2022

# SUMMARY OF PLASTIC WASTE MANAGEMENT STRATEGY FOR GUJARAT

## INDIA-NORWAY COOPERATION PROJECT ON CAPACITY BUILDING FOR REDUCING PLASTIC AND CHEMICAL POLLUTION IN INDIA (INOPOL)

INOPOL

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*New Delhi*

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## Acknowledgements

The Plastic Waste Management Strategy is a joint effort by the **Norwegian Institute for Water Research (NIVA)**, Norway's leading institute for fundamental and applied research on marine and freshwaters; **Mu Gamma Consultants Pvt Ltd (MGC)**, a research and consultancy organization working towards environmental friendly solutions in promoting green development across India; **The Energy and Resources Institute (TERI)**, a not-for-profit, multi-dimensional, policy research organization working in the fields of energy, environment, and sustainable development, and **Central Institute of Petrochemicals Engineering & Technology (CIPET)**, a premier academic institution working on developing plastics recycling technology and cost-effective recycled plastics. The research for the Plastic Waste Management Strategy for Gujarat was carried out under the scope of the **India-Norway cooperation project on capacity building for reducing plastic and chemical pollution in India (INOPOL)**, under the Marine Pollution Initiative developed by the two governments, and funded through the Norwegian Development Program to Combat Marine Litter and Microplastics. The INOPOL group would like to thank the project owner, the Royal Norwegian Embassy in New Delhi, and the Norwegian Ministry of Foreign Affairs (MFA), for funding and supporting the project.





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## Disclaimer

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## SUMMARY

### The INOPOL project

The India-Norway cooperation project on capacity building for reducing plastic and chemical pollution in India (INOPOL) is a collaboration project between Indian and Norwegian institutions with the objective to build knowledge and capacity to reduce plastic and chemical pollution from major sources within industry, public sector and civil society in India. The INOPOL project is led by the Norwegian Institute for Water Research (NIVA), in close collaboration with Mu Gamma Consultants Pvt. Ltd. (MGC), Central Institute of Petrochemicals Engineering and Technology (CIPET), The Energy and Resources Institute (TERI), SRM Institute of Science and Technology (SRMIST) and Toxics Link. The project aims to address the highly interlinked challenges of marine litter, microplastics and Persistent Organic Pollutants (POPs), with the overarching goals of enhancing capacity to reduce marine litter and microplastic pollution in Gujarat state and building capacity to reduce releases of plastic wastes and POPs in India by supporting the implementation of the Stockholm Convention (SC). The Plastic Waste Management Strategy Report for Gujarat focuses on INOPOL's work in the former domain.

### Plastic pollution in Gujarat

The INOPOL project focused on the presence of plastic pollution in the catchment areas of the rivers of Tapi (Tapti) and Daman Ganga, along the cities of Surat and Vapi in Gujarat state. These two rivers are highly affected by petrochemical and industrial activities and are major receivers and transport routes for land-based plastic pollution. Tapi river flows through the metropolitan city of Surat, which has experienced significant economic growth and

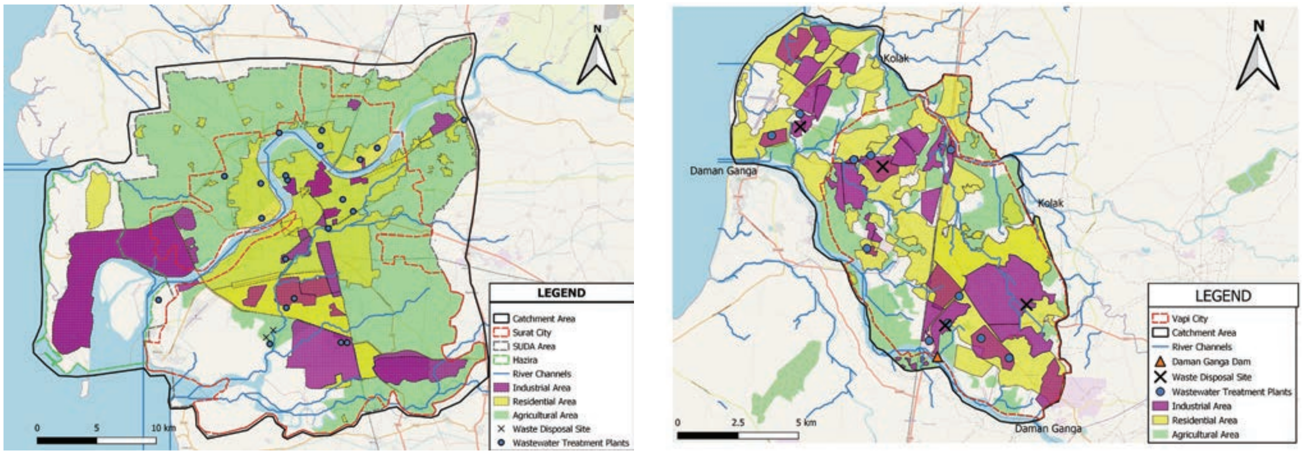


**Figure 1:** Land use map and catchment of (A). Surat & (B). Vapi (Map developed on QGIS 3.18)

has been estimated to have the highest composition of municipal plastic waste generation of 60 Indian cities. Vapi is situated near the banks of Daman Ganga and is the largest industrial area in Gujarat, dominated by chemical and paper industries.

Estimates suggest that waste generation in both Surat and Vapi will increase significantly in the next decade. Gujarat is, and has been over the past decades, one of the fastest growing states in India. It has a strong industrial and manufacturing base which caters to both the domestic and international market. Some of the leading industrial activities relate to the gems and jewellery, pharmaceutical, chemical, petrochemical, textile, pesticide and Fertiliser industries. For example, 25 % of India's plastic is manufactured in Gujarat, largely by Micro, Small and Medium Enterprises (MSMEs). While on the one hand, recent growth has created employment opportunities and prosperity, there are also environmental challenges that accompany this growth, including with respect to plastic and chemical pollution. Gujarat state is the second largest generator of plastic waste in India, with approximately 3,56,873 tonnes per annum in 2018-2019. Most of the plastic waste produced in India comes from 10 major cities which includes Ahmedabad and Surat in Gujarat state. While a portion of this is captured in the formal and informal waste management and recycling streams, plastic material also escapes from industrial and municipal plastic waste streams. Once this pollution reaches marine ecosystems through riverine systems, it can have a range of detrimental effects. The catchment areas of the Tapi and Daman Ganga rivers are polluted with plastic debris on account of high population densities, increased usage of single use plastics products (SUPPs), tourism, shipping and fishing activities.

## Monitoring

Microplastics (MPs) are tiny pollutants that are a potential hazard in the environment. Due to their slow degradability, potential ingestion by fish and other aquatic living organisms, their potential role as carriers to concentrate and transport synthetic and persistent organic pollutants, MPs are a growing environmental concern which are found in two types in the environment: Primary and Secondary. Primary MPs are those which are engineered to be small in size and are found to be mostly used in personal care products, whereas the secondary MPs are a result of fragmentation of larger plastics over time.

The world's oceans contain significant accumulations of plastic debris which are primarily delivered by river systems. Rivers can act as carrier of plastic pollution from land-based sources which is a collection of domestic and industrial activities, improper solid waste management practices and wastewater treated effluents. Thus, rivers are the major route of plastic debris transport from land to the oceans. The MPs present in rivers are of different shapes, sizes and chemical composition, including of common polymer types such as Polypropylene (PP), Polyamide (PA), Polyethylene (PE), Polystyrene (PS), Polyethylene terephthalate (PET), Polyvinyl chloride (PVC), Polymethyl methacrylate (PMMA) etc. These are the most abundantly used polymers in common households and the plastic industries for manifold applications. The analysis of microplastics in rivers is of utmost importance since a lot of information can be gained about the morphological aspect, type and quantitation of those materials which has been currently raised as an environmental threat.

For the INOPOL project, sampling campaigns were organized during the winter and the monsoon season in December 2020 and September 2021 in Vapi and Surat for collection of water samples from the rivers present in the cities. Different sampling stations were scouted in the upper, middle and lower stream of the rivers for water collection. The sampling was performed through nets of variable mesh sizes of 0.3mm, 1mm and 3cm and water was collected in glass bottles to avoid contamination. Nets of different mesh sizes were used to measure the plastic flux in the river during a specified period of time. Also, surface water from glass bottles were collected for

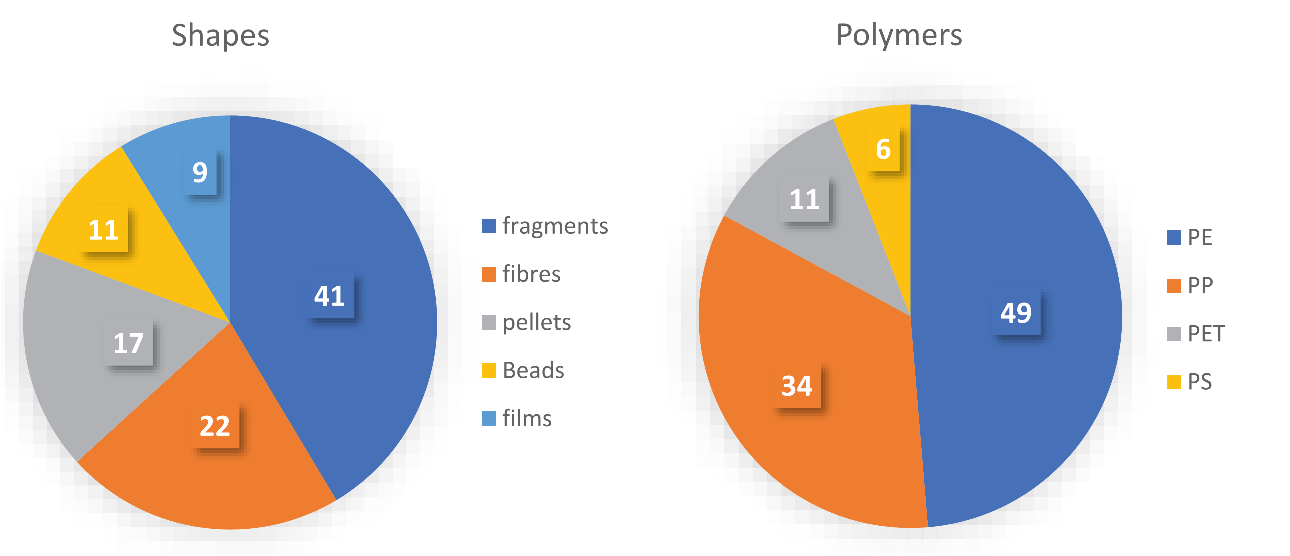


**Figure 2:** Microplastic particles identified in Daman Ganga and Tapi river and categorised in shapes and polymers (in percentage).

further analysis of microplastics present in the rivers. Additionally, samples were collected from Dumas beach to investigate MPs. Visual observation was also carried out to count the type and amount of plastics flow in the river in a specific period.

The extraction for microplastics were carried out in the laboratory in a clean environment. Different extraction process such as sieving, density separation, wet peroxide oxidation (WPO) and vacuum filtration were performed for MPs extraction from river water and beach samples. The samples were characterised through optical microscopy, micro-Fourier Transform Infrared (μ FTIR) Spectroscopy and Pyrolysis-GCMS (Py-GCMS). Optical microscopy helps in determining the shape, size and colour of MPs which further helps in quantifying and characterising the MPs in river whereas FTIR and Py-GCMS helps in identifying polymer type of microplastics found from the samples.

Visual observation of larger plastic debris in the river revealed a number of floating plastics which include items such as food packaging, plastic bottles, plastic cups and spoons, medical bottles, plastic caps, plastic woven sacks etc.

Through the optical microscopic analysis and visual identification, it was concluded that fragments were the dominant shape which constitued 41.41 % of the total particles found in both the rivers. Based on colours, white particles were predominant 46.20% in both the rivers. The highest concentration of MPs in Daman Ganga river was found in Silvassa Site (S2) with 6.99 pieces/L followed by the location just downstream of the Madhuban Dam just before Rakholi bridge (S1) with 4.35 pieces/L. Further downstream, at Daman city, the concentrations of MPs were found to be 1.71 pieces/L and 1.08 pieces/L for Jetty De Damão Grande (S3) and Nani Daman Jetty (S5), respectively. Similarly in Tapi River it was observed that the concentrations of MPs were higher upstream at Bori Savar village (located downstream of Ukai Dam) with 3.72 pieces/L (S6) and 2.48 pieces/L (S8). The concentration at Surat River Front (S9) was found to be 0.93 pieces/L . The samples collected from Dumas beach (present in Surat where Tapi River meets the sea) showed that the concentration of microplastics was higher near the Dariya Ganesh Temple (S10) with 1.39 pieces/L and the samples collected few hundred meters away from the temple (S11 and S12) were lower at 0.46

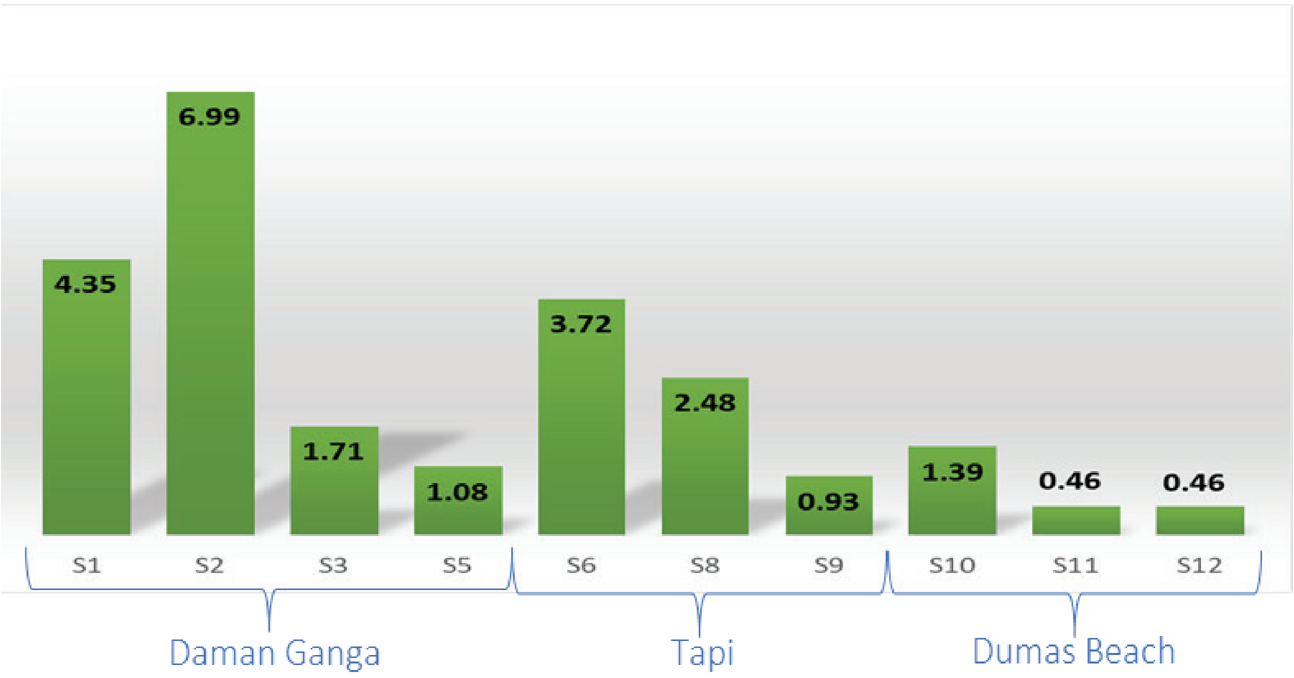


**Figure 3:** Concentration of microplastic particles quantified in surface water (pieces/L) from Daman Ganga and Tapi river, and Dumas beach.

pieces/L each (Figure 3). From the spectral analysis through FTIR, the presence of PS, Low Density Polyethylene (LDPE), High Density Polyethylene (HDPE), PET, PP was detected in Daman Ganga river. Similarly, in Tapi river, PET, PP and LDPE and from Dumas beach, PMMA and, PP were observed, respectively. The Py-GCMS analysis additionally confirmed the presence of PA, PE and PS from the Daman Ganga river, PP, PS and PVC in Tapi river and PE and PS from Dumas beach, respectively.

## Mapping the sources and fluxes

Gujarat, recognised as one of the most industrialised states in India, has significant presence of several manufacturing industries including automobile factories. The increase in numerous industrial establishments has resulted in the increase of many hazardous industrial pollutants. The state accounts for 28% of the hazardous waste generated in the country. Cities like Surat and Vapi in Gujarat are among the top cities in the state hosting many industries which contribute to waste generation thereby polluting the rivers Tapi and Daman Ganga, respectively.

Modelling has proven a useful tool to supplement and expand the predictive power of empirical data. In the present project, a hydrodynamic model was set up to assess the fluxes of plastic pollution in the studied river catchments. A key outcome was the illustration of the strong impact of flooding in the transport of plastic litter in rivers (Figure 4). This emphasises the importance of source control measures to reduce pollution, as well as timing clean up campaigns prior to the rainy season to reduce the amount of litter that is washed downstream and to the ocean.

## Regulatory developments

Over the past 30 years, starting with the Environmental Protection Act (1986) to the most recent Plastic Waste Management Rules (PWMR) Amendments (2021,2022), several regulatory and

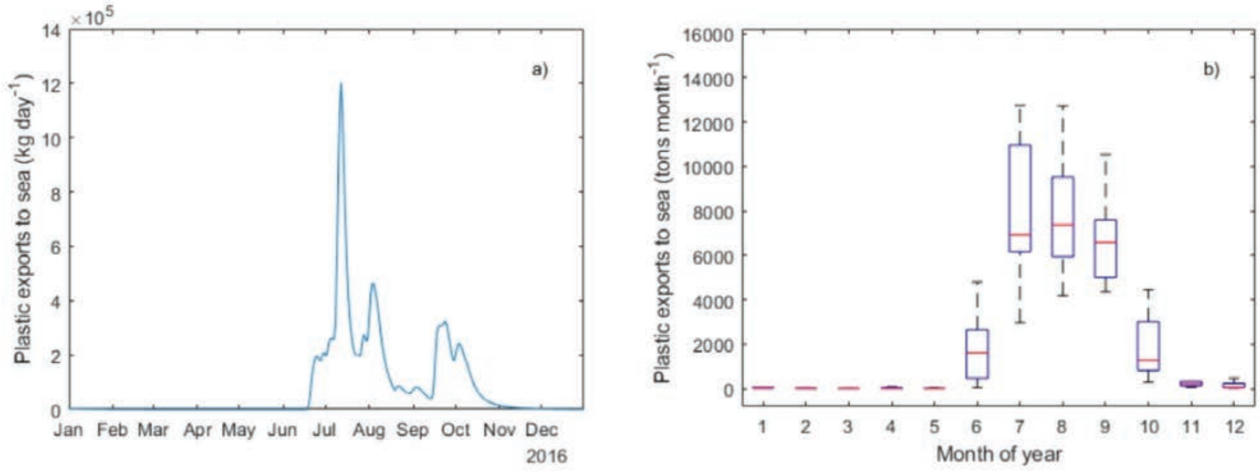


**Figure 4:** Daily (a) and monthly (b) plastic exports to sea from Tapi river estimated with the default values. Monthly exports were calculated over 2010-2020.

policy interventions have been introduced in India that inform rules, protocols and guidelines to manage waste at national, state and local level (Figure 5). Key drivers behind the recent Extended Producer Responsibility (EPR) rules and PWMR amendments (2022, 2021) are the promotion of a circular economy, as well as the control and regulation of a set of Single Use Plastics (SUPs).

Industry stakeholders, interviewed as part of this report, are broadly positive of the PWMR amendment and EPR rules, praising them for their framing and timeliness, while emphasising the importance of social considerations (i.e., workers in the informal recycling sector), limited capacities for implementation in the short run and in some cases struggling with the sudden ban on certain SUP items such as straws - especially considering the lack of viable alternative materials. Waste management is a complex issue, however, not limited to policy design. It also includes other system components ranging from infrastructure, technology, societal inequality and economic incentives to consumer behaviour. Initiatives like the (volunteer) driven 'India Plastics Pact' composed of industrial and civil society actors targets more circular solutions (e.g., through re-designs of consumer products). Other civil society and state driven initiatives (e.g., by Gujarat Pollution Control Board (GPCB)) create awareness and accessible opportunities for safer and better recycling streams and are important components towards addressing a systemic challenge.

In the context of leveraging locally appropriate solutions to plastic pollution, various initiatives, models and efforts are taking shape at the international level and India. Ongoing negotiations under the resumed fifth session of the United Nations Environment Assembly (UNEA-5.2) have led to the establishment of an Intergovernmental Negotiation Committee (INC) in 2022, with the aim to institute an international and legally binding treaty on plastic pollution in the near future.

## The informal sector

Another key component in India's waste management system is the informal recycling sector (IRS), which is estimated to consist of 2-4 million people that recycles 20-60% of the total recyclable waste. However, detailed primary data of its contribution, functioning and challenges are limited, and lack a common standard and methodology. In this report, the IRS has been mapped in association with Kabadiwalla Connect (KC) in Surat and Vapi. The findings showcase a detailed account of the role that the different actors

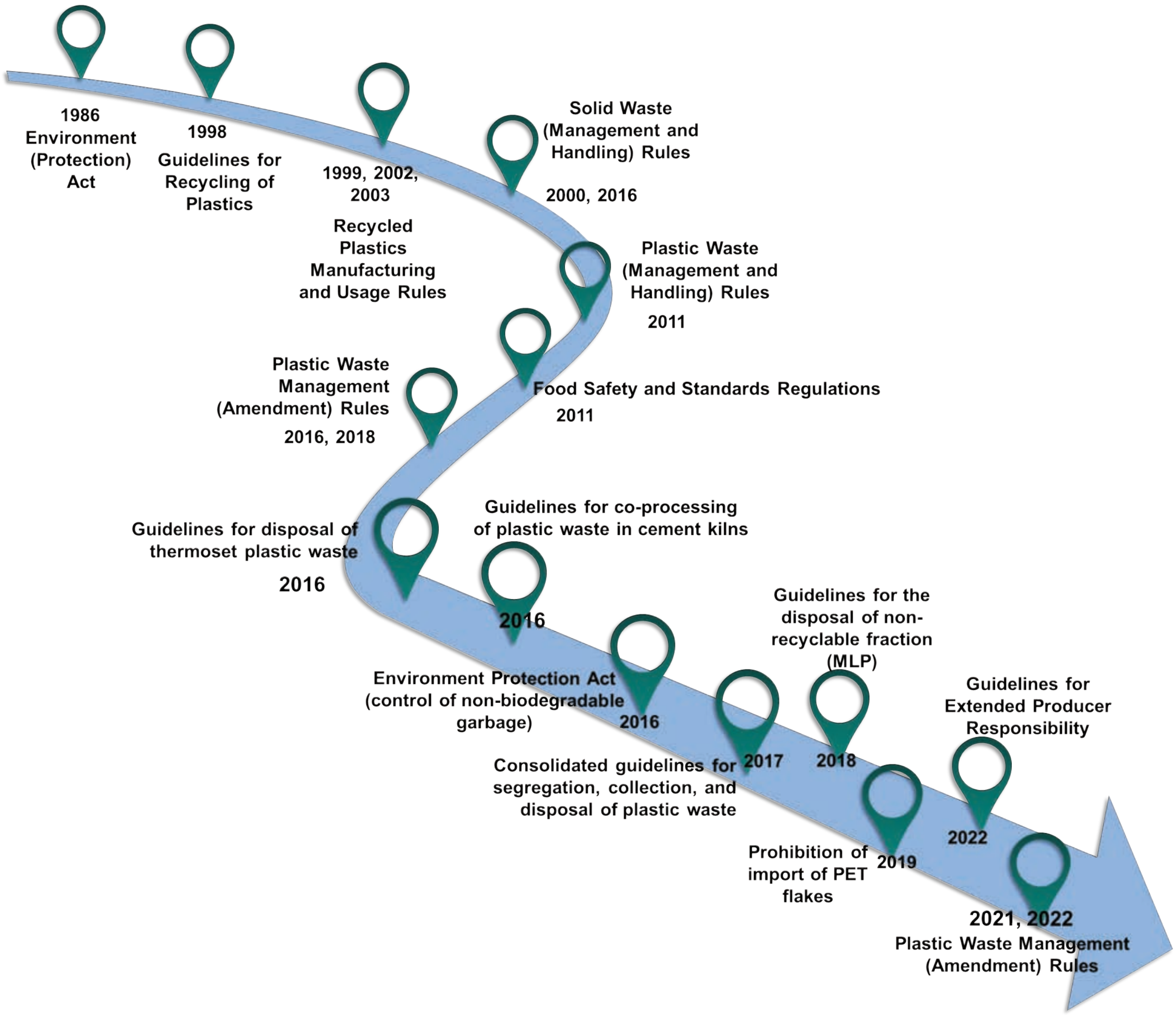


**Figure 5:** Key policy developments on PWM between 1986 and 2022 with relevance for plastic regulation and management in India.

play along the value chain in the waste management stream, their socio-economic status, as well as value creation. The study documents the large volumes and values of post-consumer recyclable waste that are processed by the IRS, as well as its active role to supplement existing, formal municipal waste management systems. It is argued that there is a need to create similar baselines for tier 1, 2 and 3 cities across the country to inform municipal policies in a targeted fashion to promote effective recycling, understand gaps, while promoting a just transition of the IRS. Given the potential adverse health impacts by which plastic materials act as vectors for POPs, the reduction of plastic pollution also assumes an important public health dimensions, both for informal labourers and the public.

## National and International best practices and experiences

The (plastic) waste management field has become an increasingly dynamic area that has been the subject of technical innovations (e.g., bioplastics), conceptual considerations (e.g., circular economy, zero waste), institutional and regulatory interventions (e.g., SUPP bans, EPR rules or import bans of waste products) and increased resource allocation. Plastic pollution has played an important role in galvanising this process internationally, motivated by the urgency to address the challenge and broad-based public support to do so. For example, circular economy and in parallel zero waste approaches have evolved to find mention in national waste management strategies across the world from India to the European Union. The banning of various SUP products such as thin plastic bags has been trialled and implemented in countries such as Bangladesh, India or Rwanda, and many Asian countries have started to ban the import and limit the trade of plastic waste. There has also been a growing interest in alternative materials to plastics, such as bioplastics, which promise to be compostable and provide an avenue to de-link the material from fossil fuels. The experience so far shows a complex picture. The adoption of circular economy practices has been rather slow and proven to be challenging in both developed and emerging economies – also on account of its relatively recent promotion. Key ingredients towards successful implementation relate to the existence of formal waste management structures, institutional and monitoring capacities, production infrastructure, investment costs and competitiveness of products, facilitating interdependent production and supply chains, as well as favourable regulation and behavioural changes. At the same time, promising initiatives have started to take root, particularly in the context of recent EPR rules world over. Bans – a popular instrument in the toolbox of plastic regulations – have had some positive effects in surveyed countries; yet, assessing the impact has proved difficult given the recent advent of comprehensive regulations such as the EU Single-use Plastic Directive (2019), or India's EPR (2021, 2022). Early adopters such as Bangladesh in 2002 reported a fall in SUP waste generation initially, but not in a sustainable fashion without adequate supportive action. The main point of consideration is that bans by themselves are of limited effect if not supplemented with other informational, economic and infrastructure measures.

Bioplastics, i.g., biodegradable and compostable plastics, are receiving significant attention as potential alternatives to plastics. However, various stakeholders, including the ones from industry sector who were interviewed, eye it critically for potentially polluting waste streams and being uneconomical at present. In addition, their environmental impacts and sustainability remain under scrutiny. They may be more resource intensive to produce and there is insufficient knowledge about the fate or impacts of these materials if they are discarded into the environment or are not fully compostable within certain climate conditions i.e., in a natural environment vs industrial processing.

While international deliberations are a key learning and feedback forum on developments in the field, it is important to adopt waste management systems and practices that are locally appropriate and sustainable for India. For example, the cities of Panaji, Indore, Bengaluru, Ambikapur, Kumbakonam and Surat have trialled various innovative interventions that hold some successes and lessons by increasing waste segregation, changing of behaviour and the more effective application of monitoring and enforcement strategies. Successes were mediated by strong leadership, effective communication strategies, cost-effectiveness and broad stakeholder participation including of civil society actors.

## Strengthening Capacity to address new Challenges

MP pollution has received substantial attention globally, yet the number of studies investigating environmental contamination by MP in India is relatively low. To strengthen existing capacity and build new competence in research institutes in India, a training programme in MP analysis and an inter-laboratory comparison (ILC) exercise were conducted within the INOPOL project. The training programme addressed aspects related to sampling, analysis, data reporting and quality control and targeted academia and state laboratories. The primary objective was to highlight important concepts, knowledge and ongoing challenges to facilitate institutes across India to undertake effective and efficient MP analysis. The ILC exercise focused on helping institutes to strengthen their capacity and address an urgent need for harmonisation in the microplastic research community. The ILC was designed in such a way that each task tested important aspects of MP analysis as well as revealing the likely root cause of possible challenges hindering accurate detection. This helped identify both unique and shared challenges amongst participating laboratories, and allowed for a tailored and targeted programme to strengthen capacity.

## Outline of the report

The proposed actions in this report speak to the goals and strategies of the Indian Plastic Waste Management Rules, including the recent EPR and SUPP-ban amendments, as well as international frameworks such as the Basel Convention, the Stockholm Convention (POPs and plastic interactions) and the ongoing global plastic treaty negotiations. Further, the report will contribute towards achieving the UN Sustainable Development Goals (SDGs) including 2.1, 3.9, 6.3, 11.6, 12.4, 12.5, 14.1 and 16.1.

The aims, objectives and context of INOPOL are outlined in **Chapter 1** of this Plastic Waste Management Strategy report. **Chapter 2** presents the overarching project background and a detailed description of the pilot catchment areas and study sites. This includes information on current waste composition, its management and recent policy developments as well as relevant hydrological, demographic, socio-economic and pollution data. **Chapter 3** presents the monitoring protocols, methodological approaches for the sampling and analysis of macro and micro plastics in the catchment areas. It also presents the results and seeks to address the issue of existing data gaps and limitations. **Chapter 4** provides an overview of key plastic pollution sources in the catchment areas, as well as the modelling of various scenarios in the river transport of plastic waste to the ocean. **Chapter 5** discusses key considerations when creating impactful policy regimes, which are to include key stakeholders (e.g., industry, consumers, civil society) in the process of formulation, as well as consider market implications, institutional capacity for compliance or technological access for their implementation. **Chapter 6** delves into recent conceptualisations, international and national perspectives, frameworks and model initiatives that hold promise and inform the direction of addressing plastic pollution in future. **Chapter 7** proposes the recommendations and way forward from this study in order to strengthen the science-policy-society interphase.

# ABOUT US

**Norwegian Institute for Water Research (NIVA),** https://www.niva.no/en, is Norway's leading institute for fundamental and applied research on marine and freshwaters. Their research comprises a wide array of environmental, climatic, and resource-related fields. NIVA's world-class expertise is multidisciplinary, and combine research, monitoring, evaluation, problem-solving and advisory services at international, national, and local levels.

**Mu Gamma,** https://www.mugammaconsultants.com/, works towards environmental-friendly solutions in promoting green development across India. Mu Gamma's work entails research, advocacy, consultancy, and capacity building on waste management (hazardous chemicals, POPs, plastics, marine litter, emerging contaminants), water resources management in rural and urban areas (water & sanitation, chemical pollution control), public health and environment, climate change, corporate social responsibility, sustainable governance, and education for sustainable development.

**The Energy and Resources Institute (TERI),** https://www.teriin.org/, is a not-for-profit, multi-dimensional, policy research organization - working in the fields of energy, environment, and sustainable development for over four decades, with capabilities in research, policy, consultancy, and implementation. TERI believes that resource efficiency and waste management are the keys to smart, sustainable, and inclusive development, and hence focusses on promoting efficient use of resources, increasing access to sustainable practices, and reducing environmental and climatic impacts.

**Central Institute of Petrochemicals Engineering & Technology (CIPET),** https://www.cipet.gov.in/#, is a premier academic institution for higher and technical education, works in all the domains of plastics, and caters to the needs of the polymer and allied industries. CIPET's 'Centre for Plastic Waste Management' helps build capacities on plastics recycling technology, promotes cost-effective recycled plastics for varied end-use applications, creates employment opportunities on plastics waste disposal, and intends to act as a 'Centre of Excellence' for plastic waste management in India.

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