCTION IN INDIA



The production principle of RDF involves recovering valuable fuel fractions from waste by removing recyclable materials such as metal and glass, and transforming the raw waste into a more uniform and higher-calorific fuel compared to raw MSW.[6]

MSW is collected by safai karamcharis of municipal bodies or authorised waste collectors/pickers and then segregated (refer table 1). After the recyclable and hazardous waste, such as biomedical waste, electronic scrap, explosives, etc. are removed from the initial batch, the remaining waste is sent for co-processing. These wastes undergo a shredding process, where they are crushed into smaller pieces, typically ranging from 2 to 4 mm in size. After shredding, the waste is dried to reduce moisture content, which enhances the efficiency of the final product. Following the drying process and thorough removal of unnecessary materials, the waste is densified into small pellets for easy transportation and application. Quality tests are then conducted to ensure that the RDF meets established guidelines and standards as per the relevant norms (which will be discussed in detail in the next section) as illustrated in figure 2.

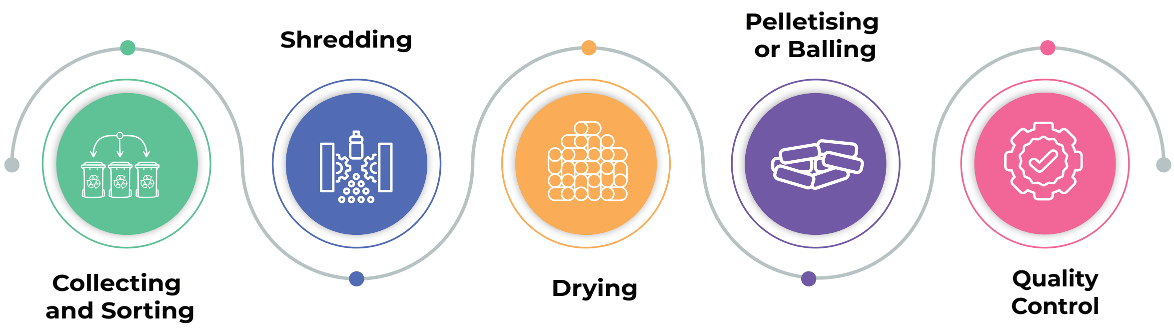


Figure 2: Key steps in manufacturing process of RDF

The following table outlines the key activities involved in managing plastic waste, along with the agencies responsible for each activity. A structured approach ensures effective collection, segregation, and utilisation of plastic waste, for environmental sustainability.

Table 1: Responsibilities for Plastic Waste Management Activities[7]

S. No	Activity	Responsible Agencies
1	Door-to-door collection and segregation of all categories of plastic waste.	Safai Karamchari (Municipal Staff) or Authorised Waste Collector/Picker
2	Collection of littered/dumped plastic waste from public places (e.g., market areas, bus stands).	Safai Karamchari (Municipal Staff) or Authorised Waste Collector/Picker
3	Storage of collected plastic waste from households and other places in a covered yard authorised by Municipal Authority.	Municipal Staff or Authorised Agency or NGO
4	Segregation of stored plastic waste and shredding those into 2-4 mm size using a shredder.	Municipal Staff or Authorised Agency or NGO
5	Storage of shredded plastic waste in bags and utilisation in various technologies:	Municipal Staff or Authorised Agency or NGO
	I) Construction of bituminous roads via hot mix plant (IRC Code SP 98:2013).	
	II) Conversion of plastic waste into liquid fuel (As per CPCB's website).	
	III) Transport to nearest cement kilns for co-processing (As per CPCB's website on Plastic Waste Management).	

These co-processed RDF is further utilised in key sectors and is claimed to address both energy needs and waste management challenges. The sectors listed below have integrated RDF into their operations to support India's broader waste-to-energy initiatives:

Cement industry: RDF is commonly used as a substitute for coal in cement kilns. It is claimed to reduce carbon footprint of cement production and help promote sustainable development[8].

Waste to energy plant (WtE): RDF is used for electricity generation to reduce reliance on fossil fuels and promote sustainable development[9].

Other industries: RDF can be used as a fuel source in various other industries such as iron, steel, pulp and paper[10].

The major sectors benefitting from RDF are cement and waste to energy plants (WTE), with the cement industries being the largest consumer, where it can replace up to 10-15% of conventional fuels like coal[11]. Other sectors also utilise RDF, but the cement industry remains the predominant user due to its high thermal energy requirements and the suitability of RDF for co-processing in kilns.

As MSW serves as a precursor in RDF manufacturing, the production of RDF is heavily reliant on the amount of MSW generated. With India producing approximately 68.8 million tonnes of MSW annually, the country has the potential to generate about 48,254 tonnes of RDF per day. However, despite this capacity, the actual production of RDF remains modest in comparison to the total waste generated. The actual production is approximately 2,000 to 3,000 tonnes of RDF daily, with more than 30 dedicated RDF plants operating across major states such as Maharashtra, Karnataka, Tamil Nadu, and Delhi[12].

The growth in RDF production is driven by increasing waste management needs and supportive government policies, including the Solid Waste Management Rules (2016), which promote WTE technologies[13]. Despite this progress, challenges such as ensuring consistent quality, developing necessary infrastructure and making it more environmentally sound, remain. With continued investment and policy support by the government of India, RDF production in India is expected to grow.

POLICY FRAMEWORK AND SPECIFICATIONS FOR RDF IN INDIA

The first official mention of RDF in India can be traced back to the **Municipal Solid Waste (Management and Handling) Rules 2000** framed under Environment Protection Act, 1986[14].

Guidelines on Co_2 processing in Cement/Power/Steel Industry (2010)[15]:

The guidelines issued in 2010 were foundational, promoting co-processing in cement, power and steel industries. The focus was on using non-recyclable and non-hazardous waste, setting the stage for later developments.

CPCB Report (2015)[16]:

The CPCB's report in 2015 assessed the status of co-incineration of hazardous waste in cement kilns in the Central Zone, highlighting its implementation and identifying the challenges. It was to evaluate the progress made since the 2010 guidelines were issued and thus inform future regulations.

Solid Waste Management Rules (2016)[17]:

The **Solid Waste Management (SWM)** Rules, 2016, released by the **MoEFCC**, Government of India, defined co-processing within a broader regulatory framework. By incorporating co-processing into the SWM Rules, the government aimed to formalise and enhance the existing guidelines, ensuring better compliance and standardisation.

The SWM Rules, 2016 defined co-processing and outlined the following key aspects:

- Local authorities and Panchayats are tasked with utilising WtE processes, including RDF, either as fuel for power plants or cement kilns.
- Non-recyclable waste with a calorific value of 1,500 Kcal/kg or more must be used for energy generation or RDF production rather than being land filled. High-calorific waste should be used in cement or thermal power plants.
- Industrial units within 100 km of RDF and WtE plants must replace at least 5% of their fuel with RDF within six months of the rule's notification.

Subsequently, **The Hazardous and Other Wastes (Management and Transboundary Movement) Rules were released in 2016[18]** giving preference to co-processing over disposal for waste recovery or as a supplementary resource, while the SWM Rules, 2016 primarily addresses the management of municipal solid waste, including segregation, collection and disposal. Additionally, the H&OW Rules include provisions for co-processing hazardous waste in industries, which are not covered in the SWM Rules.

Guidelines for Co-Processing of RDF in Cement Plants (CPCB, 2017)

After the implementation of SWM Rules, 2016, CPCB released a draft in 2017[19] for the co-processing of hazardous wastes in cement plants. The draft provided guidelines on various aspects such as material exempted from use, operating conditions, monitoring requirements, etc.

Waste exempted from use: CPCB has specified that biomedical waste, asbestos-containing waste, electronic scrap, entire batteries, explosives, corrosives, mineral acid wastes, radioactive wastes and unsorted municipal garbage should not be used for co-processing in RDF production.

Operating Conditions: Co-processing plants must achieve temperatures of 950°C for standard waste and 1100°C for hazardous waste with over 1% halogenated substances, using automatic systems to prevent waste feed if temperatures are not maintained.

Air Pollution Control: Emission standards must be met during co-processing, including limits on particulate matter and other pollutants like HCl, SO_2, and dioxins, ensuring emissions do not exceed baseline levels established during trial runs.

Monitoring Requirements: Continuous measurement of particulate matter emissions is required, with data submitted to the CPCB and relevant State Pollution Control Boards (SPCBs). Monitoring for dioxins and furans is also mandated.

Application Procedure: Proponents must submit a trial run application to the SPCB, with CPCB approval required for utilising hazardous waste. The SPCB grants permission for trial runs within 60 days, and CPCB can provide recommendations or objections within 30 days.

Regular Permission: After successful trial runs, proponents can apply for regular co-processing permission. Once granted, other cement plants can skip trial runs and directly apply for permission through the SPCB, with CPCB processing applications within 45 days.

An expert committee was constituted by the MoHUA, which issued the guidelines in 2018[20] on the use of RDF and specified grades to be used for co-processing in cement kilns. The initiative aimed to enhance collaboration between Urban Local Bodies (ULBs) and the cement industry, fostering efficient partnerships.

This expert committee has set the minimum criteria (Table 2) that should be met for the product to be certified as segregated combustible fraction (SCF) and for three grades of RDF[15].

Table 2: Specifications for different grades of Refuse-Derived Fuel (RDF)

S. No	Parameters	SCF	RDF - Grade III	RDF - Grade II	RDF - Grade I
1.	Intended Use	Input material for Waste to Energy plant or RDF pre-processing facility.	For co-processing directly or after processing with other waste materials in cement kiln.	For direct co-processing in cement kiln.	For direct co-processing in cement kiln.
2.	Size	Anything above 400mm has to be mutually agreed between Urban Local Body/SCF Supplier and Cement Plants.	<50 mm or <20 mm depending upon use in (Inert Landfill Class) ILC or (Solid Waste Landfill Class) SLC, respectively.	<50 mm or <20 mm depending upon use in ILC or SLC, respectively.	<50 mm or <20 mm depending upon use in ILC or SLC, respectively.
3.	Ash – Maximum Permissible	<20%	<15%	<10%	<10%
4.	Moisture – Maximum Permissible	<35%	<20%	<15%	<10%
5.	Chlorine – Maximum Permissible	<1.0%	<1.0%	<0.7%	<0.5%
6.	Sulphur – Maximum Permissible	<1.5%	<1.5%	<1.5%	<1.5%
7.	Net Calorific Value (NCV) – in Kcal/kg	>1500 Kcal/kg net	>3000 Kcal/kg net	>3750 Kcal/kg net	>4500 Kcal/kg net
8.	Any Other Parameter	SCF – Any offensive odour to be controlled.	RDF – Any offensive odour to be controlled.	RDF – Any offensive odour to be controlled.	RDF – Any offensive odour to be controlled.

After the implementation of Solid Waste Management Rules in 2016, the Plastic Waste Management Rules, 2016 outlined the Extended Producer Responsibility (EPR) Rules.

Plastic Waste Management Rules, 2016

The **Plastic Waste Management Rules** were introduced by the MoEFCC in India to address the growing concerns around plastic waste and its environmental impact. Initially notified in 2016, these rules aim to effectively manage plastic waste and minimise its environmental impact through several key provisions including:

- Establishing EPR, which holds producers, importers, and brand owners accountable for collection, recycling, and disposal of plastic waste.

- The rules encourage source segregation of plastic waste to enhance recycling, mandate registration for manufacturers and recyclers with CPCB, and set standards for recycling processes.
- Additionally, the rules promote public awareness initiatives and establish monitoring mechanisms to ensure compliance and effective implementation.

Amendment in 2022

The amendments to the Plastic Waste Management Rules in 2022 introduced several significant changes aimed at enhancing plastic waste management.

- A phased ban on specific single-use plastic items, effective from July 2022, was implemented to reduce plastic pollution.
- The obligations under EPR were strengthened, requiring producers, importers, and brand owners to meet more rigorous collection and recycling targets.
- Additionally, clearer definitions for terms such as “plastic waste” and “single-use plastics” were established to improve compliance.
- All plastic manufacturers and recyclers are now required to register with the CPCB and state authorities, increasing oversight and accountability.
- Furthermore, the amendments made enhanced reporting requirements to ensure transparency and track progress in plastic waste management practices.

Extended Producer Responsibility Rules

Extended Producer Responsibility (EPR) Rules in India were introduced as part of the Plastic Waste Management Rules notified by the MoEFCC in 2016. These rules were designed to hold producers accountable for the entire lifecycle of their products, particularly in managing waste generated from those products.

- Producers, importers, and brand owners are responsible for managing the waste generated from their products, including collection, recycling, and safe disposal.
- Plastic Waste Processors undertaking end-of-life disposal of plastic packaging waste, including waste to energy, waste to oil, and cement kilns (co-processing), must provide annual information on a centralised portal developed by the CPCB.

Effectiveness of Government Measures

The implementation of India’s Solid Waste Management Rules, 2016, along with the CPCB 2017 and MoHUA 2018 guidelines, specifically targets the production and utilization of RDF, which is derived from MSW. However, it is crucial to distinguish RDF from co-processing, which encompasses a broader range of non-recyclable plastic waste and other materials utilised in energy recovery processes. This distinction is vital for ensuring compliance with regulatory objectives and for the effective execution of waste management strategies.

The Plastic Waste Management Rules directly address the management, recycling, and disposal of plastic waste, advocating for EPR. EPR holds producers accountable for the entire lifecycle of their products, thereby enhancing overall waste management practices and promoting responsible manufacturing. While these regulations emphasise the importance of co-processing as a waste management strategy, the actual effectiveness of these measures remains uncertain.

Despite the government’s ongoing reforms and amendments indicating a strong commitment to promoting RDF as a sustainable alternative to fossil fuels—aimed at increasing its thermal substitution rate (TSR)—the results have been mixed. The policies designed to streamline the co-processing process and enhance its acceptance within the industry have not fully addressed the underlying challenges.

The variability of waste characteristics in India, combined with operational and management hurdles, significantly hampers the success of these initiatives. Even with potential improvements, reliance on RDF technology is not a long-term solution. Instead, it risks providing only short-term benefits while inadvertently reducing manufacturers’ incentives to decrease plastic production. This could lead to a cycle of increased consumption and production, ultimately undermining the very objectives these regulations aim to achieve.

Moreover, the environmental consequences of RDF cannot be overlooked. In reality, despite several regulations being in place, a large part of this ‘reprocessing’ is to create RDF which are bales or pellets of mixed waste to be burned in cement kilns or other industrial furnaces. The combustion of these pellets releases harmful emissions, including dioxins and furans, which pose serious health risks to communities and contribute to air pollution. It also has major implications for climate change as plastic fuels are derivatives of fossil fuels. Burning plastic waste, including as a “reprocessed fuel product”, is not recycling or clean energy. It is clear that RDF is not a sustainable solution and there is an urgent need for more comprehensive strategies that prioritise waste reduction and responsible resource management.

PLASTIC WASTE TRADE IN INDIA: IMPORTS AND EXPORTS

In recent years, global plastic waste trade has sharply declined, falling from 12.4 million metric tonnes (Mt) in 2017 to 6.3 Mt by 2022—a 49% drop. This decline intensified from 2021 to 2022, presumably due to stricter Basel Convention regulations promoting responsible trade. Despite this, imports to non-OECD (Organisation for Economic Co-operation and Development) nations in South and Southeast Asia remain high, with Indonesia's imports surging by 26% in 2022. This trend raises concerns about the transfer of waste from wealthier countries to poorer ones, posing risks to environmental sustainability, public health, and highlights the complexities of the global waste trade.

In India, MoEFCC regulates import and export of hazardous and other wastes. India's regulations for import and export of plastic waste are primarily governed by the **Plastic Waste Management Rules, 2016** and **The Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016**, and subsequent amendments, which includes:

Import Regulations[23]

- **Banned Imports**: India has prohibited the import of certain categories of plastic waste that are considered hazardous or difficult to recycle.
- **Permissible Imports**: Only non-hazardous plastic waste that is recyclable can be imported, subject to specific conditions.
- **Clearance Requirements**: Importers must obtain necessary clearances from MoEFCC and comply with hazardous waste management guidelines.
- **Compliance Standards**: Imported plastic waste must meet strict quality standards to ensure environmental safety.

Export Regulations (Hazardous and other Wastes (Management & Transboundary Movement) Rules, 2016)

- **Prohibition of Hazardous Exports**: The export of certain hazardous plastic waste types has been banned to prevent environmental harm.
- **Permissible Exports**: Non-hazardous plastic waste can be exported for recycling to countries with responsible waste management practices.
- **Regulatory Compliance**: Exporters must comply with international regulations and obtain necessary clearances to ensure that exported waste is managed sustainably in the receiving country.
- **Documentation Requirements**: Comprehensive documentation is required to track the movement of plastic waste and ensure compliance with both Indian and international regulations.

Under current regulations, only specific categories of plastic waste that meet prescribed quality and processing standards are allowed for import and export. However, India established its hazardous waste rules in 1989, prior to the Basel Convention's enactment in 1992, and became a party to the Convention that same year. Subsequent amendments were made to align national law with the Convention in 2000 and 2003, leading to a revised version of the Hazardous Waste Rules in 2008. Over the years, the transboundary movement of hazardous waste has remained a critical issue, resulting in further revisions in 2016, now known as "The Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016."

In March 2019, the MoEFCC issued a media statement announcing a complete prohibition on the import of solid plastic waste, including in Special Economic Zones (SEZs) and by Export Oriented Units (EOUs). This plastic ban represents a significant step by the Indian government to protect the environment. However, India does not have a national ban on importing hazardous wastes and has yet to ratify the Basel Ban Amendment, which is crucial for addressing global waste trade. Notably, other major waste-importing countries in Asia, such as China, Indonesia, and Malaysia, have ratified this amendment.

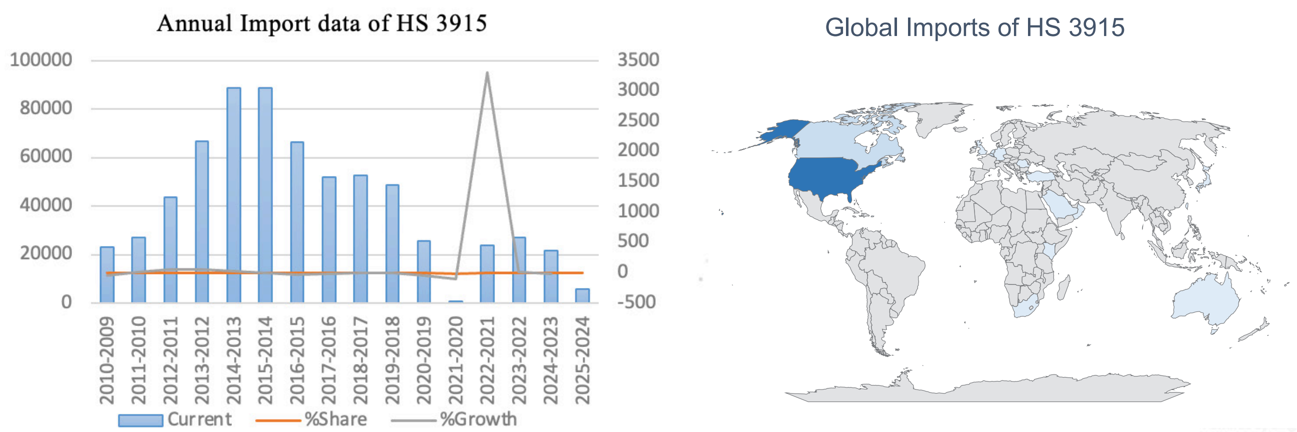
In November 2021, the Directorate General of Foreign Trade (DGFT) held a consultation meeting to discuss potential amendments to the import policy for polyethylene terephthalate (PET) flakes and PET waste. This led to the introduction of some relaxations to the previous complete ban on solid plastic waste, resulting in a partial lifting of the ban that took effect in 2022. These types of waste fall under HS (Harmonized System) Code 3915, which covers "waste, parings, and scrap of plastics." This code includes various recyclable plastic materials that can be imported into India if they meet specific environmental standards. Importantly, while HS Code 3915 encompasses a significant portion of recyclable plastics, it does not include RDF. Therefore, when analysing import-export data given in the graph below, it is essential to recognise that most of this waste consists of recyclable plastics. The term "RDF" is not explicitly mentioned in the existing regulations concerning ban, making it challenging to ascertain the specific rules governing its import and export.

Additionally, responses to Right To Information (RTI) (annexure II) queries indicate no information regarding RDF. As a result, understanding the actual scenarios for the import and export of RDF remains ambiguous.

The classification of RDF as either waste or a product is still under the blanket, as it attracts Goods & Service Tax (GST). This raises concern over RDF trade as product, which can exempt RDF from regulatory norms. This highlights the need for clearer regulatory definitions in India regarding RDF's status as either waste or product. This gap poses challenges for enforcement and clarity within India's regulatory framework.

Import Trends of HS Code 3915

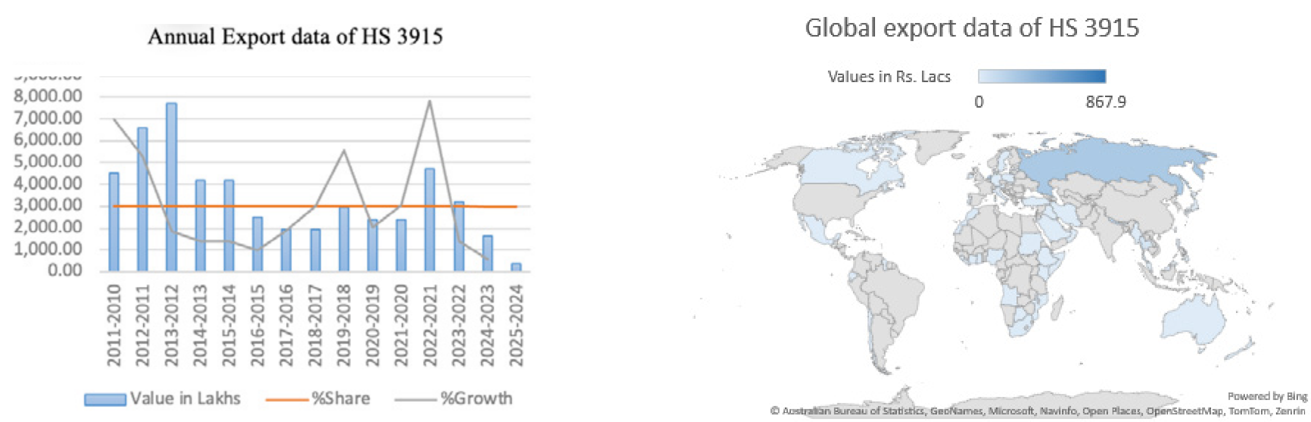
Graph 1: Imports Data of HS Code 3915 in India



India's imports under HS Code 3915 shows considerable fluctuations. In the period from 2022 to 2023, Belgium was a leading supplier. However, in 2023-2024, the USA emerged as the leading exporter, with imports valued at 16,483.67 lakh—a substantial increase from earlier years.

Export Trends of HS Code 3915

Graph 2: Export Data of HS Code 3915 in India



OVERVIEW OF WASTE-TO-ENERGY PLANTS IN INDIA

The export data reveals significant volatility. Exports nearly doubled in 2022, but then experienced sharp declines of 32.27% in 2023 and 48.39% in 2024. This variability underscores the complex factors affecting the HS Code 3915 export market[21].

India imports significantly more plastic waste (HS Code 3915) than it exports, likely due to a higher domestic recycling rate compared to the global average[22]. The current regulatory framework underscores India's intent on waste management, emphasising recycling and using waste as a co-processed fuel.

In India, Waste-to-Energy (WtE) technology is predominantly implemented through the Build-Operate-Transfer (BOT) model, playing a crucial role in tackling the intertwined challenges of waste management and energy production[23]. This process involves combusting RDF in controlled furnaces to generate steam, which drives turbines to produce electricity for the national grid, thereby addressing the country's growing energy demands[24]. To ensure environmental compliance, Indian regulations mandate the use of advanced emission control technologies, such as electrostatic precipitators and flue gas scrubbers, "which effectively capture pollutants like dioxins and particulate matter"[25]. While Indian regulations mandate the use of advanced emission control technologies like electrostatic precipitators and flue gas scrubbers to capture pollutants such as dioxins and particulate matter, the reality on the ground often falls short of these expectations. Many facilities processing RDF may lack adequate air pollution control devices (APCDs), and even when such technologies are installed, they are frequently not monitored effectively. This gap in implementation leads to significant emissions that can harm air quality and public health.

For instance, in the case of the Okhla WtE plant, residents have consistently reported issues with air quality and emissions, raising concerns about the plant's compliance with environmental standards (Delhi High Court, 2017). Similarly, the Bandhwari WtE plant has faced scrutiny for its operational practices and the effectiveness of its pollution control measures, leading to community protests and calls for better regulatory oversight (National Green Tribunal, 2019). These cases highlight that compliance with environmental standards is inconsistent, with some plants operating without the necessary technologies or failing to maintain them properly. As a result, the intended benefits of these regulations are undermined, and the potential risks associated with RDF processing remain a critical concern for surrounding communities and the environment. As of November 2016, India had 33 operational WtE facilities with a combined installed capacity of 275 MW, with Andhra Pradesh contributing the highest capacity at 74 MW (27%). According to the Ministry of New and Renewable Energy (MNRE), WtE plants across 35 states and union territories generate approximately 1,532 MW of power annually. States such as Maharashtra, Uttar Pradesh, Tamil Nadu, West Bengal, and Delhi show the highest potential for energy generation from MSW[26]. The list of WtE plant which are operational or under construction are given in Table no. 3, with their output, as documented in MoUHA 2018.

These facilities are strategically located in major urban centres like Delhi, Mumbai, Bengaluru, Hyderabad, and Chennai. As per CPCB, "Addressing the existing challenges will be crucial to maximising the effectiveness of WtE technology and enhancing its contribution to a sustainable energy future in India"[27]. As per Right to information (RTI, refer annexure II) response, the total number of industries, other than cement using RDF (i.e WtE plants), registered on CPCB EPR portal are 35.

Figure 3: Mapping of waste to energy plants in India

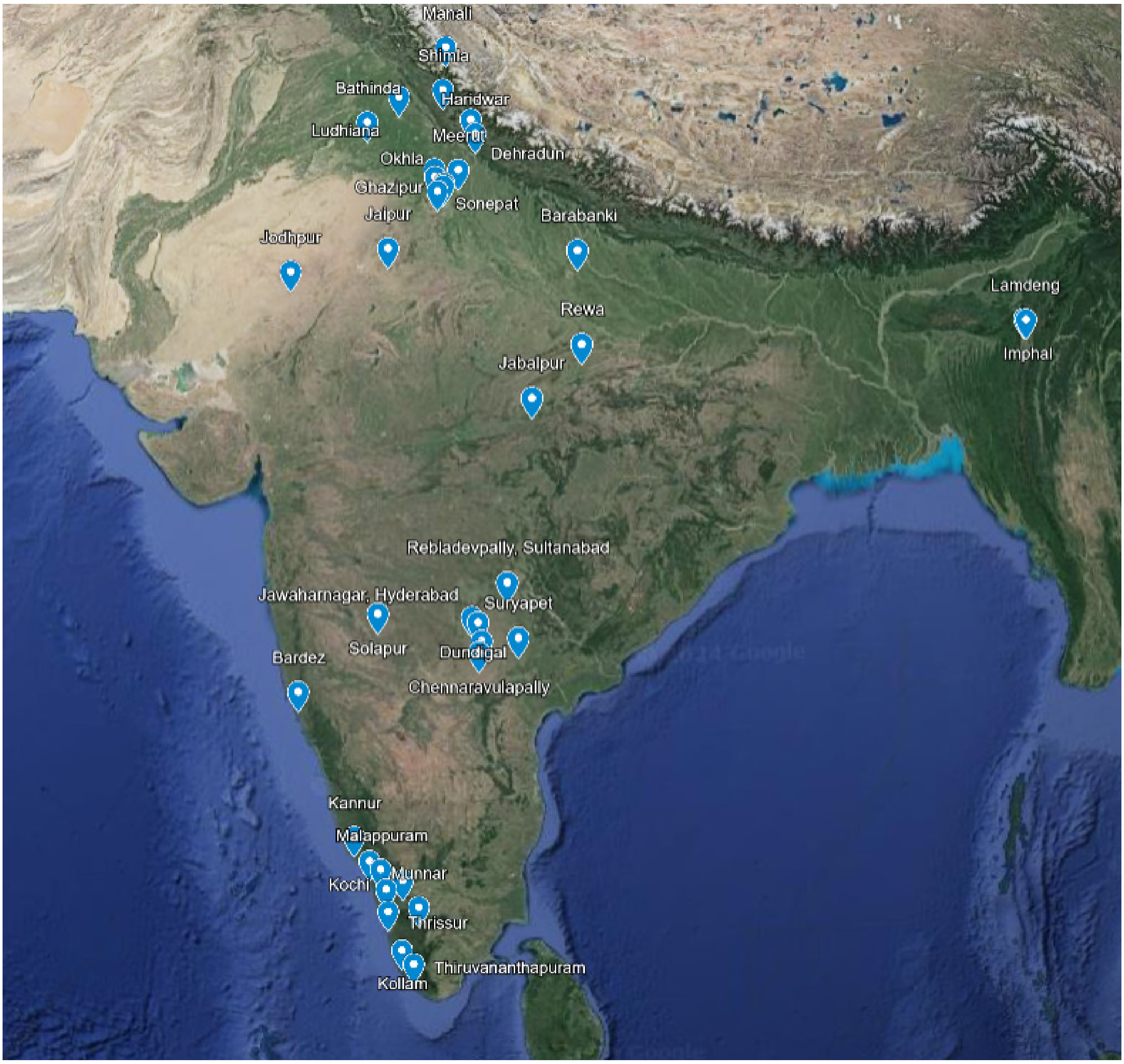


Table 3: Waste to energy facilities in India and their status (MoUHA 2022)[28]

S. No.	State	Plant Location	Power Generation (MW)
1	Andhra Pradesh	Visakhapatnam, Guntur	15, 15
2	Goa	Hindustan Waste Treatment Plant Pvt. Ltd., Sailogo, Bardez	0.6
3	Haryana	Sonepat, Gurugram (Bhandwari)	7, 23
4	Himachal Pradesh	Shimla, Manali	Not Provided
5	Kerala	Kozhikode, Kannur, Kollam, Palakkad, Kochi, Thiruvananthapuram, Munnar, Thrissur, Malappuram	Various stages
6	Madhya Pradesh	Jabalpur, Rewa	11.5 MW, 2x6 MW
7	Maharashtra	Solapur Municipal Corporation	4
8	Manipur	Lamdeng, Imphal	Nil
9	Punjab	Bathinda, Ludhiana	-
	Rajasthan	M/s JITF Urban Infrastructure Ltd., Jaipur, Jodhpur	600 TPD, 400 TPD

S. No.	State	Plant Location	Power Generation (MW)
10	Telangana	M/s Integrated Municipal Solid Waste Management Project, Jawaharnagar, Hyderabad	19.8
11	Telangana	Chennaravulapally, Bibi Nagar (M/s RDF Power Projects)	11
12	Telangana	Yacharam, Ibrahimpatnam	12
13	Telangana	Rebladevpally, Sultanabad	12
14	Telangana	Suryapet	12.6
15	Telangana	Dundigal	14.5
16	Uttarakhand	Haridwar, Dehradun	5
17	Uttar Pradesh	Barabanki, Meerut	2.5, 2.5
18	Chandigarh	Opp. Dumping ground, Dadumajra, Sector-25 West	RDF production Approx. 60 TPD
19	Delhi	Okhla, Ghazipur, Bawana	23, 12, 24

Shortcomings of Waste to Energy (WtE) Plants

- **Pollution and associated health risk**: WtE plants can pose significant health risks due to various emissions. Particulate matter can lead to heart and lung diseases, while heavy metals like lead and mercury are linked to neurological disorders[29]. Toxic chemicals, such as dioxins, furans and PFAS, can contribute to cancer and other health issues [30]. Additionally, acid gases and oxides of nitrogen and sulphur are notable pollutants from these facilities. Health impacts may include increased cancer rates, respiratory problems, congenital abnormalities, hormonal issues, and altered sex ratios[31]. The extent of these risks varies based on the type of waste processed, operational conditions, and risk assessment models used.
- **High Initial Costs**: Establishing WtE facilities requires significant capital investment, particularly for front-end processing to recover the fuel fraction, which deters municipalities and companies.
- **Inefficient Energy Recovery**: The energy yield from RDF is typically lower than that from the traditional coal, resulting in less overall energy generation[32].
- **Conflict with Waste Hierarchy**: WtE contradicts the principles of the waste hierarchy, which prioritise waste prevention, segregation at the source, recycling, reuse, and the biological treatment of organic waste. By focusing on incineration, WtE undermines efforts to implement more environmentally sustainable practices.
- **Undermining Sustainable Practices:** Relying on WtE discourages the adoption of more sustainable waste management solutions, such as composting, and the development of renewable energy sources. It shifts focus away from waste reduction and resource recovery, promoting incineration as a quick fix rather than addressing the root causes of waste generation.
- **Impacts on communities**: Local communities are affected by WtE facilities due to their toxic emissions, which cause severe health impacts, contaminated air and water, and decreased quality of life.
- **Residual Waste generation**: The process generates ash and other residues that require attention, resulting in environmental pollution.

The Indian Government is promoting RDF with the goal of achieving 25% thermal substitution rate (TSR) in the cement sector by 2025

Overview of RDF in Cement Kiln Operations in India

Over the past decade, the use of RDF in the cement industry has gained significant momentum, driven by its benefits in reducing landfill waste and enhancing energy recovery. The Indian Government is promoting RDF with the goal of achieving 25% thermal substitution rate (TSR) in the cement sector by 2025. However, the composition of MSW varies with area, making it difficult to adopt. For instance, Lafarge, a prominent industry in Austria, began using alternative fuels in 1996, and since then, the Austrian cement industry has achieved fossil fuel substitution rates of up to 80%.

RDF is produced and analysed for quality, with a calorific value requirement of over 3,000 Kcal/kg. It is blended with traditional fuels like coal or petcoke and fed into cement kilns through automated systems. At temperatures of 1400–1600°C, RDF combusts, providing the energy necessary for the calcinations of raw materials. This process not only diverts waste from landfills. To successfully implement this substitution, cement plants must consider several costs, including material expenses, kiln and equipment upgrades, pre-processing and operational overheads. As coal and petcoke prices rise, along with potential CO_2 emissions pricing, the economic viability of RDF is expected to improve.

The current TSR averaging at around 2.5%, is quite low. The Cement Manufacturers Association (CMA) indicates that the industry could reduce conventional fuel costs by about 20% through the use of single-use plastics as an alternative fuel. As on date, the total number of Cement plants using RDF, registered on CPCB EPR portal are 74 (RTI, refer annexure II). The cement facilities using RDF documented in MoHUA RDF guidelines 2018[33], along with their status are listed below (Table 4).

Figure 4: Mapping of cement facilities using RDF in India

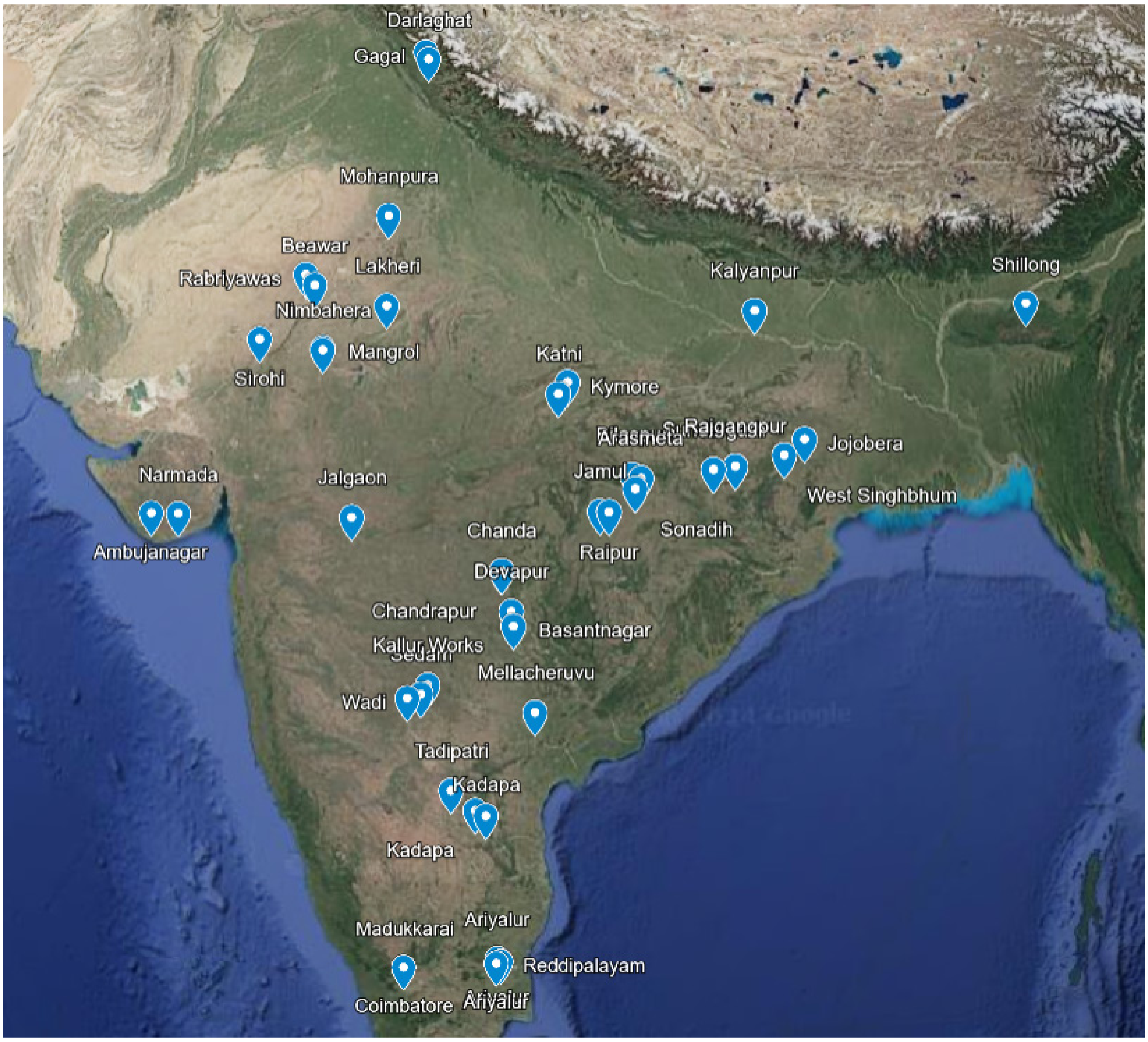


Table 4: Overview of Cement Companies Utilising Co-Processing and Alternative Fuels (MoUHA)34

Sr. No	Company	Location	Details
1.	**ACC Cement**	Wadi (Karnataka) Chandrapur (Maharashtra) Coimbatore (Tamil Nadu) Bilaspur (Himachal Pradesh) Katni (Madhya Pradesh) West Singhbhum (Jharkhand) Lakheri (Rajasthan) Kymore (Madhya Pradesh) Madukkarai (Tamil Nadu) Gagal (Himachal Pradesh) Jamul (Chhattisgarh) Chanda (Maharashtra)	Uses various waste materials as alternative fuels.
2	**Ambuja Cements**	Rabriyawas (Rajasthan) Darlaghat (Himachal Pradesh) Suli (Himachal Pradesh) Ambujanagar (Gujarat)	Incorporates waste-derived fuels into their production processes.
3	**UltraTech Cement**	Tadipatri (Andhra Pradesh) Reddipalayam (Tamil Nadu) Aditya (Chittorgarh, Rajasthan) Rajashree (Gulbarga, Karnataka) Narmada (Gujarat) Mohanpura (Jaipur, Rajasthan)	Engages in co-processing of waste materials, including RDF.
4	**Shree Cement**	Beawar (Rajasthan) Raipur (Chhattisgarh) Jaitaran (Rajasthan)	Utilises co-processing activities to reduce waste and optimise fuel use.
5	**Dalmia Bharat Cement**	Kadapa (Andhra Pradesh), Ariyalur (Tamil Nadu)	Incorporates alternative fuels in their cement production processes.
6	**JK Cement**	Nimbahera (Rajasthan) Mangrol (Rajasthan) Muddapur (Bagalkot, Karnataka)	Active in using waste materials as part of their fuel mix.
7	**Binani Cement**	Sirohi (Rajasthan)	Involved in co-processing waste materials in its cement manufacturing.
8.	**Ramco Cements**	Ariyalur (Tamil Nadu) Ramasamy Raja Nagar (Tamil Nadu)	Uses alternative fuels including RDF in their cement manufacturing.
9	**Kalyanpur Cement Ltd**	Kalyanpur (Uttar Pradesh)	Engages in co-processing of industrial waste and by-products.
10	**Birla Shakti Cement**	Kadapa (Andhra Pradesh)	Incorporates waste-derived fuels in cement production.
11	**Orient Cement**	Devapur (Telangana), Jalgaon (Maharashtra)	Utilises co-processing of alternative fuels in their manufacturing processes.
12	**Adhunik Cement**	Sundergarh (Odisha)	Employs co-processing to handle industrial waste and by-products.
13	**Powercon Cement**	Adilabad (Telangana)	Integrates alternative fuels into cement production.
14	**OCL Cement**	Rajgangpur (Odisha)	Uses co-processing methods for waste management in cement production.
15	**Lafarge India**	Jojobera (Jharkhand) Sonadih (Chhattisgarh) Arasmeta (Chhattisgarh)	Engages in co-processing to utilise waste materials as alternative fuels.

Sr. No	Company	Location	Details
16	**Meghalaya Cement**	Shillong (Meghalaya)	Incorporates co-processing practices to manage waste and enhance sustainability.
17	**Vasavadatta Cement**	Sedam (Karnataka)	Involved in co-processing waste materials in its cement manufacturing.
18	**My Home Industries**	Mellacheruvu (Nalgonda, Telangana)	Uses alternative fuels in their cement production.
19	**Kesoram Cement**	Basantnagar (Karimnagar, Telangana)	Uses alternative fuels in their cement production.
20	**Chettinad Cement**	Kallur Works (Gulbarga, Karnataka)	Engages in co-processing of industrial waste and by-products.

While many cement plants have embraced RDF as an alternative fuel source, significant management shortcomings still hinder optimal performance, leading to low thermal substitution rates. The shortcomings include:

Insufficient supply of RDF: Most cement companies rely on third-party suppliers for RDF or, more commonly, SCF, a less processed version. While many plants are working to enhance their ARF facilities, they face uncertainty about the consistent supply of RDF from vendors.

The Wonder Cement Plant in Nimbahera, Rajasthan, has 1,500 square meters of storage for 5,000 tonnes of SCF. However, it receives only about 300 tonnes per day, far below the planned input for its operations[35].

Inconsistency in Quality and lack of skilled workforce: Cement plants report receiving non-homogeneous waste with 30-50% moisture and 30-40% ash content. Operators must tightly control these levels, as they can disrupt cement production and lead to significant losses. Frequent breakdowns of shredders occur due to the processing of this inconsistent waste.

For instance, Prism Cement Plant in Satna, Madhya Pradesh, imposes pro-rata penalties on SCF vendors based on calorific value and moisture content to prevent malfunctions and maintain cement quality[38].

Transportation and handler's issue: The transportation of waste from handler sites to cement plants is a significant issue, with waste being transported from distances of 500-1,000 kilometres. Due to the lower calorific value of waste compared to coal, transporting waste is much less efficient, requiring nine trucks of waste to match the calorific value of one truck of coal.

For instance, Trashonomy Pvt Ltd in Udaipur, witnesses frequent staff injuries from handling contaminated and hazardous waste, such as biomedical waste and sharp objects[38].

Lack of proper infrastructures: Medium-scale waste handling facilities often lack the resources for regular lab testing of waste samples and face financial constraints that delay plant operations and maintenance.

Sector experts believe that while cement plants are willing to use RDF due to its economic benefits, municipalities need to prioritise selecting technically competent vendors over those offering the lowest commercial value. This would ensure the quality of RDF and in maintaining product quality and equipment integrity in cement plants[36].

These inefficiencies negatively impact the overall effectiveness of RDF usage, resulting in higher costs, overconsumption of RDF, and increased emissions. Addressing these issues is crucial for enhancing cost efficiency and minimising environmental impact.

The combustion of RDF can lead to the release of significant amounts of CO_2, contributing to climate change. In addition to this, RDF combustion can release toxins including dioxins, furans, PFAS, and heavy metals

Emissions Profile of RDF and Environmental Hazards

RDF plants are often evaluated for their environmental impact using key metrics including global warming potential (GWP), acidification potential, abiotic depletion, photochemical ozone creation potential, human toxicity potential and terrestrial eutrophication.

Key emissions include methane (CH_4), carbon dioxide (CO_2), and more potent gases such as sulphur hexafluoride (SF_6) and per fluorocarbons (PFCs).[37] Despite some evidence suggesting that RDF can reduce greenhouse gas emissions compared to landfills, the overall impact on global warming remains substantial.[38] In particular, the combustion of RDF can lead to the release of significant amounts of CO_2, contributing to climate change.[39] In addition to this, RDF combustion can release toxins including dioxins, furans, PFAS, and heavy metals.[40] These toxic chemicals can bio-accumulate in soils and water systems, posing the risk of contamination and toxicity to wildlife and humans. Although emission limits are set by regulations, the management of these metals remains challenging and can lead to long-term environmental damage.[41]

In India, the MoFECC has established stringent emission limits outlined in the Environmental Management Plan (EMP) for waste co-processing in cement plants, including parameters for dust, SO_2, NOx, and heavy metals. A comparison of emission limits set by different countries is given in **Table 5**.[42] Continuous Emission Monitoring Systems (CEMS) are required to ensure compliance with these limits. As per CPCB, with RDF usage currently at less than 1% in these plants, the full potential of RDF to mitigate environmental impacts remains underutilised.[43]

Compared to traditional landfills and incineration methods, RDF plants are assumed to offer some environmental benefits, such as reducing methane emissions from landfills and lowering the volume of waste. However, the drawbacks are significant. Landfills can leach heavy metals and produce greenhouse gases, while incineration without RDF can result in higher emissions of pollutants. As a solution, RDF maybe aiming to bridge these issues but comes with its own set of environmental challenges.[44] The claims of environmental gains from RDF fall short because emission controls are insufficient and that there needs to be more effective strategies to capture and neutralise these pollutants. It contributes to the rerelease of toxins such as dioxins and furans, which are persistent in nature. Lacking efficiency compared to coal is another obstacle, that raises the concern of adapting RDF as an alternative fuel. These challenges significantly undermine the advantages that RDF is proposed to offer, overshadowing its potential benefits.[45&46]

Table 5: Comparison of Emission Limits for Cement Plants

Parameter	EU Limit	US (Load Based)	South Africa	India
Total Dust	30 mg/Nm^3	0.005 kg/t of clinker	30 mg/Nm^3	50 mg/Nm^3 (or 0.125 kg/t of clinker)
HCI	10 mg/Nm^3	10 mg/Nm^3	10 mg/Nm^3	10 mg/Nm^3
HF	1 mg/Nm^3	1 mg/Nm^3	1 mg/Nm^3	1 mg/Nm^3
NOx (Existing Plants)	800 mg/Nm^3	0.75 kg/t of clinker	800 mg/Nm^3	800 mg/Nm^3
NOx (New Plants)	500 mg/Nm^3	-	-	600 mg/Nm^3
Cd + Tl	0.05 mg/Nm^3	0.05 mg/Nm^3	0.05 mg/Nm^3	0.05 mg/Nm^3
Hg	0.05 mg/Nm^3	0.05 mg/Nm^3	0.05 mg/Nm^3	0.05 mg/Nm^3
Sb + As + Pb + Cr + Co + Cu + Mn + Ni + V	0.5 mg/Nm^3	0.5 mg/Nm^3	0.5 mg/Nm^3	0.5 mg/Nm^3
Dioxins and Furans (ng I-TEQ/Nm^3)	0.1	0.1	0.1	0.1
SO2	50 mg/Nm^3	0.2 kg/t of clinker	50 mg/Nm^3	100 mg/Nm^3 (Relaxable up to 400 mg/Nm^3 in special cases)

NOTE: EU Limit: Values are daily average for continuous measurements. US: Emissions based on a 30-operating day rolling average. India: Limits came into effect from August 1, 2015. Exceptions may be authorised by the competent authority for TOC and SO2 if not from waste incineration. SO_2 limits may vary based on sulphur content in raw materials.

In India, RDF plants seeking carbon credits must undergo a certification process to demonstrate real, measurable reductions in GHG emissions compared to a baseline scenario, such as landfilling waste.

Carbon Credits and RDF: India's Certification and Impact Challenges

Carbon credits are tradeable certificates that allow companies to emit a specified amount of greenhouse gases (GHGs). They are generated by projects that either reduce or remove carbon emissions, such as renewable energy installations or reforestation efforts. Companies purchase these credits to offset their own emissions, and they are traded in carbon markets to help meet emission reduction goals.
RDF, made from waste, can power facilities including WtE plants. For example, in Sweden, RDF is used in a WTE plant to generate electricity and provide district heating, showcasing its potential as a viable energy source derived from waste.
In India, RDF plants seeking carbon credits must undergo a certification process to demonstrate real, measurable reductions in GHG emissions compared to a baseline scenario, such as landfilling waste. This process involves continuous monitoring and reporting of emissions, with data verified by certification bodies. However, ensuring accurate reporting and addressing local environmental and health impacts that may not be fully reflected by carbon credits, the challenges include. The regulatory framework follows United Nations Framework Convention on Climate Change (UNFCCC) guidelines and supports RDF projects, but ongoing scrutiny is necessary to enhance the system transparency and effectiveness.

The Carbon Credit Trading Scheme (CCTS) 2023 is a key initiative by the Indian Government to incentivise and regulate GHG emission reductions. It features two primary mechanisms: the Compliance Mechanism, which targets emissions from the energy and industrial sectors with set reduction goals, and the Offset Mechanism, which encourages voluntary emission reductions by non-obligated entities, allowing them to earn Carbon Credit Certificates. The Bureau of Energy Efficiency (BEE) oversees the identification of sectors and methodologies for generating these credits. The CCTS 2023 supports the broader goal of decarbonising the Indian economy, with RDF plants benefiting by earning and trading carbon credits, thus incentivising the adoption and expansion of WtE technologies. However, what is also desired is to ensure that the non-obligated entities earning carbon credits are equally concerned about environment and public health.

For instance, such as the Okhla RDF plant in Delhi, illustrate these challenges. While the plant has received carbon credits under the Clean Development Mechanism (CDM), it has faced significant criticism for its local environmental and health impacts. This situation underscores the need for comprehensive assessments to ensure that carbon credits accurately reflect the true impacts of RDF projects and that the system effectively supports both emission reductions and local environmental health.

CASE STUDIES

Case Study: “The Okhla RDF Plant Controversy”

Background

The Okhla RDF plant in Delhi, managed by Ramky Enviro Engineers Ltd., was established to address Delhi’s waste management crisis by converting municipal solid waste into energy. However, the plant has faced significant opposition due to environmental and health concerns. Residents living near the Okhla RDF plant have reported severe issues, including foul odours, increased air pollution, and associated health risks. The locals have experienced heightened respiratory problems and discomfort due to the plant’s emissions, which they attribute to the RDF processing. The community protests have included demonstrations, legal actions, and public appeals for improved conditions. The pervasive smell and pollution have led to widespread discontent, significantly impacting the quality of life of nearby residents.

One of the local residents, Mr Dhruv Kapoor, stated how his seven-year-old son suffers from recurring adenoids and relies on antibiotics during times of poor air quality. Kapoor himself battles chronic sinusitis, exacerbated by the plant’s emissions. His elderly parents are largely confined indoors with an air purifier due to the worsening air quality. Kapoor’s narrative underscores the human cost of living near the plant, reflecting the broader concerns of thousands affected by the plant’s operations.

A former resident of Jasola Vihar, who wished to remain unnamed, shared that he was once proud to own a home there but had to sell it and relocate to Saket last year. He explained that after years of dealing with respiratory issues, unpleasant odours, and inadequate responses from authorities, he could no longer tolerate the negative impact on his family’s health, particularly concerning his children. Adjacent to the Okhla WtE plant is Haji Colony, a congested and neglected settlement. Imraana, a shopkeeper in the local market, is concerned about the well-being of her two young children, aged 5 and 7. She regrets moving from her hometown in Uttar Pradesh to this area, reflecting her worries about the environment and living conditions. According, to its official website, the Okhla WtE plant is equipped with a flue gas cleaning system, which when combined with proper combustion, ensures that emission standards are maintained. The plant also has a leachate treatment facility. But this is far from reality as the resident is fighting this battle for 15 long years still the situation hasn’t improved.

Figure 5: Residents of Sukhdev Vihar and Jamia Nagar form a human chain demanding the shutting down of the Waste to Energy Plant in Okhla

Legal battle between the authorities and locals

Residents of Sukhdev Vihar filed a writ petition against the proposed Okhla WtE plant in 2009, which the Delhi High Court dismissed. After a subsequent review application, the case was transferred to the National Green Tribunal (NGT) in 2013. Despite concerns about harmful emissions like furans, dioxins and heavy metals, the NGT allowed the plant to continue operating in 2017, ordering it to pay Rs 25 lakh for past pollution violations. Dissatisfied, residents appealed to the Supreme Court in 2017, but the case scheduled for hearing on July 18, 2024, was not listed. Additionally, in 2021, the Delhi Pollution Control Committee fined Delhi's three WtE plants, including Okhla, Rs 5 lakh each for failing to meet environmental standards. Despite several petitions, and court cases filed over the last decade, residents say the government is yet to take meaningful action, leaving them to suffer the consequences. Residents have not backed down from their fight against the WTE plant. Various Residents' Welfare Associations (RWAs) from surrounding areas have united to address this pressing issue. They expressed hope that the Supreme Court would be sympathetic to their plight and provide a more permanent solution to restore health to their neighbourhood.

Carbon Credit Issue**:** The Okhla RDF plant has received carbon credits under the Clean Development Mechanism (CDM) to offset greenhouse gas emissions by promoting sustainable practices. Critics argue that the credits do not fully account for the plant's adverse effects on local air quality and public health, questioning the fairness and accuracy of the carbon credit system. The UNFCCC, which oversees the CDM, sets standards and verifies emission reduction criteria for such projects. Despite this oversight, there are concerns that the carbon credits issued to the Okhla plant do not adequately reflect its local environmental and health impacts. This situation has led to calls for the UN to reassess and potentially revise its carbon credit evaluation processes to better align with the true environmental and health costs of projects like Okhla.

Over the past three years, from May 2019 to May 2022, 5.1 million tons of waste have been disposed of. The monthly disposal rate has significantly increased, surpassing 400%, with an average of 600,000 tons now being disposed of compared to the previous average of 141,000 tons.

Insights from Interview with Industry Stakeholders on the Use of RDF in Cement Kiln Factories

To gain a comprehensive understanding of the use of RDF in cement kiln factories, we held an interview with **Ulhas Parlikar,** an expert in waste management and circular economy and a global consultant focused on policy advocacy, alternative fuel resources and co-processing. He is a Former Director of Geocycle Business at ACC Limited and Former Deputy Head of Geocycle India and is currently on the Board of Directors at Material Recycling Association of India (MRAI). He was asked a set of questions covering various aspects related to RDF usage, including its benefits, challenges and regulatory issues.

Given below are Highlights from the Interview with Ulhas Parlikar on RDF in Cement Kilns:

Calorific Value and Grades

- Cement industries prefer RDF close to Grade I, II, or III as per MoHUA guidelines.
- RDF has higher moisture and chlorine levels than coal, making it less convenient for use.

Types of RDF

- "Segregated Combustible Fraction" (SCF) from raw MSW is mainly used in incinerators.
- RDF for cement should meet specific guidelines; in power plants, its use is limited by chloride levels.

Production and Consumption

- Approximately 40-50% of MSW is SCF; processed RDF generation potential is around 20 million tonnes per annum (TPA).
- Current RDF production is about 4 million TPA, with cement industries utilising 2.5-3 million tonnes per annum (TPA).

Industries Using RDF

- Key industries: Cement, Power, and WtE.
- Benefits include reduced production costs and lower CO2 emissions.

Substitution Rates

- Cement industries can replace over 80% of coal with RDF, but the average substitution in India is around 5-7%.

RDF Composition and Hazards

- Contains combustible materials (plastics, paper, textiles), moisture, ash, chlorine, and sulphur.
- Typical composition: Net calorific Value ~ 2000 Cal/g, moisture ~ 25%, ash ~ 25%, chlorine ~ 1%, sulphur ~ 0.5%.

Import Regulations

- Import of RDF is banned in India due to its MSW origin.

Quality Comparison

- RDF quality in India is generally lower than in developed countries due to better segregation practices abroad.

Successful Utilisation Examples

- Companies like Dalmia Cement, JK Cement, ACC and Ambuja Cement effectively use large quantities of RDF.

Operational Challenges

- Inconsistency in RDF quality (size, calorific value, moisture, etc.) is a major challenge.
- Cement industries may establish pre-processing facilities to improve RDF quality.

Industry Support for RDF

- Cement industries generally support RDF use due to cost savings and reduced emissions.

Future Prospects

- Aim to increase coal replacement with RDF to at least 30%.

Government Regulation

- Pollution Control Boards regulate emissions from RDF use; the government encourages higher RDF usage through schemes but does not currently offer specific incentives.

Classification of RDF

- RDF is classified as a product rather than waste when used in cement production. As such, it is subject to GST.

Carbon Credits

- Cement companies can earn carbon credits through the Perform, Achieve, and Trade (PAT) scheme for using RDF, though formal notification of the carbon credit scheme is pending.

Suggestions for Improvement

- While current guidelines are adequate, there's a need for clearer guidelines on processing MSW to maximise RDF quality and suitable cost structures to encourage greater utilisation. Tax incentives for RDF use should also be considered.

Discussion

The responses obtained from the interview provide valuable insights into the current practices, challenges, and regulatory environment surrounding the use of RDF in cement kilns. RDF offers less efficacy compared to coal in the cement industry, with companies preferring RDF grades that meet MoHUA guidelines and have a calorific value above 2,000 kcal/kg. While industries like cement, power, and WtE facilities utilise RDF to reduce costs and carbon footprints, challenges such as high moisture and chlorine content, as well as inconsistencies in quality, hinder its ease of use compared to coal.

India has substantial RDF production potential, estimated at around 20 million tonnes per annum from municipal solid waste, although actual production is closer to 4 million tonnes. Cement companies like Dalmia and ACC have successfully integrated RDF, replacing up to 30% of coal. While the government regulates emissions and promotes higher RDF usage through the PAT scheme, there are no direct incentives. Improving processing guidelines and pricing strategies could enhance the sustainable use of RDF as an alternative fuel in the cement sector.

Over the past three years, from May 2019 to May 2022, 5.1 million tonnes of waste have been disposed of. The monthly disposal rate has significantly increased, surpassing 400%, with an average of 600,000 tons now being disposed of compared to the previous average of 141,000 tonnes.

Insights from Field Visits: RDF Management at Delhi’s Landfill Sites

During our visit to two landfill sites (Ghazipur and Okhla) in Delhi, we gained valuable insights into the workings of RDF. Ghazipur is the most prominent landfill area, covering approximately 70 acres. In these landfill areas the non-recyclable plastic waste is segregated is sent in its raw form to the respective cement plants, where it is pelletised to meet quality standards. In conversation with one of the site engineers, we learned that daily, 300 to 400 tonnes of RDF are transported.

Similarly, the Okhla landfill site, which covers 56 acres, transports about 150 tonnes of RDF daily. Currently, five cement companies, as far away as Chittorgarh in Rajasthan, are sourcing RDF from Delhi’s landfill sites. Additionally, paper mills located in western Uttar Pradesh, in districts such as Shamli, Muzaffarnagar, and Itawa, have begun lifting nearly 100 tons of RDF waste per day from Delhi.

Over the past three years, from May 2019 to May 2022, 5.1 million tonnes of waste have been disposed of. The monthly disposal rate has significantly increased, surpassing 400%, with an average of 600,000 tonnes now being disposed of compared to the previous average of 141,000 tonnes.

Figure 6: Gazipur Landfill site

Figure 7: Okhla landfill site

Figure 8: RDF samples collected from Okhla landfill

The segregated plastic waste, as shown in Figure 8 & 9, is transported directly to cement industries, raising questions about the quality of the RDF being delivered. During our conversations the site engineer, mentioned that it is up to the cement plants to decide how to handle the plastic waste—whether to use it as is or to process it further through pelletising. Notably, the process of pelletising is not specified in the contracts with these companies.

Challenges also persist in the RDF supply chain, including fluctuating waste composition and varying quality standards among cement companies. Addressing these issues is crucial for improving the sustainability of waste management practices in Delhi region. Overall, these revelation highlights the complexities and opportunities within RDF management in Delhi, emphasising the importance of quality control and standardisation.

Loopholes in present regulations

Indian MSW has a moisture content of approximately 50%, significantly higher than the 20%-25% moisture content found in European and American waste. As a result, the efficiency of waste incineration processes is reduced in India, making it less effective.[47] The current regulations governing RDF in India exhibit several significant loopholes:

- Firstly, there is a lack of comprehensive emission standards for RDF plants, which means inadequate control over pollutants that can compromise air quality and public health. Additionally, the gaps in monitoring and enforcement permit RDF facilities to operate with minimal oversight, risking pollution limits to exceed due to insufficient inspection and real-time monitoring.
- Current regulations also fall short in mandating thorough health impact assessments prior to the establishment of RDF plants, potentially overlooking adverse health effects on nearby communities. Furthermore, ambiguities in waste classification can lead to the inclusion of hazardous materials in RDF, resulting in the emission of harmful substances during combustion.[48]
- The regulatory framework exhibits limited public consultation and transparency, leaving affected communities without sufficient avenues to voice their concerns or access information about RDF operations and their environmental impacts. There is also inadequate attention to the management of residuals and by-products from the RDF process, which can lead to environmental contamination.[49]
- The inefficiencies in RDF transportation are yet to be addressed. Due to RDF's lower calorific value compared to coal, transporting it requires significantly more resources—nine trucks of RDF to match the calorific value of one truck of coal—making the process less efficient and potentially more environmentally taxing.[50]

Recommendations

To address the challenges associated with RDF in India and ensure a more sustainable waste management system, a comprehensive strategy focusing on data transparency, policy reform, and trade regulation is essential. The following recommendations aim to enhance the efficiency of the RDF sector while reducing its negative environmental and health impacts:

- **Reclassify RDF as Waste, not a Product**: RDF should be classified and regulated as waste rather than a fuel product. This reclassification would impose stricter environmental regulations, ensuring that RDF processing and combustion comply with waste management standards. The ambiguous treatment of RDF as a product allows it to bypass key regulations, leading to health risks and environmental degradation. Treating RDF as waste would close regulatory loopholes and hold facilities accountable for emissions.
- **Increase Transparency in Data Collection and Public Access**: The trade data on RDF should be made readily available on public platforms to promote transparency and accountability. Information on RDF production, transportation, emissions, and environmental impacts must be accessible to the public and civil society organisations. Establishing a centralised database for RDF facilities, emissions, and trade data will help assess the true scale of its environmental and health impacts, informing better policy decisions.
- **Enforce Stringent Quality and Emission Standards**: Strict quality standards for RDF production should be enforced to reduce contamination and moisture content, improving its performance and minimising harmful emissions. Regular audits and inspections of RDF facilities should be mandated, and penalties for non-compliance must be more stringent. Advanced sorting and processing technologies should be required to ensure RDF meets established guidelines. Emission controls need to be updated to include comprehensive standards for pollutants like dioxins, furans, and heavy metals.
- **Strengthen Policy Framework for RDF and Co-Processing**: India's regulatory framework needs to prioritise stricter guidelines for RDF co-processing in cement kilns and WtE plants. The government should revisit policies like the Solid Waste Management Rules (2016) to ensure they reflect the latest environmental data and global best practices. RDF's current thermal substitution rate targets in the cement industry should be reassessed, focusing on long-term sustainable alternatives rather than short-term gains from RDF.
- **Ban RDF Use in Incineration and Co-Processing Facilities**: The use of RDF should be phased out in cement kilns and WtE plants due to the environmental and health hazards it poses. Civil society organisations and NGOs have highlighted the risks of incineration and co-incineration, particularly the release of toxic pollutants. As India transitions towards more sustainable waste management, RDF should no longer be considered a viable fuel alternative.
- **Promote Sustainable Waste Management Alternatives**: India must shift its focus to zero-waste and circular economy models. Civil society, academic institutions, and industries should collaborate to develop safer, cost-effective, and sustainable waste management solutions. This could include expanding waste management infrastructure, enhancing composting for organic waste, and investing in technologies that promote resource recovery without incineration or co-processing.
- **Conduct Comprehensive Environmental and Health Impact Assessments**: Independent and regular environmental and health impact assessments should be required for all RDF facilities. These assessments must evaluate air quality, toxic emissions, and the long-term effects on nearby communities. The results should be made publicly available, and facilities found violating environmental standards should face closure or severe penalties.
- **Strengthen Public Engagement and Awareness Campaigns**: To build a broader consensus on safer waste management practices, public awareness campaigns must be initiated. These campaigns should inform citizens about the risks of RDF use, the benefits of sustainable alternatives, and the importance of waste reduction at the source. Regular community engagement and updates from the government will help foster support for policy changes and more sustainable practices.
- **Support Research and Innovation**: India should invest in research and development (R&D) for innovative waste management solutions that do not rely on RDF. This includes technologies to enhance recycling rates, improve organic waste composting, and develop alternatives to plastic use. By prioritising R&D, India can reduce its reliance on WtE technologies and RDF and focus on long-term sustainable practices.

Conclusion

India is increasingly looking to RDF as a solution to its waste management crisis, especially given the growing pressure to manage MSW sustainably. With the government's promotion of RDF as a means of addressing both energy needs and waste disposal, India has seen a rise in RDF production and usage in sectors like cement and WtE plants. However, while RDF is marketed as an environment friendly alternative, it is, in reality, more of a problem than a solution. Its use introduces significant challenges, from public health concerns to environmental degradation, raising questions about its long-term sustainability and the true cost of reliance on this method.

India faces unique challenges when it comes to RDF. One major issue is the inconsistent quality of waste streams used for RDF production. The high moisture content and contamination of MSW in India make RDF less efficient and more polluting compared to traditional fuels. This leads to the release of harmful emissions, including dioxins, PFAS, furans, and heavy metals, which have serious implications for both human health and the environment. Communities living near RDF processing facilities and cement kilns are particularly vulnerable to these emissions, often experiencing respiratory problems, increased cancer risk, and a general decline in quality of life. Additionally, many of these RDF plants lack adequate pollution control mechanisms, and even when such systems are in place, they are often poorly monitored and enforced, exacerbating the problem.

Furthermore, India's regulatory framework around RDF has significant loopholes. There is a lack of comprehensive emission standards for RDF plants, and many facilities operate with minimal oversight. Enforcement mechanisms are weak, allowing pollution limits to be exceeded with little consequence. The classification of RDF as a "product" rather than waste adds to the complexity, allowing RDF to bypass stricter regulations that typically govern waste management. This ambiguity is further compounded by the fact that there is insufficient transparency in how RDF is managed and traded within India.

The need for increased transparency is paramount. Currently, there is limited publicly available data on the environmental and health impacts of RDF usage in India. Access to detailed information on RDF production, usage, emissions, and the associated risks remains restricted, leaving the public largely uninformed about the dangers of this practice. Transparency in RDF trade data is equally crucial. Classifying RDF as waste and ensuring that its trade data is made accessible on public platforms would allow for greater accountability and help in assessing the true scale of its impact.

Moreover, India needs to invest in greater public awareness and research on the health and environmental consequences of RDF. Civil society organisations, academic institutions, and NGOs are already working on the ground, advocating for more sustainable and cost-effective waste management models. These groups are calling for a shift towards zero-waste strategies, enhanced recycling programs, and better resource recovery systems that reduce the country's dependency on incineration and co-incineration of waste. Their efforts, along with increased data in the public domain, could galvanize broader public support for safer alternatives to RDF.

The appetite for change in India is strong. Frontline communities facing the direct threat of incineration, along with civil society groups, are demanding cleaner, healthier solutions. The solution lies not in promoting RDF but in rejecting it as a viable option. India must classify RDF as waste and strictly prohibit its use. By prioritising waste reduction, recycling, and the development of clean technologies, India can move towards a more sustainable future. This requires stronger government policies, increased investment in safer waste management practices, and above all, transparency and accountability in the handling and trade of RDF. Only then can India truly address its waste problem in a way that protects both the environment and public health.

ANNEXURE I

Interview Insights from Industry Stakeholders on the Use of RDF in Cement Kiln Factories

To gain a comprehensive understanding of the use of Refuse-Derived Fuel (RDF) in cement kiln factories, we conducted an interview with **Ulhas Parlikar,** is a seasoned expert in waste management and circular economy, serving as the Former Director of Geocycle Business at ACC Limited and Former Deputy Head of Geocycle India, and currently as a Board Director at the Material Recycling Association of India (MRAI) and a global consultant focused on policy advocacy, alternative fuel resources, and co-processing. The following set of questions were posed to explore various aspects related to RDF usage, including its benefits, challenges, and regulatory issues.

Interview Questions and Responses:

- **What is the calorific value or grade of RDF used by cement industries? Is RDF better as compared to traditional fuels?**
  Cement industry prefers to use RDF that is close to the specifications of Grade I or II or III as specified in the RDF co-processing guidelines published by MoHUA. RDF is inferior in terms of the ease in utilisation compared to coal. Mainly due to the presence of higher quantum of moisture and Chlorine levels present in RDF compared to that in coal.
- **What are the different types or grades of RDF used in various industries? What grade of RDF is sent to incinerators?**
  Generally, raw MSW or raw RDF - I have coined a term for it called “Segregated Combustible Fractoipn (SCF) - is used in incinerators (Waste to Energy facility). RDF required to be used in cement must be close to the Grade I, II & III as specified in the MoHUA guidelines. RDF to be used in power plant depends upon the Chloride level present in it. Generally, it is limited in quantity to replace about 10%-15% of the coal maximum. Use of RDF in any other industry is not common.
- **What is the total production and consumption of RDF in India? Is the demand for RDF by industries being met?**
  The SCF content in the MSW is generally 40% to 50%. When processed, RDF produced from it amounts to about 30% to 40%. Assuming MSW generation in the country to be about 70 million TPA, the RDF generation potential is about 20 million TPA at least. However, the present generation—my guess value—is about 4 million TPA and out of the same, cement industry utilises about 2.5 million to 3 million TPA and balance is used by power plant and WTE facilities.
- **Which industries are utilising RDF? What are the primary advantages these industries gain from using RDF?**
  Cement, Power and WTE are the industries that use RDF. All of these industries use it to reduce the cost of production and the CO_2 foot print.
- **What is the average percentage of RDF used as a substitute in cement kilns? What is the maximum percentage of RDF substitution achieved by cement industries?**
  In cement, we can replace more than 80% of the coal using RDF. Globally, the average value of RDF would be about 15% to 20% out of the average figure of Alternative Fuel and Raw material (AFR) usage of about 27%. In India we are replacing coal with RDF about 5% to about 7% on an average. Some industries are replacing about 25% to 30% of the coal with RDF.
- **What is the typical composition of RDF? What potential environmental hazards are associated with its use?**
  RDF contains combustible fraction, Inert material and moisture with some level of chlorine and sulphur contamination. The combustible fraction contains non-recyclable plastics, contaminated paper, plastics, old clothes, pieces of thermocol, rexin, rubber, leather, tyres, etc., old chappals and shoes, etc. Net Calorific Value (NCV) of the RDF utilised in the cement industry is generally 2,000 Cal/g. Its typical composition is: moisture 25%, ash 25%, chlorine approximately 1%, and sulphur 0.5%.
- **From which countries is RDF imported, and what are the typical quantities involved?**
  RDF — being a product of MSW — is banned for import in India. This is clearly documented in the Rules.
- **How does the quality of RDF in India compare to that of RDF from other countries?**
  Generally, the segregation level of MSW is very good in developed countries. Hence, the contamination of RDF with food & inert material is very less. Also, many developed countries do not have well developed recycle facilities for plastic and other similar materials. Hence, the RDF quality is substantially better from these countries compared to that in India.
- **Are there any notable case studies or examples of successful RDF utilisation in the cement industry? Please provide details.**
  We have some of the cement plants of companies such as Dalmia Cement, JK Cement, ACC Cement, Ambuja Cement, etc consume large quantum of RDF in their cement manufacturing process.

- **What operational challenges do cement industries face when using RDF? How are these challenges typically addressed?**
  The major challenge is the inconsistency in the quality of RDF in terms of Size, Calorific Value (CV), Moisture, Ash, Chlorine and Sulphur content. Cement industry typically accepts material having size of 50–80 mm; NCV of 2,000 Cal/g; moisture content of 25%; ash content of 25%; chlorine content of 1%; and sulphur content of 0.5%. If the RDF supplier is not in a position to supply RDF of desired quality, cement industry sets up the pre-processing facility and processes the available RDF to achieve the desired quality.
- **Do cement industries generally support or oppose the use of RDF? What are the primary reasons for their stance?**
  They support the use of RDF because reduction in cost and CO_2 emission is their objective.
- **To what extent has RDF replaced traditional coal in cement industries? What are the future prospects for increased substitution of coal with RDF?**
  As informed above the average replacement of coal using RDF in India is about 5% to 7% and there are also plants that replace upto 30% coal replacement. The cement industry would desire to achieve an average replacement of coal with RDF to a level of 30% at least.
- **How does the government regulate the use of RDF in the cement industry? What role does the government play in its regulation? Are there any government incentives for using RDF?**
  Government – Pollution Control Boards – only regulate the emissions from use of RDF in cement & other industries. Government is encouraging higher level of coal replacement with RDF through PAT scheme, Carbon credit route etc. There are no incentives offered to use RDF in cement or other sectors. The government must facilitate setting up of more and more MSW and RDF processing facilities.
- **Is RDF considered a product or waste when used in cement kilns? Additionally, what is its HS code?**
  As RDF for cement use is a processed output, it is considered as a product and attracts GST on the same. (I think it is 5%)
- **Are carbon credits provided to cement companies for using RDF? If so, what are the criteria for obtaining these carbon credits? Do you know which companies are collecting carbon credits due to RDF?**
  The PAT scheme has been encouraging the use of RDF in cement industry and many cement companies have gained E-certs from the same. Carbon credit scheme is yet to be formally notified as per my understanding. I understand the suitable mechanism is envisaged in the carbon credit scheme to derive suitable benefit from use of RDF.
- **Are you satisfied with the current government regulations and guidelines? If not, what are your suggestions for improving and ensuring the sustainable use of RDF?**
  The current guidelines are fine. However, there are no guidelines from government on processing of MSW to produce maximum RDF of desired quality. This is required to be configured in the MSW treatment tender documents. The cost of RDF needs to be pegged suitably for the cement industry to utilise it maximally and also it must provide tax incentives for use of RDF.

Discussion:

The responses obtained from the interview provide valuable insights into the current practices, challenges, and regulatory environment surrounding the use of RDF in cement kilns. RDF offers less efficacy as compared to coal in the cement industry, with companies preferring RDF grades that meet MoHUA guidelines and have a calorific value above 2000 kcal/kg. While industries like cement, power, and WtE facilities utilize RDF to reduce costs and carbon footprints, challenges such as high moisture and chlorine content, as well as inconsistencies in quality, hinder its ease of use compared to coal.

India has substantial RDF production potential, estimated at around 20 million tonnes per annum from municipal solid waste, although actual production is closer to 4 million tonnes. Cement companies like Dalmia and ACC have successfully integrated RDF, replacing up to 30% of coal. While the government regulates emissions and promotes higher RDF usage through the PAT scheme, there are no direct incentives. Improving processing guidelines and pricing strategies could enhance the sustainable use of RDF as an alternative fuel in the cement sector.

ANNEXURE II

RTI Responses

- Please provide the total number of Refuse-Derived Fuel (RDF) plants that were operational in India from 2019 to 2024.
  As on date, the total number of plants (Cement plants and Waste to Energy plants using RDF) registered on CPCB EPR portal are 109.
- Please provide the number of cement plants in India that started using Refuse-Derived Fuel (RDF) from 2019 to 2024.
  As on date, the total number of Cement plants using RDF, registered on CPCB EPR portal are 74.
- Please provide information on how many RDF plants in India used imported Refuse-Derived Fuel (RDF) from 2019 to 2024.
  Information is not available.
- Please provide the number of industries, other than cement plants, that utilized Refuse-Derived Fuel (RDF) in India from 2019 to 2024.
  As on date, the total number of industries, other than cement using RDF (i.e Waste to Energy plants), registered on CPCB EPR portal are 35.

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Date of action	19/09/2024
Reply :- Reply for 1: As on date, the total number of plants (Cement plants and Waste to Energy plants using RDF) registered on CPCB EPR portal are 109. The same information is available at CPCB EPR website, https://eprplastic.cpcb.gov.in , Navigate to Dashboards open then go to SPCBs/PCCs option and then to PWP. Reply for 2: As on date, the total number of Cement plants using RDF, registered on CPCB EPR portal are 74. Reply for 3: Information is not available. Reply for 4: As on date, the total number of industries, other than cement using RDF (i.e Waste to Energy plants), registered on CPCB EPR portal are 35.	
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