



REMEDIES: Co-Creating a Plastic Litter Free Future

DELIVERABLE: D2.4

TITLE: Clean-up and valorisation guideline

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Abbreviations

Acronym	Title
WP	Work Package
IHA	Impact Hub Athens

KPI	Key Performance Indicator
EU	European Union
MPA	Marine Protected Area
EIA	Environmental Impact Assessment
H&S	Health and Safety
SoA	State of the Art
DTO	Digital Twin of the Ocean
EMODnet	European Marine Observation and Data Network
JRC	Joint Research Centre
ML	Marine Litter
PP	Polypropylene
PE	Polyethylene
PET	Polyethylene Terephthalate
PA	Polyamide

Executive Summary

Deliverable 2.4 “Clean-up and valorisation guideline” provides the methodological framework for the implementation of community-based litter collection and plastic valorisation activities within the REMEDIES project. Developed under Work Package 2: *Collection of plastic litter*, the deliverable translates the commitments of the Grant Agreement into a practical set of operational guidelines that support partners, local authorities, NGOs, schools and community groups in organising effective beach and river clean-ups while ensuring consistency across all demonstration sites.

The first part of the deliverable focuses on the organisation and implementation of people-based clean-ups under Task 2.4. It provides step-by-step guidance covering the entire lifecycle of a clean-up activity, including site selection, environmental and safety considerations, volunteer mobilisation, operational procedures during the event, and post-event reporting. Particular emphasis is placed on the adoption of harmonised methodologies aligned with European monitoring frameworks, ensuring that citizen-led actions generate reliable information on marine litter. Through the use of the REMEDIES digital tools, including the Shoreline Marine Litter Monitoring App and the REMEDIES Citizen Science App, clean-up activities contribute not only to litter removal but also to the generation of structured datasets that support long-term monitoring, research and policy development.

The second part of the deliverable introduces plastic valorisation pathways, describing how collected materials can move beyond simple disposal towards reuse, recycling and circular applications. Drawing from the activities of Task 2.5, the guideline outlines different valorisation routes ranging from low-tech community-based processing solutions, such as small-scale shredding and plastic remanufacturing initiatives, to more advanced recycling processes for specific waste streams such as fishing gear. The document also highlights key considerations related to material sorting, contamination, traceability, safety and compliance with local waste-management systems.

By connecting community mobilisation with circular economy approaches, D2.4 demonstrates how marine litter removal can generate broader environmental, societal and educational benefits. Clean-ups become entry points for awareness raising and citizen science, while valorisation activities open opportunities for innovation, experimentation and local circular solutions.

Overall, the Clean-up and Valorisation Guideline establishes a replicable and scalable framework that enables partners and external organisations to organise safe, harmonised and impactful clean-up activities while exploring sustainable pathways for transforming collected plastic waste into valuable resources. In doing so, the deliverable strengthens the contribution of REMEDIES to the objectives of the EU Mission “Restore our Ocean and Waters by 2030”, fostering citizen engagement, improving knowledge on marine litter and supporting the transition towards more circular coastal and riverine ecosystems.

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I Introduction

This deliverable is developed within Work Package 2 (WP2) of the REMEDIIES project, which focuses on the implementation of practical solutions for plastic litter collection, monitoring, and valorisation in coastal and riverine environments. WP2 aims to move beyond analysis and pilot actions towards structured, community-based and replicable interventions that combine environmental impact with citizen engagement.

Within this framework, two core tasks are addressed:

- Task 2.4 (Clean-ups) focuses on the organisation and implementation of people-based clean-up activities. Its objective is to mobilise communities to remove marine litter while ensuring that these actions follow harmonised methodologies, generate reliable data, and contribute to broader monitoring efforts.
- Task 2.5 (Valorisation) complements clean-up actions by addressing what happens after collection. Its objective is to explore and enable pathways for reuse, recycling, and circular applications of collected plastic, transforming waste into potential resources and linking environmental action with circular economy practices.

These two tasks are inherently interconnected: clean-ups generate material flows and data, while valorisation provides pathways for their sustainable management and further use.

In this context, Deliverable D2.4 is designed to operationalise and connect these objectives into a unified framework. It provides the methodological backbone that ensures that:

- clean-up activities are implemented in a consistent, safe, and scalable way,
- data collection is aligned with European monitoring standards,
- and collected materials can be channelled into structured valorisation processes.

Rather than functioning as a descriptive report, this deliverable acts as a practical guideline and reference framework, enabling partners and external stakeholders to replicate activities across different geographical and socio-environmental contexts.

By addressing both the implementation of clean-ups (T2.4) and the valorisation of collected materials (T2.5), D2.4 ensures continuity between citizen action, data generation, and circular economy solutions. In doing so, it supports the transition from isolated activities to integrated, impact-oriented interventions within the REMEDIIES project.

II Clean-up Guideline

I. REMEDIES Context & Links to WPs

D2.4 is situated within the implementation framework of Work Package 2 Demonstration of Plastic Collection, Valorisation and Zero-Waste Activities, where Task 2.4 focuses specifically on people-based beach clean-ups in selected coastal and riverine environments. Its role is to operationalise community engagement and provide the standard methods that allow activities to be replicated consistently across all demo sites. In this sense, the deliverable serves as the practical bridge between hands-on citizen action and the structured data flows, communication activities and valorisation pathways supported by the project.

The deliverable is linked to WPI Mapping, Surveying and Monitoring of Plastic Pollution, which provides the scientific backbone for all monitoring and data-collection actions. Clean-ups performed under T2.4 follow the classification systems, size thresholds and methodological rules that WPI has established. Tools such as the Shoreline Marine Litter App and Data Repository (DI.2) create the digital infrastructure into which clean-up data is recorded, ensuring that findings from citizen-led actions can be integrated into the broader European datasets and contribute to the Digital Twin of the Ocean. Clean-ups therefore do not operate in isolation: they generate evidence that strengthens the long-term monitoring of pollution patterns along coastlines.

The connection to WP6 Dissemination, Communication and Community Engagement is equally important. Clean-ups offer a powerful opportunity for awareness-raising, education and public visibility. The photos, videos, testimonies and participation numbers generated during each activity directly feed into WP6 communication outputs, including news articles, social-media storytelling and citizen-engagement reporting. This ensures that every clean-up becomes part of a wider narrative about environmental stewardship, community ownership and the urgency of reducing plastic pollution in the Mediterranean.

Finally, D2.4 also aligns with the broader objectives of WP5 Exploitation, Replication and Market Uptake of Innovations, although its connection is indirect. Clean-ups help map the availability and types of plastic waste found along shorelines, offering valuable insights into what materials may be relevant for future valorisation pilots or market-uptake activities. These observations support the project's replication ambitions by providing a clearer understanding of the waste streams present in each region.

People-based clean-ups take place across the five demo sites identified in the Grant Agreement, Slovenia, Italy, Greece, France and Morocco, and additional localities involved in community-driven monitoring. Each site works with local municipalities, NGOs and citizen groups to ensure that clean-ups respect environmental sensitivities, adhere to safety rules and generate high-quality data. Through these coordinated efforts, D2.4 helps create a shared operational language among partners and establishes the methodological foundation for all community-based clean-ups delivered under REMEDIES.

2. Clean-Ups Methodology

This chapter provides a practical, step-by-step methodology for organising people-based beach clean-ups under Task 2.4. It translates the technical guidance produced by Venice Lagoon Plastic Free and the REMEDIIES consortium into an easy-to-follow operational sequence: from site selection and risk checks, to volunteer briefing, waste separation, documentation and reporting.

For full operational detail and ready-to-use material, partners should always consult:

- Annex 1 – Beach Litter Monitoring and Clean-Up at a Glance: Do's and Don'ts (VLPPF)
- Annex 2 – REMEDIIES Citizen Science Protocol – Beach Litter Clean-Ups

2.1 Principles & Safety

Where monitoring is conducted under the extended scientific framework (as applicable), partners may align with JRC/EMODnet standards. This means that whenever possible:

- beach litter data are collected in a way that can feed into EMODnet Chemistry and the Digital Twin of the Ocean,
- monitoring activities respect the standard transect length, size thresholds (>2.5 cm) and counting rules.

Seasonal timing is a core principle. Both the Protocol and the Do's & Don'ts emphasise that monitoring and clean-ups should:

- avoid periods with exceptional weather events such as storm surges or floods,
- avoid the peak tourist season where beach management may interfere with monitoring results,
- preferably take place between the end of February and April, or in the second half of September, to both limit disturbance to breeding birds and ensure comparability over time.

Protected areas and wildlife are another key safety concern. Organisers must check whether the intended site falls within or near:

- habitats of sea turtles, seabirds or shorebirds, marine mammals or sensitive beach vegetation,
- officially designated protected areas or zones with specific conservation rules.

In such cases, they must consult the protected area management authority before proceeding and, if necessary, choose another site.

Finally, the Do's & Don'ts stress a broad safety culture around REMEDIIES activities:

- plan the event with waste management authorities and local authorities,
- ensure adequate insurance for the activity,

- provide basic safety equipment (gloves, closed shoes, first-aid kit) and clear instructions to participants.

2.2 Planning

Planning before the clean-up follows three main blocks: site selection, authorisations and logistics, and communication.

Site selection

According to the Annex I guidelines, the identification of a suitable beach includes:

- defining a macro-area of investigation (e.g. a stretch of coast),
- scouting to identify specific hotspots with visible litter accumulation,
- ensuring:
 - free public access (no private, restricted beaches),
 - easy and safe access for volunteers and for removal of collected litter,
 - a low to moderate slope (approximately 1–45°, excluding very shallow tidal mudflats),
 - uninterrupted shoreline segments (not heavily obstructed by breakwaters or jetties),
 - proximity to a road, parking area or public transport,
 - the presence of well-defined hotspots that make the clean-up impactful.

During scouting, organisers should collect GPS coordinates of the selected hotspots and take photos or short videos of the area, including close-ups of litter accumulation. This material is later used both for planning and for communication.

Authorisations, waste coordination and risk checks

Before announcing the event, organisers must:

- contact city departments or relevant authorities to secure any required authorisations for the clean-up,
- coordinate with the waste management authority to:
- arrange removal, treatment and final disposal of collected litter,
- agree on pick-up points and time windows,
- request logistical support if needed (e.g. containers, bags, equipment),
- clarify possibilities for recycling and separate collection,

- confirm that the site is safe for volunteers (no hazardous access, no high risk of landslides, tides, etc.),
- take out insurance for the event, as explicitly recommended by the Do's & Don'ts.

These steps reduce operational risk and ensure that the clean-up does not itself create waste-management problems.

Digital Set-Up (REMEDIES Citizen Science App)

The organiser must create the clean-up campaign and group structure in the REMEDIES Citizen Science App prior to the event, assign coordinators, and ensure bag-level recording of weights and types as required by the App workflow.

Communication and mobilisation timeline

Pre-event communication is described both in the Do's & Don'ts and in the Beach Clean-Ups Communication Guide.

Key points include

- starting outreach 10–14 days before the clean-up to maximise participation,
- choosing days like Saturday or Sunday if a higher number of volunteers is desired,
- clearly communicating:
 - date and time (start and end),
 - exact meeting point near the beach, easy to find and close to transport or parking,
 - contact person (phone and email),
 - partners/organisers/sponsors,
 - basic recommendations on clothing and equipment (gloves, shoes, caps, etc.).

Organisers are encouraged to design an appealing event flyer and share it across social media, mailing lists and local channels. They should also provide the REMEDIES Communication & Dissemination lead with suitable material for project-wide promotion.

2.3 Delivery

On the day of the clean-up, the methodology focuses on structured arrival, clear briefing, safe collection and correct separation of waste.

Set-up and volunteer arrival

The organiser should arrive at least 30 minutes before the announced starting time to set up a registration table, display REMEDIES and EU logos, prepare equipment and mark the meeting point.

When volunteers arrive, organisers:

- register participants,
- introduce the REMEDIES project and the purpose of the clean-up (including the link to data collection and the App where applicable),
- explain the area that will be cleaned and any restricted zones to avoid,
- briefly recall key safety rules and environmental precautions.

Team structure and roles

It is a recommended practice to organise volunteers in teams, each with:

- one designated data recorder,
- two people responsible for holding and managing the trash bag,
- additional members collecting litter and bringing it to the bag.

This simple structure ensures that data (weights, participants, location, notes) are captured consistently without overburdening a single person.

Separation of plastics and non-plastics

Both the Protocol and the Communication Guide emphasise that:

- plastic and non-plastic litter must be collected in separate bags,
- the final weight of each category is reported separately in the WP2 Excel and any data forms.

Coloured bags are recommended to visually distinguish fractions.

What to collect and what to avoid

During the clean-up, volunteers are reminded of key Do's and Don'ts, based on the Annex I:

- Do collect: non-biodegradable items such as plastics, glass, metal, polystyrene, and small items like sweet wrappers and polystyrene balls.
- Do not collect: driftwood, coconuts, seeds, seaweed, shells, coral or vegetation.
- Do not burn any trash.
- Do not trample beach vegetation or disturb wildlife.

For monitoring components, volunteers should only collect what is naturally stranded and visible on the surface and must not dig or disturb other accumulations.

Documentation during the event

Organisers and team leaders should:

- take photographs before, during and after the clean-up (overall beach view, volunteers in action, collected bags),
- where monitoring is included, record litter items according to the JRC/G codes and, in case of doubt, take a photo for later validation,
- note any particular observations (e.g. presence of specific hotspot, unusual items, interaction with passers-by).

These materials later feed into REMEDIES communication outputs and into the data repository (via the App and forms).

2.4 Closure & Reporting

The clean-up does not end when volunteers stop collecting; a structured closure phase ensures that data, waste and communication outputs are properly handled.

Weighing and data recording

After collection, all bags are brought to a designated weighing point. Following the Communication Guide and Protocol:

- total plastic waste (kg) and non-plastic waste (kg) are weighed and recorded separately,
- the number of participants, the length of the beach cleaned/monitored, and other key metadata are written on the data sheet and in the WP2 Excel,
- where relevant, data are also entered into the REMEDIES Shoreline Marine Litter App for harmonised digital reporting.

Local disposal and recycling

Organisers must ensure that no waste is left on site after the event. As described in the Do's & Don'ts and Communication Guide:

- collected litter should be placed at previously agreed pick-up points,
- arrangements with the waste management authority should cover transport, treatment and, where possible, recycling,

- volunteers may be informed about any existing local recycling schemes and how their effort fits into them.

Acknowledgement and basic communication

Immediately after the clean-up:

- organisers are encouraged to hold a short thank-you circle,
- a final group photo is taken, ideally including the REMEDIIES flag and logos,
- participants are reminded of the project hashtags and handles if they wish to share their experience online (e.g. #REMEDIIESforOCEAN, #20tonnesChallenge, #REMEDIIESClean-up)

2.5 Do's & Don'ts

To make the methodology easy to use in the field, the VLPP team has prepared concise Do's & Don'ts cards for monitoring and clean-ups. These can be printed and handed to team leaders or displayed at the meeting point. A simplified extract is shown below, in Table 1.

For full safety and methodology details, including monitoring-specific rules (e.g. 100 m transect, >2.5 cm threshold, J/G coding), partners must refer to Annex 1 and Annex 2. These annexes are the authoritative operational guides for all people-based clean-up activities under T2.4.

Table 1 Do's and Don'ts for monitoring and clean-ups

Do's	Don'ts
Choose accessible, public beaches with visible litter hotspots.	Do not select extremely shallow tidal mudflats or unsafe areas.
Coordinate in advance with waste management authorities and local institutions.	Do not organise clean-ups without clarifying how waste will be removed and treated.
Plan activities outside periods of extreme weather and avoid peak tourist season; respect wildlife and protected areas.	Do not carry out activities after storms or in protected areas without consulting management authorities.
Provide gloves, bags, data sheets, first-aid kit, and clear instructions to volunteers.	Do not allow volunteers to burn trash, trample vegetation, or disturb wildlife.
Collect and record non-biodegradable litter, separating plastics and non-plastics into different bags.	Do not collect driftwood, coconuts, seeds, seaweed, shells, coral or live vegetation.

Take photos before, during and after the clean-up and record all required data.	Do not leave any collected waste or equipment behind on the beach.
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3. Monitoring vs Clean-up: Using the REMEDIES Apps

Monitoring and clean-up activities constitute two complementary but fundamentally different pillars of REMEDIES' citizen-science approach. While clean-ups (Task T2.4) focus on mobilising volunteers, removing litter, raising awareness, and documenting quantities, monitoring focuses on collecting scientifically robust datasets following EU-harmonised methodologies.

Although monitoring and clean-ups can take place in parallel, although not on the same beach transect, their methodologies and data outputs must not be mixed. Clean-ups involve collecting all litter beyond the strict methodological boundaries applied to their roll out, the spatial and geomorphological settings within which they must be carried out. Moreover, due to the nature of KPIs, of T2.4, particularly the 20.000 kg challenge of plastics litter removed from nature in the Mediterranean basin, plastics and non-plastics litter are separated and computed separately. The clean-up simplified methodological approach is translated into figures whose metrics follow the VLPF clean-up datasheet. Monitoring, by contrast, uses the Joint List of Litter Categories for Macrolitter Monitoring, prepared by the MSFD Technical Group on Marine Litter (MSFD TG ML) (100 m, >2.5 cm, J-codes) and must follow EMODnet's scientific standards. Mixing datasets would violate comparability rules and compromise data quality at EU level.

For this reason, REMEDIES has developed two distinct digital tools, each designed for a specific purpose and user group.

The **REMEDIES Shoreline ML App** is designed exclusively for beach litter monitoring. It supports accurate, protocol-aligned surveys and produces harmonised datasets that can be integrated into the Marine Litter Database and the European Digital Twin of the Ocean. It is not a general-purpose clean-up reporting tool and must not be used to track bags, kilograms, or volunteer numbers.

In parallel, the REMEDIES consortium introduced the **REMEDIES Citizen Science App**, which is designed exclusively to support beach litter clean-up actions. This second app facilitates citizen participation, basic documentation of clean-up outputs, and simplified reporting aligned with Task T2.4 objectives. The clear separation between the two apps ensures methodological integrity, data quality, and appropriate use of citizen-generated information within the project.



Figure 1 Field Setup for Monitoring a 100 m Transect (Source: Cheshire et al., (2009))

3.1 REMEDIIES Digital Tools

3.1.1 REMEDIIES Shoreline ML App

The REMEDIIES Shoreline ML App is a dedicated beach litter monitoring tool, developed by Infodata Sistemi in collaboration with Venice Lagoon Plastic Free and the University of Maribor. Its sole purpose is to support scientifically robust, standardised beach litter monitoring, in full alignment with EU-harmonised methodologies. The app is used exclusively during monitoring activities and enables the collection of comparable data across all REMEDIIES demo sites. Key characteristics include:

- EMODnet-aligned metadata collection (location, date, transect length),
- JRC Joint List (J-code) classification for macro litter,
- Recording of items larger than 2.5 cm,
- Photo documentation for validation,

- AI-assisted categorisation and automated error correction,
- Integration with the central REMEDIES data portal,
- FAIR-compliant data outputs suitable for the Marine Litter Database and the Digital Twin Ocean (EDITO).

The Monitoring App does not support the recording of clean-up indicators such as kilograms of litter collected, number of bags, or volunteer participation. It must not be used for clean-up reporting.

Download the **REMEDIES Shoreline ML App** [here](#).

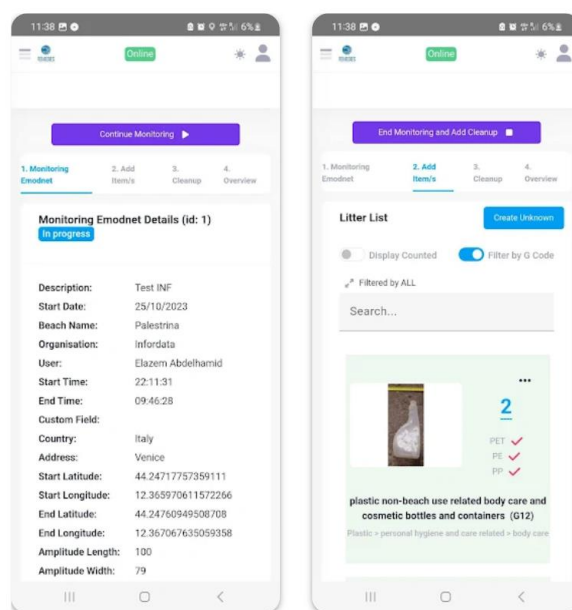


Figure 2 Overview of the REMEDIES Shoreline ML App

3.1.2 REMEDIES Citizen Science App

The REMEDIES Citizen Science App is a separate and distinct digital tool, designed exclusively to support beach litter clean-up actions within the REMEDIES project. Its primary purpose is to facilitate:

- citizen participation and engagement during clean-up events,
- documentation of collected litter in an accessible and user-friendly way,
- recording of basic clean-up outputs for communication and impact reporting,
- alignment with clean-up KPIs under Task T2.4.

The REMEDIES Citizen Science App follows a simplified methodological approach, suitable for awareness-raising activities and large-scale public participation. It is used by organisers, coordinators, and participants

to document clean-up events in line with International Coastal Clean-up methodology and datasheet. The app itself was developed based on a concept proposed for, and tailored to the needs of Čista obala (2024) and Greek Eco Project (2025), while the underlying methodology was co-developed in collaboration with its representatives.” Specifically, the app supports the recording of:

- separation of **plastic and non-plastic litter** using different bags,
- aggregation of collected quantities (kg of plastics and kg of non-plastics),
- number of participants involved,
- photographic documentation of waste bags and group activities,
- basic event information (location, date, description).

The app can be used on-site via smartphones or, where needed, data can be entered afterwards through the REMEDIES web portal.

The REMEDIES Citizen Science App does not follow monitoring protocols, does not use J-code classification, and does not generate datasets intended for scientific analysis or EU-level policy reporting. Its role is complementary to monitoring, ensuring that clean-up actions are documented consistently while remaining accessible to a broad public.

Download the **REMEDIES Citizen Science App** [here](#).

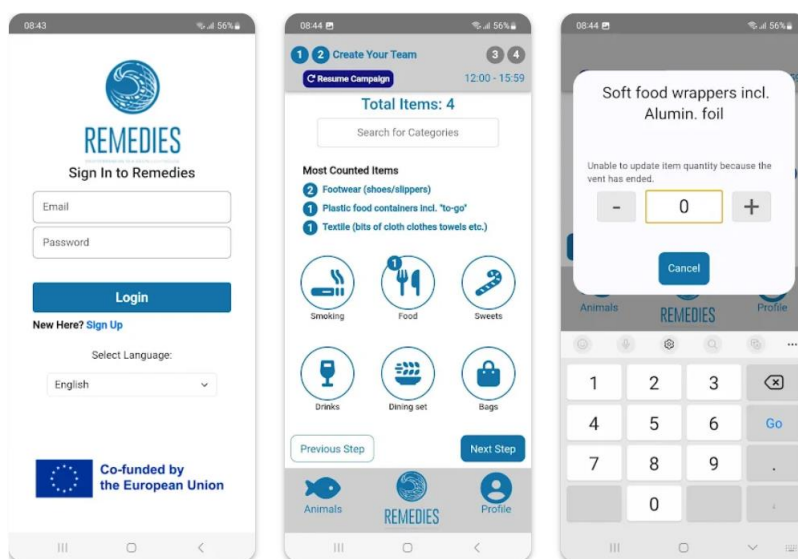


Figure 3 Overview of the REMEDIES Citizen Science App

4. Clean-up Data & Evidence from T2.4 Campaigns

This chapter consolidates the available evidence emerging from the beach litter clean-up and monitoring activities implemented under Task 2.4. All actions follow the REMEDIIES methodology as defined in the official Beach Clean-ups Communication Guide, the Citizen Science Protocol for Beach Litter Monitoring & Clean-Ups, and the technical documentation of the REMEDIIES Shoreline Marine Litter App. The purpose of this chapter is to articulate why these data are collected, how partners report results, and how the data will be integrated into both scientific and communication objectives across the project.

The results presented here reflect the structure and reporting logic of the internal WP2 “Clean-Ups Database”. As the reporting process continues throughout Months 8 to 40, all figures will be updated following validation and consistency checks, ensuring compliance with the harmonised protocols.

4.1 Why We Track

Task 2.4 collects data not only to document the removal of marine litter but also to capture a broader range of community and environmental impacts. According to the REMEDIIES citizen science methodology, each clean-up or monitoring event must report multiple types of evidence: the number of participants, the types of organisations involved, the beach length surveyed (for monitoring), the weights of plastic and non-plastic waste, and photographic documentation before, during and after the activity. These requirements ensure that the data are scientifically meaningful and suitable for integration with the REMEDIIES App and digital portal.

The Citizen Science Protocol emphasises the role of community members as contributors to larger, harmonised datasets aligned with EMODnet and JRC classifications. This means that the value of each activity extends beyond the local clean-up: it contributes to regional datasets, bonds data gaps in poor data regions, supports long-term beach litter baselines, and strengthens the scientific grounding for decision-making. Monitoring results, such as transect counts and the classification of litter using the Joint List of Litter Categories, enable consistent tracking of macrolitter >2.5 cm and support the overarching Mission objectives.

Tracking community participation is equally important. The Communication Guide notes that collaboration with schools, NGOs, municipalities, volunteer groups and local networks is a key success factor for citizen engagement. By systematically recording participation data, the project can demonstrate the activation of local communities and measure awareness-raising over time. These metrics also provide essential input to WP6 for storytelling, social media content, and communication reporting to CINEA.

Altogether, the collection of these indicators enables a comprehensive assessment of the environmental, social and behavioural dimensions of clean-ups, ensuring that T2.4 achieves its contribution to monitoring, community mobilisation and communication.

4.2 Consolidated Results

All partner contributions are compiled in the internal WP2 database, following a unified reporting structure. The dataset includes mandatory fields for: location (country/city/beach), dates, organising

partner(s), participant numbers, quantities of collected litter (plastic vs. other), and, where applicable, confirmation of pre-clean-up monitoring. Before inclusion in this deliverable, all entries undergo a validation and completeness screening (see Section Data Validation and Quality Checks), including checks for separate reporting of plastic vs. non-plastic weights, plausibility of weights/participants, and internal consistency of location/date fields.

As of 25 February 2026, the WP2 database contains 131 validated clean-up records, exceeding the programme KPI (115 clean-ups) by 16 actions (+13.9%). The recorded implementation period spans 08 March 2023 to 07 January 2026. Results presented below reflect the dataset colluded under T2.4.

Headline results

- Total clean-up actions recorded: 131 (KPI target: 115 → overachieved)
- Total participants engaged: 4,320
- Total litter collected: 18,371.32 kg (*Plastic: 6,352.88 kg / Non-plastic: 12,018.44 kg*)
- Total shoreline/area length reported as cleaned: 71,049 m
- Monitoring integration: 62/131 actions (47.3%) report pre-clean-up monitoring

Overview of Activities by Country

The Table 2 below includes all countries currently reported under T2.4 (10 countries).

Table 2 Overview of Activities by Country

Country	Locations Mentioned in the Excel (top cities)	Dates of Activities (range)	Responsible Partner(s) (as entered)	No. of Clean-ups	Total Participants	Plastic Collected (kg)	Non-Plastic Collected (kg)	Length Surveyed/ Cleaned (m)	Activity Type (Clean-Up / Monitoring)
Greece	Mykonos, Rhodes, Athens, Thessaloniki, (multiple coastal sites)	2023-03-08 – 2025-10-30	IHA, MCG, Marine Conservation Greece, VITO	44	1,590	1,159.78	1,236.36	7,866	Clean-up + monitoring (<i>pre-monitoring in some events</i>)
Italy	Venice, Cabras, Torregrande, (Sardinia + lagoon/coastal sites)	2023-04-17 – 2025-11-21	CNR, VLPP	34	1,135	1,197.51	1,825.59	14,774	Clean-up + monitoring (<i>pre-monitoring in some events</i>)

Slovenia	Strunjan, Koper, Izola, Piran, Barisoni	2023-04-15 – 2025-11-15	NIC, UM, University of Maribor	17	679	361.69	490.17	38,583	Clean-up + monitoring (<i>pre-monitoring in some events</i>)
Albania	Durres, Koder, Rrogozhine	2023-09-16 – 2025-11-16	ETMI (also entered as “etmi”)	12	201	1,712.93	4,459.24	1,600	Clean-up + monitoring (<i>pre-monitoring in some events</i>)
France	Porquerolles, Port-Cros, Le Levant	2024-01-13 – 2026-01-07	SMILO	11	236	201.20	230.80	2,007	Clean-up + monitoring (<i>pre-monitoring in all events</i>)
Morocco	Saïdia (incl. “cap de l'eau” site label)	2023-11-30 – 2025-04-06	UMF	6	195	730.07	483.82	1,878	Clean-up + monitoring (<i>pre-monitoring in some events</i>)
Croatia	Umag	2023-12-12 – 2025-05-24	UM, EXIT, University of Maribor	3	89	235.70	591.96	2,850	Clean-up only (<i>no pre-monitoring reported</i>)
Portugal	Guimarães (river context)	2024-07-29 – 2024-08-13	<i>Not specified in Excel field</i>	2	41	370.00	433.00	441	Clean-up + monitoring (<i>pre-monitoring in some events</i>)
Malta	Bugibba	2024-07-06 – 2024-07-06	Esplora and Zibel	1	69	78.00	573.50	50	Clean-up only (<i>no pre-monitoring reported</i>)
Montenegro	Donji Štoj (Ada Bojana beach)	2023-09-20 – 2023-09-20	Foundation EXIT	1	85	306.00	1,694.00	1,000	Clean-up only (<i>no pre-monitoring reported</i>)

KPI delivery and geographic spread

- The programme exceeded the clean-up KPI (131 vs 115) by +16 actions (+13.9%), demonstrating sustained mobilisation capacity over time.

- The current Excel extract covers 10 countries, with the most frequent implementation in Greece (44) and Italy (34), followed by Slovenia (17) and Albania (12).
- The dataset confirms that activities are not limited to demo sites only, aligning with your narrative that the “20,000 kg challenge” can be supported by external organisations adopting the same approach.

Engagement and participation intensity

- The programme engaged 4,320 participants across 131 actions (~33 participants per action on average).
- Participation scale varies substantially by context: some actions are small expert-led operations, while others are mass-volunteering mobilisations. This is normal, but it strengthens the case for reporting both:
 - absolute totals (participants, kg), and
 - efficiency indicators (e.g., kg/action; kg/participant) in a separate analysis box or annex.

Waste composition

- Total collected litter recorded: 18.37 tonnes.
- By mass, non-plastic is dominant in the current dataset (~65.4%). This strongly suggests that several interventions are impacted by:
 - bulky mixed waste streams (e.g., construction debris, textiles, glass, mixed household waste),
 - river/estuary transport effects (where mixed waste accumulates),
 - storm or seasonal deposition events.
- A clear outlier pattern appears in a small number of actions producing very high non-plastic loads (e.g., river mouth contexts). This is not an error by default; it’s a known field reality. However, it’s exactly where validation (photos, weight plausibility, and short context notes) is most important.

Monitoring integration

- 47.3% of actions report pre-clean-up monitoring. This is a strong operational signal: nearly half the clean-ups are being conducted in a way that strengthens comparability and potential integration into longer-term monitoring workflows.
- France stands out as fully consistent on this field, which you can reference as a *good practice consistency example*.

- Recommendation for final reporting: add a short sentence that pre-monitoring uptake increased data usability, and that remaining actions can still contribute to the KPI but may have reduced comparability for time-series analysis unless repeated.

Country patterns worth stating explicitly

- Albania contributes the highest total mass (~6.17 t), driven by a small number of high-yield actions, likely linked to river/river-mouth accumulation dynamics (as suggested by location names such as river mouth entries).
- Italy and Greece deliver the largest volume of actions and participant engagement, underpinning the programme's continuity and replication capacity.
- Slovenia reports the largest total cleaned length (38,583 m), which can be highlighted as strong coverage on shoreline extent.

Data Validation and Quality Checks

Before inclusion in this deliverable, all T2.4 entries undergo the following validation steps, which are explicitly required in the guidelines:

- Verification of litter weights, ensuring plastic and non-plastic are reported separately.
- Confirmation of the 100-m transect rule for monitoring events.
- Review of photographic documentation to confirm accuracy of the reported activity.
- Cross-checking classification codes with the JRC list.
- Ensuring activities avoid restricted areas or sensitive species, as stated in the precautionary notes.

These steps ensure that the T2.4 dataset meets the standard required for integration into the REMEDIES App and the project's long-term data portal.

Discover the more about the beach clean-ups, in the Annex 3 – Clean-up & monitoring photographs per country.

5. Clean-up Training & Knowledge Exchange

Clean-ups in REMEDIES are supported not only through field methodologies but also through a comprehensive ecosystem of training, capacity-building, and knowledge-exchange activities. The PLASTIC FANTASTIC webinar series and the International Workshops on marine-litter monitoring together form a shared learning architecture that equips volunteers, NGOs, demo-site leaders, municipalities and educators with the skills and scientific understanding necessary to conduct high-quality clean-ups.

These activities directly reinforce the Clean-up and Valorisation Guideline in several essential ways. They build the technical capacity required to implement clean-ups safely and consistently, especially in plastic identification, recyclability, and monitoring procedures. They also introduce partners to innovative tools and methods, such as the REMEDIES Shoreline Marine Litter App, drone and AI-based monitoring systems, and advanced assessment techniques that enhance the accuracy, precision and comparability of field data. Equally important, they foster a culture of co-creation across Mediterranean regions, enabling demo-site leaders and local actors to replicate tested approaches in their own communities.

The training and workshop ecosystem also strengthen the communication and visual documentation dimension of clean-ups. Through demonstrations, tool showcases and hands-on exercises, participants gain a clearer understanding of how to record visual evidence, articulate observations and communicate insights that feed directly into WP6 dissemination activities. In this sense, these training moments function as the knowledge backbone of the Guideline, ensuring that clean-ups across REMEDIES are safe, impactful, scientifically compliant and easily replicable.

5.1 What is the PLASTIC FANTASTIC webinar?

PLASTIC FANTASTIC is a recurring webinar series designed to build the technical capacity of volunteers, citizens, educators and local organisations involved in REMEDIES clean-ups. The series focuses on recognising plastic types, understanding recyclability and management options, and applying standardised monitoring methods in the field. Sessions are delivered in collaboration with the University of Maribor (UM), Venice Lagoon Plastic Free (VLPF), Impact Hub Athens (IHA), demo-site leaders, and tech providers, ensuring both scientific rigor and local contextualisation.

Each edition is localised to national contexts, allowing content to be tailored to regional environmental challenges and community engagement profiles. The educational content of the webinars, meaning the plastic litter identification and the plastic litter monitoring are made available online, forming a growing knowledge base that supports ongoing learning. Across all editions, core themes include recognising common plastic types, linking identification skills to responsible disposal or valorisation efforts, and introducing field-monitoring tools developed by project partners.

Watch the [REMEDIES - PLASTIC FANTASTIC Webinar on Plastic Identification & Beach Litter Monitoring](#)

5.2 Country Editions and Technical Spotlights

Greece Edition (June 2024)

The first PLASTIC FANTASTIC online session was hosted in Greece on June 26, 2025 facilitated by Impact Hub Athens with contributions from the University of Maribor, Venice Lagoon Plastic Free, MCGreece and All for Blue, as part of the Greece Anti-litter Campaign, with the support of WWF Adopt a Beach program. The training targeted volunteers and ocean enthusiasts, providing updates on the Cyclades Demo Site, practical guidance on identifying plastic types during clean-ups and improving the quality of citizen-science data reported within REMEDIES. Read more about the session, [here](#).

Italy Edition (Nov 2024)

The second edition took place in Sardinia, delivered as a hybrid seminar and curated by scientists and chemists specialising in plastics and microplastics. The session offered a comprehensive exploration of plastic identification and management, helping participants understand recyclability categories and consumer behaviour. Content was adapted to the specific environmental challenges of Sardinia and formed part of a broader cluster of REMEDIIES activities implemented in the Oristano coastal area. The Sardinia Demo Site updates were presented as well. The partners involved were IHA, CNR, UM, and VLPF. Read more about the session, [here](#). Watch the Sinis Peninsula Demo Site updates, [here](#).

France Edition (Jan 2025)

The third PLASTIC FANTASTIC webinar took place online on January 28, 2025 and was hosted by SMILO, VLPF, the UM, and IHA. Centred on the Porquerolles Demonstration Site, the session explored advanced methods for plastic identification and management, helping participants understand different plastic types, their recyclability, and how to foster more sustainable practices in coastal communities. The webinar also presented scientific approaches developed under REMEDIIES for monitoring and categorising plastic waste during clean-ups, ensuring that citizen-led actions generate robust data and higher-impact results on the ground. Read more about the session, [here](#). Watch the Porquerolles Demo Site updates, [here](#).

Albania Edition (April 2025)

The fourth PLASTIC FANTASTIC webinar, held on April 10, 2025, was embedded within the Albanian Anti-litter Campaign spanning Durrës and Tirana. The webinar addressed local plastic pollution challenges and introduced participants to improved identification practices in support of higher-quality monitoring data. Also, RC presented the River Cleaning REMEDIIES innovation, and ETMI presented updates from the Albanian Demo Site. Other partners involved were IHA, UM, and VLPF. Read more about the session [here](#). Watch the REMEDIIES Innovation, [here](#). Watch the Durres & Tirana Demo Site updates, [here](#).

Morocco Edition (July 2025)

Morocco hosted two online sessions, on July 3 and July 23. Two REMEDIIES Innovations were presented: REMEDIIES Shoreline ML App, presented by INFORDATA and VITO, and the Aerial Drones & AI, presented by MOH. The edition highlighted cross-country contributions, including those from Morocco and Malta, reflecting a growing Mediterranean knowledge-sharing community around innovation and monitoring. IHA hosted the session, and UM and VLPF presented their education content on plastic litter monitoring and plastic litter identification. Read more about the sessions, [here](#) and [here](#). Watch the REMEDIIES Innovations presentations, [here](#) and [here](#). Watch the Saidia Demo Site updates, [here](#).

5.3 International Workshops on Marine-Litter Monitoring, Removal & Blue Circular Economy

Lighthouse Training Workshop - Beach Litter Monitoring & Clean-up - 2023

Held in parallel with Venice activities, the Lighthouse Training Workshop, hosted by VLPF, combined theoretical sessions with hands-on field practice. Participants explored the Dune degli Alberoni WWF

oasis, where they applied monitoring methods supported by an innovative application. The workshop encouraged the co-assessment of local observations with experts, illustrating how grassroots data feed into joint decision-making and coastal stewardship. Read more, [here](#).

4th International Workshop on Marine Litter Monitoring, Removal, and Circular Economy - 2024

The 4th International Workshop, hosted by VLPF, convened researchers, policymakers, industry representatives and environmental organisations to share innovative approaches supporting the monitoring, removal and prevention of marine litter. Its objective was to accelerate the implementation of the EU Mission “Restore Our Ocean and Waters” across the Mediterranean by strengthening the innovation ecosystem and promoting technological, social and governance solutions. Read more, [here](#).

5th International Workshop on Marine Litter Monitoring and Blue Circular Economy - 2025

The 5th International Workshop, held in Venice at the *Torre di Porta Nuova* within the Venice International Boat Show and hosted by VLPF, focused on three program strands: marine litter monitoring and assessment, clean-up solution demonstrations and blue circular economy. The workshop showcased practical tools and solutions, reflecting REMEDIES’ commitment to accelerating innovation in marine-litter management. Read more, [here](#).

6. REMEDIES Demo Sites Anti-litter Campaigns

Anti-litter campaigns within REMEDIES extend the impact of T2.4 beach and river clean-ups by embedding them in a wider ecosystem of community mobilisation, environmental education, innovation showcases and policy dialogue. While clean-ups focus on removing litter and generating standardised monitoring data, anti-litter campaigns amplify these results by raising awareness, supporting citizen-science methodologies, highlighting REMEDIES innovations, connecting with local institutions and strengthening the project’s communication and valorisation framework. Each campaign is therefore both a field activity and a platform for knowledge exchange, demonstrating how coordinated action at the local level contributes to the broader objectives of the Mission Restore our Ocean and Waters.

Greece: Impact Hub Athens and WWF Greece, Adopt a Beach Campaign

The Greek anti-litter campaign is a partnership between Impact Hub Athens and WWF Greece under the #20TonnesChallenge and the Adopt a Beach initiative. Running from May to September 2024 across multiple Greek coastal locations, it aims to reduce litter, increase public awareness, and strengthen the national Adopt a Beach network. It targets more than 1,000 individuals already engaged in ocean protection and contributes directly to the REMEDIES target of 120 clean-ups and 20 tonnes of plastic removed by 2026. Activities include an open call to Adopt a Beach teams, coordinated clean-ups, community participation and a PLASTIC FANTASTIC webinar on plastic identification held on 26 June with the University of Maribor, Venice Lagoon Plastic Free, NTUA, MCGreece and All for Blue. Monitoring is integrated through citizen-science reporting and documentation of collected litter, communication is

strengthened through social media content, blog posts and visual materials, and valorisation is supported by feeding reliable data and behavioural insights into REMEDIES' broader prevention efforts.

How others can replicate:

Leverage an existing citizen-science programme, embed a focused training webinar and ensure that clean-ups produce both monitoring data and communication material.

Read more, [here](#).

Greece: All For Blue, Impact Hub Athens and MCGreece, Second National Campaign

A second Greek anti-litter campaign, also part of the #20TonnesChallenge, is delivered by All For Blue in collaboration with Impact Hub Athens and MCGreece. Starting in early September 2024 and continuing through late autumn, it mobilises volunteers for beach clean-ups across the country. The campaign builds on All For Blue's long-standing experience in beach and underwater clean-ups and educational programmes. Its objectives are to sustain public engagement after the first campaign, attract new volunteers, and contribute to REMEDIES' monitoring and prevention goals. Monitoring occurs through the reporting of collected litter and clean-up documentation, communication is supported by targeted social media posts, blogs and before-and-after visual updates, and valorisation is linked to REMEDIES' data-driven approach to identifying waste streams and hotspots.

How others can replicate:

Work with an experienced marine NGO, develop a follow-up campaign to maintain momentum and treat each clean-up as both a data point and a public-awareness opportunity.

Read more, [here](#).

France: SMILO and Explore & Preserve, Porquerolles Campaign

In France, the anti-litter campaign is led by SMILO, the Porquerolles Island demo-site leader, together with Explore & Preserve. Focused on Porquerolles and the broader Var coastline, the campaign aims to reduce plastic pollution, engage local communities and disseminate circular and zero-waste practices. Activities include beach clean-ups, educational sessions and innovation demonstrations that engage local and regional authorities, marina operators, tourism actors, NGOs, researchers and technology providers. Monitoring is an important component, with the campaign documenting multiple clean-ups on Porquerolles Island and analysing waste composition. Communication is strengthened by the in-person Fifth Cluster Meeting, "Uniting for a Plastic Free Mediterranean: Strategies and Solutions", held in view of the Sixth General Assembly on 1 April, which brings together experts to discuss strategies, share progress and connect field experience with policy conversations. A PLASTIC FANTASTIC webinar co-organised with the University of Maribor, Venice Lagoon Plastic Free and Impact Hub Athens complements the campaign by presenting

plastic identification techniques and demo-site updates. Valorisation is supported by introducing zero-waste tools and circular solutions relevant to the island's tourism sector.

How others can replicate:

Combine clean-ups with policy-oriented cluster meetings and innovation showcases and anchor the campaign in a strong local demo-site institution.

Read more, [here](#).

Albania: ETMI and Milieukontakt Albania, Durrës–Tirana River Campaign

The Albanian anti-litter campaign is delivered by ETMI and Milieukontakt Albania from April to September 2025 and shifts the focus from coasts to rivers in the Durrës–Tirana region. Its primary objective is to reduce plastic pollution in freshwater systems and prevent waste from reaching the Adriatic Sea. Activities include river clean-ups, local monitoring sessions, educational programmes for schools and community groups and demonstrations of innovative solutions tailored to rivers. A central element is the River Cleaning System, a REMEDIES innovation that collects floating plastic autonomously using renewable energy, preventing its transport to marine environments. Monitoring is strengthened by collecting and analysing riverine waste data, communication is enhanced through awareness events and guidelines for activists and community groups, and valorisation is advanced by presenting practical solutions that support circular approaches to river waste. A PLASTIC FANTASTIC webinar on plastic identification supports citizen learning and improves the quality of monitoring performed during clean-ups.

How others can replicate:

Adapt beach methodologies to rivers and canals, combine clean-ups with a technology demonstration and set clear mobilisation targets.

Read more, [here](#).

Morocco: Mohammed Premier University and Ecoloplatform du Maroc du Nord, Saïdia Campaign

The Moroccan anti-litter campaign is organised by Mohammed Premier University and Ecoloplatform du Maroc du Nord in the Saïdia demo-site area from May to August 2025. It aims to reduce coastal pollution, mobilise local citizens and institutions and promote innovative technological solutions. Activities include community clean-ups, awareness-raising initiatives and two PLASTIC FANTASTIC sessions. The 3 July edition focuses on beach-litter monitoring and is led by Venice Lagoon Plastic Free, while the 23 July edition focuses on plastic identification and is delivered by the University of Maribor. Both sessions feature Saïdia demo-site updates and presentations of REMEDIES innovations. The campaign highlights two key technologies: the Shoreline ML App by INFORDATA, which enables EMODnet-aligned citizen-science monitoring, and an aerial drone with AI detection developed by Mohammed Premier University, which is

also presented at the First African Conference on Sustainable Development of Energy, Water and Environment Systems in Oujda–Saïdia. Monitoring is strongly integrated through the use of these tools in the field, communication is enhanced via training and local mobilisation, and valorisation is explored through the potential scalability of the innovations.

How others can replicate:

Integrate digital and AI tools into anti-litter work, connect the campaign to a scientific conference and use webinars to train potential technology adopters.

Read more, [here](#).

Spain: Aitiip Technology Centre, Zaragoza Campaign

The Spanish anti-litter campaign, led by Aitiip Technology Centre, takes place in Zaragoza from September to October 2025 and aims to raise awareness, activate local actors and showcase circular-innovation pathways. Positioned within the broader REMEDIES objectives for detection, prevention and valorisation, the campaign includes community engagement activities, awareness events and a central workshop titled “Remedies for the Future”, held at Ceste Business School on 24 October for students and young entrepreneurs. The workshop presents the REMEDIES vision, supports discussion on innovation and concludes with a hands-on clean-up at the Zaragoza Canal, linking education to practical monitoring. Communication is strengthened through targeted outreach and the production of three short videos that present the Zaragoza demo site, Aitiip’s role in REMEDIES and highlights from the workshop. Valorisation is reinforced by establishing synergies with related EU projects such as ATRIUM, UPSTREAM, ECOSISTEMA GO and REDOL.

How others can replicate:

Combine an anti-litter campaign with innovation and entrepreneurship training and produce concise video outputs that communicate both learning and action.

Read more, [here](#).

Italy: CNR and Sea Scout Group, Sardinia and Southern Italy Campaign

The Italian anti-litter campaign is coordinated by the National Research Council of Italy, through the Institute for Marine Environment and the Institute of Polymers, Composites and Biomaterials, in partnership with the Sea Scout Group NGO. Launched in September 2025 across Sardinia and Southern Italy, it combines scientific expertise, community engagement and innovation transfer. The campaign is connected to major scientific and policy events. The Sixth REMEDIES Cluster Meeting, titled “Protected areas and citizens against plastic pollution”, takes place in Oristano during the Seventh General Assembly and explores challenges in protected areas, the role of marine protected areas as natural observatories for litter and regulatory implications such as the EU ban on intentionally added microplastics. Another

major event is the Fourth International Conference on Microplastic Pollution in the Mediterranean Sea, hosted by CNR in Ischia, which examines detection methods, impacts and mitigation strategies and discusses circular materials in emerging value chains. The campaign showcases a REMEDIIES innovation, biodegradable fishing nets developed by Cittadini and Next Technology Tecnotessile with CNR, Bio-Mi, Aitiip and the University of Maribor, designed to retain mechanical performance during use and degrade fully under industrial composting. Monitoring, communication and valorisation are integrated through scientific sessions, field testing in Sardinia and engagement with fisheries, youth and NGOs.

How others can replicate:

Build a campaign around scientific and policy events, use them to showcase concrete innovations and link community action with market and regulatory developments.

Read more, [here](#).

Common Features of Successful Anti-litter Campaigns

Across all REMEDIIES regions, successful anti-litter campaigns share four core features. They combine clean-ups with education by embedding training moments such as the PLASTIC FANTASTIC webinars and school sessions, strengthening the technical capacity of participants. They integrate monitoring by using standardised methods or innovative tools such as the Shoreline Marine Litter App, drones or river-cleaning technologies. They amplify communication through storytelling, visual documentation and public events such as cluster meetings and conferences. They pave the way for valorisation by showcasing technologies, analysing collected waste and linking local actions with circular-economy pathways. These elements create a replicable model where clean-ups become catalysts for awareness, science, innovation and long-term behavioural change.

7. Replication & Community Participation

The REMEDIIES model is designed for scale. Clean-ups, monitoring activities, and valorisation pathways can be replicated by any organisation, municipalities, NGOs, schools, volunteer groups, diving clubs, research teams, youth organisations or citizen movements, provided they follow the shared protocols, safety rules, and communication standards. Replication is essential for the Mission Restore our Ocean & Waters, because the project's impact grows when local actors adopt its approach, generate new data, activate communities, and feed validated results back to the wider Mediterranean network.

This chapter explains how external organisations can participate, how to access the REMEDIIES Protocol Pack, and how Associate Regions funded through the Open Calls are already acting as multipliers. Together, these components create an open, participatory ecosystem that extends the project far beyond its eight core demonstration sites.

7.1 How to Join

External organisations can join REMEDIES activities through several straightforward pathways. The first step is typically to get in touch with the consortium via hello@remedies-for-ocean.eu or to contact the relevant demo-site lead based on geographical proximity or thematic alignment. Organisations may co-organise beach or river clean-ups, adopt the monitoring protocol, use the REMEDIES Shoreline ML App (as it becomes publicly available), or host local awareness and valorisation workshops.

The eight REMEDIES demo sites and the lighthouse demo site of Venice and its lagoon represent diverse environmental and social contexts, each coordinated by a partner with deep territorial experience:

- Koper, Slovenia - University of Maribor (UM): coastal monitoring, citizen-science training, port and shoreline clean-ups.
- Sinis Peninsula, Sardinia - CNR: marine protected area clean-ups, scientific monitoring, fishing-gear circularity.
- Cyclades, Greece - MCG & NTUA: diver clean-ups, collaboration with local fishermen, coastal monitoring, citizen mobilisation.
- Umag, Croatia - EXIT Festival: youth-based environmental campaigns integrated into cultural events.
- Porquerolles, France - SMILO: island-scale awareness actions, beach clean-ups, and coordination with Port-Cros National Park.
- Durrës–Tirana, Albania - ETMI: river and coastal clean-ups, youth engagement, identification of upstream–downstream litter flows.
- Saïdia, Morocco - Mohammed Premier University: coastal clean-ups, drone and AI-based monitoring, shoreline litter assessments.
- Zaragoza, Spain - AITIIP: riverine clean-ups, innovation-focused awareness campaigns and valorisation workshops.

To participate, organisations may:

- Co-organise clean-ups with demo-site partners, following the Citizen Science Protocol for safe and effective field operations.
- Adopt the monitoring protocol using the 100 m EMODnet-aligned method and contribute data that becomes interoperable with the Marine Litter Database.
- Share clean-up metrics—kg collected, volunteers, types of litter—using standard WP2 templates, which allows aggregation across regions.
- Host valorisation workshops, school events or awareness campaigns using REMEDIES communication materials.

- Request support for reporting and branding alignment to ensure compliance with EU visibility rules.

Additional information on all eight demo sites is available [here](#).

7.2 Useful material

To support replication, REMEDIES provides materials that external organisations can download and use independently. This set of documents ensures that all clean-ups and monitoring activities, whether organised by core partners or external groups, follow the same standards, safety rules, and communication requirements.

The Pack includes:

Core methodological documents

- REMEDIES Citizen Science Protocol – Beach Litter Clean-ups, which describes in detail how to prepare, execute and document monitoring and clean-up events, including safety, equipment lists, waste management arrangements and roles. See more at Annex 1.
- Beach Litter Monitoring and Clean-up – Do's & Don'ts, a concise, visual guide summarising key safety and methodological rules, including seasonal restrictions, protected-area cautions, 100 m sampling design, >2.5 cm item threshold, bottle-and-cap rules and when to take photos for validation. See more at Annex 2.

Branding & visibility materials

To ensure compliance with EU visibility rules and support effective communication, the Protocol Pack includes all official REMEDIES branding assets. These can be downloaded directly from the REMEDIES website:

- [REMEDIES Flag \(vertical\)](#)
- [REMEDIES Flag \(horizontal\)](#)
- [Partners Logo Pack](#)
- [REMEDIES Logo](#)
- [EU Emblem](#)
- [Flyers](#)
- [Posters](#)
- [Generic REMEDIES Flag Pack](#)
- [Social Media Graphics](#)

These materials can be used for event branding at clean-up meeting points, volunteer group photos, banners, posters, and social media posts, local awareness campaigns, ensuring all activities comply with EU funding visibility requirements. Organisers should combine these materials with the citizen-science protocol, and reporting templates to create a coherent, REMEDIES-aligned clean-up or monitoring event.

Organisations should:

- Read carefully the Annex I and Annex 2. to ensure compliance with methodological and safety rules.
- Coordinate with local waste authorities for proper disposal and obtain permits where necessary.
- Share results back with the REMEDIES consortium using the WP2 reporting format or through the REMEDIES App once available.
- Notify the consortium at hello@remedies-for-ocean.eu if they wish to receive further support and for targeted communication actions.

By following the suggested process, organisations can run high-quality clean-ups and monitoring events that align with REMEDIES standards, generate reliable data, and contribute to the wider Mission Ocean community.

7.3 Open Call Associate Regions as Multipliers along with established cooperation with other Projects

The Associate Regions from Open Call 1 and Open Call 2 extend REMEDIES methodologies beyond the original demo sites, acting as replication hubs that translate the project's approach into local contexts. They demonstrate how municipalities, science centres and public agencies can combine citizen mobilisation, education, monitoring and targeted interventions to reduce plastic pollution. The following three cases illustrate exemplary implementation of the REMEDIES model.

Guimarães, Portugal: CLEAN-UP 4Guimarães (Open Call 1 Winner)

The CLEAN-UP 4Guimarães initiative integrates REMEDIES methodologies into the city's sustainability strategy "Guimarães 2030", with a mission to restore the ecological health of the Selho River. The project launched on 27 March 2024, engaging local media and mobilising citizens through TV and social channels. To prevent waste from reaching downstream ecosystems, eco-barriers made of 94% cork were installed to intercept floating litter.

Guimarães organised multiple community clean-ups. On 29 June 2024, the 774 Queijas Scout Group collected 233 kg of waste. On 14 August 2024, 28 volunteers from the Green Brigades and Portuguese Red Cross cleaned a 303 m by 21 m section of the river, removing over 200 kg of plastic and 200 kg of other waste, including textiles. Educational activities included an itinerant exhibition, nine online banners, three newspaper advertisements, a promotional video and distribution of recycling kits made from repurposed billboards. Furniture items created from recycled plastic (benches ~5.46 kg, tables ~19.48 kg) reinforced circularity messaging. Both clean-ups can be shown in the Figures 3 and 4 below.

Guimarães successfully demonstrates how REMEDIES can be scaled to river systems, combining clean-ups, behavioural awareness, nature-based solutions and strong municipal leadership.



Figure 4 Clean-up at the Selho River in Guimarães, Portugal – I



Figure 5 Clean-up at the Selho River in Guimarães, Portugal – 2

Esplora Interactive Science Centre, Malta: Island Guardians (Open Call 1 Winner)

Esplora's Island Guardians project is a science-driven community initiative that activates Maltese citizens around shoreline and underwater litter issues. On 25 July 2024, Esplora and NGO Żibel conducted a seabed and shoreline clean-up at South Quay Cirkewwa and Paradise Bay, mobilising 47 volunteer divers and snorkellers. They collected 919 kg of waste, of which 173 kg was plastic, highlighting the level of marine debris in recreational diving zones.

Beyond the event, Island Guardians runs hands-on educational programmes at the science centre, turning young visitors into active stewards. The initiative gained international visibility through a special mention at the Society4Med Awards, and participated in REMEDIATION Open Days, showing how innovation and clean-ups complement each other. The combination of coastal action, underwater engagement, and public science education makes Esplora a model for island-based replication.



Figure 6 Clean-up at South Quay Cirkewwa and Paradise Bay, Malta

Mersin Metropolitan Municipality, Turkey: Up-FreeCoasts (Open Call 2 Winner)

Mersin’s “Unite for Plastic-Free Coasts! (Up-FreeCoasts)” project demonstrates city-scale replication. During a three-week campaign in March–April 2025 across five coastal sites (Soli, Hilton, Taşkıran, Davultepe, Viranşehir), 182 volunteers collected 572.84 kg of marine litter, including 292.53 kg of plastic.

Education and innovation are central elements. The Mercan Climate and Environment Science Center hosted workshops attended by over 1,300 young people, teaching recycling, composting and zero-waste practices. Mersin also installed a smart reverse-vending machine that turns plastic waste into flower pots, and new coastal water fountains to reduce single-use bottles.

On 25 April 2025, the city hosted a REMEDIES Open Day with 74 participants, including local authorities, NGOs, universities, and REMEDIES mentors from NTUA and NIC, reinforcing knowledge transfer and long-term community engagement.

Mersin exemplifies a comprehensive municipal approach to replication, linking volunteer mobilisation, circular infrastructure, education, and stakeholder collaboration.



Figure 7 Clean-ups at Soli, Hilton, Taşkıran, Davultepe, and Viranşehir, Türkiye

Finally, VLPPF, as the lead organization of T2.4 for people-based beach clean-up and monitoring, has scaled up the use of the Mission Ocean and Waters apps it designed (namely the Shoreline Beach Litter Monitoring – REMEDIES - and SeaClear- Mare Pulito apps) by involving a new network of affiliated entities from the INTERREG IPA ADRION JOINABLE Project:

- AMAP REGION OF MARCHE (Italy)
- Municipality of Punat (Croatia)
- UOM University of Montenegro

They have been trained in the use of: (i) Shoreline Beach Litter Monitoring app (REMEDIES) and (ii) SEACLEAR2.0 App for Clean ups and are now implementing a plan (from September last year onward) for beach litter monitoring and clean up and we welcomed them to join the 20.000 kg plastic challenge of the REMEDIES Project.

8. Conclusions

This guideline demonstrates how REMEDIES transforms beach and river clean-ups into a structured framework that combines community mobilisation, scientific monitoring, communication, and innovation. Through the coordinated implementation of Task T2.4, partners across the Mediterranean and associated regions have applied common methodologies, safety rules, and reporting systems that ensure activities are comparable, replicable, and aligned with European monitoring standards. The integration of citizen engagement with tools such as the REMEDIES digital applications, harmonised protocols, and standardised reporting allows clean-ups to generate both environmental impact and valuable datasets that support long-term monitoring and policy-relevant knowledge. In this way, community-driven actions become part of a broader evidence-based approach to tackling marine litter.

Beyond the removal of thousands of kilograms of waste and the mobilisation of thousands of citizens, the REMEDIES clean-up framework demonstrates the importance of coupling local action with training, knowledge exchange, innovation, and replication mechanisms. Anti-litter campaigns, training initiatives such as the PLASTIC FANTASTIC webinars, and the involvement of Associate Regions illustrate how the methodology can be adopted and adapted across diverse coastal and riverine contexts. By linking clean-ups with monitoring, awareness, and valorisation pathways, REMEDIES contributes to the objectives of the EU Mission “Restore our Ocean and Waters” and provides a practical model for communities, institutions and organisations wishing to take coordinated action against plastic pollution.

III Valorisation Guideline

I. REMEDIES Context & Links to WPs

Within the Remedies framework, valorisation serves as the critical bridge between the environmental mitigation of plastic pollution and the creation of a functional circular economy. While monitoring and collection are essential to remove plastics from our ecosystems, the project's success involves also the ability to transform these diverse waste streams into secondary raw materials with industrial or social value.

Valorisation in Remedies is not a “one-size-fits-all” process; it is a technical response to the specific degradation and contamination profiles of different plastic families. From the single-use thermoplastics found in tourists' hotspots to the complex, bio-fouled ghost nets and the new generation of bio-based polyesters, each material requires a dedicated technological pathway. The objective of these guidelines is to move beyond “downcycling” (low-value disposal) towards a cascading use of resources. By optimising mechanical recycling, compounding, and additive manufacturing, we ensure that the effort invested in collecting plastic debris translates into tangible products, reducing the demand for virgin fossil-based resins and lowering the overall carbon footprint of the plastic life cycle.

2. Valorisation Pathways - Practical Guidelines by Value Chain

2.1 Value Chain I (PP, PE, PET): Technical feasibility study for a decentralised recycling transformation center

Background and Rationale

Santorini, an island in the southern Aegean Sea, is one of the most iconic and recognizable of the Cyclades. Renowned for its dramatic volcanic caldera, stunning sunsets, and picturesque villages with white-washed houses clinging to cliffs, the island is a premier global tourist destination. This unique landscape, a result of one of the largest volcanic eruptions in recorded history, shapes both its natural beauty and its socio-economic structure, which is heavily reliant on tourism.

Population:

- Permanent Population: Approximately 15,500 residents.
- Tourist Population: The island attracts around 3.4 million visitors annually.

Economy:

- Gross Domestic Product (GDP): While specific GDP data for Santorini alone is not readily available, the island significantly contributes to the overall GDP of Greece through its robust

tourism sector. Greece's GDP per capita is €21,892 at nominal value and €38,290 at purchasing power parity.

Tourism:

- Annual Visitors: Approximately 3.4 million.
- Daily Cruise Visitors: Up to 17,000 during peak season.
- Tourism Revenue: Tourism is a major contributor to the local economy, supporting numerous businesses and services.

Agriculture:

- Key Products: Wine (1,200 hectares – 3,000 tons of grapes) - A significant portion of the wine produced is consumed locally, supporting the island's tourism industry.
- Vineyards: Notable for producing unique wines such as white nikteri and sweet red vissanto.

Employment:

- Tourism Sector: Provides the majority of employment opportunities, including jobs in hotels, restaurants, transportation, and recreational services.
- Agriculture: Also a significant source of employment, particularly in the production and trade of local agricultural products.

The Plastic Lab initiative in Santorini is part of a broader campaign called "Plastic-Free Santorini," launched by the Greek Tourism Ministry, the Municipality of Thira, and supported by Lidl Hellas and the Laskaridis Foundation. The initiative aims to eliminate plastic pollution on the island, promoting environmental awareness and sustainability.

Key Points:

- Objective: The campaign seeks to reduce and eventually abolish plastic usage on Santorini, making it the first island in the Cyclades free of plastic
- Phases:
 - Phase 1: Focuses on high tourist traffic areas such as airports, ports, and passenger ships, along with online promotions
 - Phase 2: Involves educational programs and direct interventions on island beaches, collaborating with environmental organizations
- Promotion: The campaign will be promoted through various channels, including local media, posters at key locations, and advertisements within Greece

- **Environmental Impact:** The initiative addresses the significant increase in coastal pollution during peak tourist months, with a focus on reducing plastic waste

The campaign reflects a universal trend towards ecological sensitivity and aims to position Santorini as a leading example of environmental protection in the tourism sector.

The Kind of Plastics

The intense tourist activity on Santorini generates a substantial volume of plastic waste. While precise official figures are limited, estimates based on the 3.4 million annual visitors suggest the generation of over 900 tonnes of plastic waste from tourism alone each year. This waste stream is dominated by single-use packaging and items, which are ideal feedstocks for the proposed transformation center. The primary plastics targeted by this project are:

- **Polyethylene Terephthalate (PET):** Constituting an estimated 45% of the tourist plastic waste stream (approximately 405 tonnes annually), PET is primarily found in single-use water and soft drink bottles. Its clarity and strength make it a valuable resource for producing high-quality recycled products, including 3D printing filament and durable souvenirs.
- **Polypropylene (PP):** Representing about 25% of the waste (around 225 tonnes annually), PP is used in a wide range of products including bottle caps, takeaway food containers, yogurt pots, and single-use cutlery. Its versatility and heat resistance make it suitable for injection-moulded items like travel accessories and functional parts.
- **Polystyrene (PS):** This material, often found as disposable cups, plates, and some food containers, accounts for an estimated 15% of the total (approximately 135 tonnes annually). While sometimes challenging to collect, it can be transformed into decorative objects and educational materials.
- **Other Plastics (HDPE, LDPE, ABS):** The remaining 15% (around 135 tonnes) includes High-Density Polyethylene (HDPE) from shampoo and cleaning product bottles, Low-Density Polyethylene (LDPE) from plastic bags, and Acrylonitrile Butadiene Styrene (ABS) from broken consumer items like luggage parts or electronics casings. While HDPE and LDPE are collected, the project will specifically focus on ABS for its potential in creating robust 3D printed parts and durable goods.

This significant and consistent stream of plastic waste not only poses an environmental threat but also represents a valuable, untapped local resource that can fuel a circular economy on the island.

Lidl, as a key partner, also contributes to the local plastic stream, primarily through packaging. The company is actively working to reduce its plastic footprint through its REset Plastic initiative, which includes:

- **Packaging Reduction:** Removing plastic overlids from dairy products (PET) and replacing flow wrap on produce trays (PP) with recyclable alternatives.
- **Recycled Content:** Incorporating "Prevented Ocean Plastic" (recycled PET) into its packaging for fresh fish and meat.

- Sustainable Alternatives: Introducing reusable mesh bags (PE/PP) for fruits and vegetables and trialing compostable bags (PLA).

Objectives of the Study

This feasibility study aims to assess the viability of a small-scale Recycled Transformation Center in Santorini, providing a framework to transform tourism-generated plastic waste into valuable products, in line with the "Plastic-Free Santorini" initiative.

The specific objectives are:

1. Evaluate Technical Feasibility: Assess the suitability of small-scale recycling technologies for processing common plastics (PET, PP, PS, ABS) and determine the necessary infrastructure, equipment, and expertise, including the potential for creating 3D printing filament.
2. Analyze Economic Viability: Design marketable products like tourist souvenirs and parts for local industries (e.g., wineries), estimate operational costs and revenues, and explore sustainable business models.
3. Define Operational Frameworks: Develop a logistical strategy for plastic collection and sorting with local partners, propose criteria for site selection, and outline human resource needs.
4. Assess Environmental and Social Impact: Evaluate the project's potential to divert plastic waste, create educational workshops for tourists and locals, and provide inclusive employment opportunities.
5. Propose a Replicable Model: Document the findings to serve as a blueprint for Santorini and create a framework that can be replicated in other tourist destinations.

Scope and Limitations

This study and the proposed pilot project are defined by the following scope:

- Geographical Focus: The initiative is geographically centered on the island of Santorini. Waste collection and facility siting will prioritize high-traffic tourist zones to maximize impact and visibility.
- Material Focus: The project will concentrate on recycling the most common thermoplastics generated by tourism: PET (Polyethylene Terephthalate), PP (Polypropylene), PS (Polystyrene), and ABS (Acrylonitrile Butadiene Styrene). Other plastic types, composites, or hazardous materials are outside the current scope.
- Technological Focus: The feasibility assessment is limited to small-scale, decentralized recycling technologies, including shredding, injection moulding, sheet pressing, and extrusion for 3D printing filament. The study does not extend to large-scale industrial plants or chemical recycling processes.

- **Product Focus:** The primary objective is the creation of high-value, locally relevant products aimed at the tourism market (e.g., souvenirs, travel accessories) and specific niche applications (e.g., components for local wineries). The mass production of generic plastic goods is not an objective.
- **Operational Phase:** The scope encompasses the feasibility, planning, setup, and pilot operation of the transformation center. This includes establishing waste collection logistics, developing community and tourist engagement programs, and creating a sustainable operational model.

The project's success is subject to several potential limitations:

- **Scale of Impact:** The proposed micro-factory is a small-scale intervention. While it will serve as a powerful educational tool and a visible symbol of circularity, its direct contribution to reducing the total volume of plastic waste on Santorini will be modest.
- **Dependence on Tourism:** The economic model and the supply of raw materials are intrinsically linked to tourist activity. The system's viability could be affected by seasonal fluctuations or major disruptions to the travel industry.
- **Material Quality and Contamination:** The quality of the final products depends entirely on the purity of the collected plastic waste. Contamination from food residues, non-target materials, or incorrect sorting can compromise the integrity of the recycled material and requires labor-intensive manual sorting and cleaning.
- **Technical Constraints:** While accessible, open-source recycling machinery may have lower throughput, consistency, and higher maintenance needs compared to industrial-grade equipment. Sourcing spare parts or specialized technical support could present logistical challenges.
- **Market Acceptance:** The commercial success of the output products hinges on tourist interest in purchasing items made from recycled waste. While sustainable consumerism is a growing trend, market demand and the willingness to pay a premium for such products must be actively cultivated through storytelling and marketing.
- **Regulatory and Logistical Hurdles:** The project may encounter unforeseen administrative or regulatory hurdles related to waste management, small-scale manufacturing permits, or local zoning laws. Furthermore, island logistics can add complexity and cost to supply chains and transportation.

Description of recycling and transformation Technologies

Tourism generates a significant volume of plastic waste, particularly single-use packaging and consumer products made from thermoplastics such as PET (Polyethylene Terephthalate), PS (Polystyrene), PP (Polypropylene), and ABS (Acrylonitrile Butadiene Styrene). These materials, while often discarded after a single use, retain physical properties that make them highly suitable for recycling and transformation into new, valuable products.

The recycling process generally involves collection, manual sorting, cleaning, and shredding of plastic waste into small flakes.

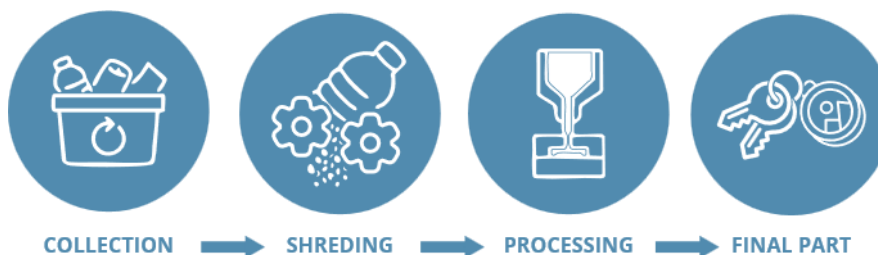


Figure 8 Recycling flowchart

These flakes serve as feedstock for a range of accessible, small-scale technologies developed by platforms such as [Precious Plastic](#) and [Plasticpreneur](#), which provide open-source, modular solutions for decentralized plastic processing.



Figure 9 Recycled carabiners made of PP (Source: [Carabiners Mould | plasticpreneur](#))

Key transformation technologies include:

- **Granulator:** Washed and sorted plastic is fed into the hopper and enters the cutting box. Blades on a motor driven rotor, grind the plastic into small flakes.
- **Injection Moulding:** Melted plastic is injected into moulds to produce functional items such as tools, accessories, souvenirs, or construction components.
- **Compression Moulding:** Heated plastic flakes are pressed into flat or shaped moulds to create panels, tiles, furniture, or artistic pieces.
- **Extrusion:** Plastic is melted and continuously extruded through a shaped die to form profiles, planks, or beams, useful in construction or design applications.
- **Sheet Pressing and Thermoforming:** Recycled plastic is compressed into sheets that can later be thermoformed into packaging, trays, or signage.

In addition, some thermoplastics like PET and ABS can be extruded into filament for use in desktop 3D printing (Fused Filament Fabrication). This approach enables the production of high-value customized objects and prototypes, while promoting the reuse of local waste streams in digital manufacturing workflows. Recycled 3D printing filament is gaining traction as a sustainable alternative to virgin plastic, especially in educational, maker, and design-driven environments.



Figure 10 DIY machine for turning plastic bottles into 3D printing filament

To ensure effective transformation of plastic waste into valuable products, it is essential to understand the characteristics of each material and match them with suitable recycling and fabrication processes. The following table summarizes the most common thermoplastics found in tourism-related waste, such as PET, PP, PS, and ABS, along with their typical sources, compatible processing methods, and potential applications within a small-scale circular economy model. This overview serves as a practical guide for selecting appropriate input materials and designing efficient, localized recycling workflows.

Table 3 Tourism Plastic Waste: Materials and Valorisation Options

Material	Typical Sources (Tourism Waste)	Compatible Processes	Example Applications
PET (Polyethylene Terephthalate)	Water bottles, food containers, transparent packaging	Shredding & extrusion (filament) Sheetpress Injection moulding	3D printing filament Souvenir keychains Tiles or plaques
PP (Polypropylene)	Bottle caps, food trays, single-use items	Injection moulding Extrusion Sheetpress	Travel accessories (clips, luggage tags) Reusable items
PS (Polystyrene)	Disposable cutlery, food containers, festival cups	Injection moulding Sheetpress	Decorative objects Educational pieces or game tokens

ABS (Acrylonitrile Butadiene Styrene)	Broken plastic objects, housings, consumer electronics	Extrusion filament) 3D printing Injection moulding	(for Collectible souvenirs 3D printed prototypes Mechanical parts
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By adopting these decentralized recycling and transformation technologies, tourist regions (especially those in remote or coastal areas) can implement circular economy models, reduce environmental impact, create local employment opportunities, and raise awareness about the value of plastic as a resource rather than waste.

Site selection and infrastructure requirements

The successful implementation of small-scale plastic recycling and transformation technologies requires careful site selection and adequate infrastructure to ensure operational efficiency, safety, and community engagement.

Site Selection Criteria:

- **Proximity to Waste Generation Points:** The facility should be located near areas with high volumes of plastic waste from tourism-related activities (e.g., beaches, hotels, restaurants, campsites, festivals), to minimize transportation costs and environmental impact.
- **Accessibility:** Easy access for delivery of raw plastic waste and distribution of final products is essential. The site should allow access for small vehicles or collection trolleys.
- **Community Integration:** Choosing a site within or close to the local community promotes awareness, participation, and education. Integration with schools, makerspaces, local workshops, or environmental centres can increase impact and visibility.
- **Environmental Considerations:** The site should comply with local environmental and zoning regulations, avoiding ecologically sensitive areas and ensuring proper management of emissions, noise, and waste residues.

Table 4 Essential equipment

Equipment	Function	Key Role in the Process	Example/Model
Granulator (Shredder)	Reduces plastic waste into uniform flakes.	Preparation: The critical first step to prepare raw material for all other processes.	Precious Plastic Shredder Pro / Fila-Shredder
Injection Moulding Machine	Injects melted plastic into custom molds to	Production (High Volume): Ideal for creating consistent products	IMK2 Injection Moulding Machine (Plasticpreneur)

	produce detailed, high-strength parts.	like souvenirs, clips, or functional parts.	
Sheetpress	Compresses heated plastic flakes into flat sheets.	Material Creation: Produces versatile panels and sheets for signage, furniture, or thermoforming.	Precious Plastic Sheetpress V4
Extrusion System	Melts and pushes plastic through a die to form continuous profiles like beams or filament.	Versatile Output: Creates structural elements or feedstock for other technologies like 3D printing.	Precious Plastic Extrusion Pro / PETamentor 2
3D Printer (FFF/FDM)	Builds objects layer-by-layer from extruded filament.	Customization & Prototyping: Allows for high-value, complex, and on-demand production using recycled filament.	Bambu Lab X1 Carbon / Prusa i3 MK4
Fume Extractor	Captures and filters volatile organic compounds (VOCs) released during heating.	Safety: Essential for maintaining safe indoor air quality, especially when processing PS or ABS.	BOFA PrintPRO / Weller Zero Smog
Plastic Scanner	Helps identify different types of plastic.	Quality Control: Ensures proper material separation, which is crucial for the quality and safety of the final product.	Re-plastic / Open-source NIR scanners

- Granulator (Shredder): For reducing plastic waste into uniform flakes suitable for further processing. This is the first and most critical step to prepare raw material from collected plastics.
- Injection Moulding Machine: For producing detailed, high-strength parts using custom molds. Example: IMK2 Injection Moulding Machine by Plasticpreneur is a compact, user-friendly option suited for small-scale or educational use.
- Sheetpress: For creating flat plastic sheets that can be used for signage, trays, panels, or further thermoforming. It requires adequate pressure and heating control.
- Extrusion System: To create continuous profiles (e.g., planks, filament, rods) from melted plastic. Can be adapted for filament production for 3D printing, particularly with PET or ABS.

- **Fume Extractor:** A must-have for ensuring safe indoor air quality, especially when working with plastics that may release volatile compounds. It should be placed near machines that involve heating or melting plastics.
- **Plastic Scanner (Material Identifier):** Optional but useful tool for identifying the type of plastic (e.g., PET, PP, PS) to ensure proper separation and optimal processing conditions. Handheld infrared scanners or visual tools can improve sorting accuracy.
- **3D Printer (FFF/FDM):** A filament-based 3D printer, such as the Bambu Lab X1 Carbon, allows for the use of recycled filament to manufacture highly customized, detailed parts and prototypes. This expands the range of outputs, especially in education, design or local craft contexts.



Figure 11 Injection moulding machine (Plasticpreneur) & Sheetpress for recycled plastic sheets (Precious Plastic)

Infrastructure Requirements:

- **Covered and Ventilated Space:** A sheltered working area of approximately 40–80 m² is recommended, depending on the scale of operations. Proper ventilation is required for safe handling of melted plastics, especially materials like ABS or PS that may release fumes.
- **Electrical Supply:** Standard industrial electrical connections (e.g., 230–400V) are required to operate shredders, extruders, injection and compression machines. Power stability and energy efficiency should be considered.
- **Material Storage Zones:** Clearly defined areas for incoming waste, cleaned and shredded plastic, and finished products help streamline operations and improve safety and hygiene.
- **Safety Equipment and Protocols:** Fire extinguishers, personal protective equipment (PPE), signage, and emergency procedures must be in place, especially when dealing with high temperatures and mechanical equipment.

- **Optional Add-ons:** Depending on the chosen transformation methods, the site may benefit from additional features such as a water point for cleaning plastics, a filament winder for 3D printing material, or a display area for products and educational purposes.

In conclusion, establishing a local recycling micro-facility does not require large investments but does depend on strategic placement, basic infrastructure, and community involvement. With the right setup, these spaces can become catalysts for sustainable innovation and circular economy practices in tourism-heavy regions.

Input materials: sources and logistics of plastic waste collection

The efficiency and viability of a decentralized plastic recycling initiative depend heavily on the consistent availability of input materials and the design of an effective waste collection system. In tourism-dominated areas, thermoplastic waste such as PET, PS, PP, and ABS is frequently generated through short-term consumption patterns and single-use products.

Primary Sources of Plastic Waste:

- **Hospitality Sector:** Hotels, hostels, and holiday rentals generate high volumes of bottled water containers (PET), toiletry packaging, disposable cups, and food trays.
- **Food & Beverage Services:** Restaurants, beach bars, cafés, and take-away services are key contributors of PP and PS waste in the form of food containers, lids, and cutlery.
- **Tourist Activities & Events:** Open-air festivals, sports activities, excursions, and beach visits often result in improperly disposed packaging, drink bottles, and other short-lived plastic items.
- **Retail and Souvenir Shops:** Packaging waste from tourist purchases, often made from PP or PET, adds to the volume of recoverable plastic.

Logistics of Collection:

- **Segregated Collection Points:** Clearly marked recycling bins for plastic waste should be installed in high-traffic tourist zones, including beaches, ports, parks, and accommodation facilities.
- **Partnerships with Local Businesses:** Engaging hotels, restaurants, and shops in voluntary collection schemes fosters cooperation and ensures regular waste flow. Incentives or awareness campaigns can enhance participation.
- **Mobile Collection Units:** In areas with dispersed tourism activity, mobile collection systems (e.g., bike trailers, electric carts) can efficiently gather waste while minimizing emissions and traffic.
- **Sorting and Preprocessing Hubs:** A preliminary sorting and cleaning station may be necessary prior to transporting the materials to the recycling site. This reduces contamination and increases the quality of the end product.

- **Seasonal Considerations:** Tourist seasons can greatly influence the volume of plastic waste. Flexible logistics and storage capacity should be planned to manage peak periods.

By building strong collaborations with local stakeholders and designing a tailored logistics strategy, plastic waste collection can become a reliable and sustainable input stream for transformation technologies. Beyond resource recovery, this approach raises awareness among visitors and residents, reinforcing environmental responsibility in tourism-driven economies.

Output products: types, quality standards, and applications

The outputs of small-scale plastic recycling facilities can serve both functional and symbolic purposes, particularly when aligned with tourism, sustainability, and local identity. By transforming plastic waste into new objects, the initiative not only adds value to discarded materials but also creates a strong emotional and educational connection with users, especially tourists.

Types of Output Products:

- **Souvenir Keychains and Tokens:** Custom-moulded keychains shaped like iconic landmarks, symbols, or motifs associated with each city or region (e.g., Eiffel Tower in Paris, tram in Lisbon, basilica in Zaragoza). These can serve as limited-edition collectibles, encouraging travellers to collect them in each destination they visit and recycle in.
- **Collectible Series:** A branded series of recycled plastic “tiles,” badges or mini-sculptures, each representing a city or location. Travelers could complete a collection by recycling plastic waste on-site and receiving a unique piece linked to that place. These objects could be numbered, color-coded, or part of a global map initiative.
- **Functional Everyday Items:** Small, practical objects with tourist appeal, such as:
 - Luggage tags made from recycled PET or ABS
 - Phone stands or card holders
 - Reusable clips or travel accessories (e.g., toothpaste tube rollers)
- **Educational and Promotional Objects:** Items designed to raise awareness of plastic recycling, such as:
 - Puzzle sets or interlocking parts showing the journey from waste to product
 - Co-branded products with local museums or environmental NGOs
 - DIY kits or small assembly toys using extruded or injection-moulded parts



Figure 12 Visualization of the possible recycled items

Quality Standards and Aesthetic Appeal:

All products must comply with basic safety and material handling standards, especially when produced with thermoplastics like ABS or PS. Finishing should be carefully managed to remove sharp edges and ensure durability. Where applicable, items should include markings that indicate the type of recycled material used, promoting transparency and education.

Visual appeal is essential: using coloured flakes, marbled textures, or layered effects gives products a distinctive aesthetic that also highlights the recycled origin of the material. Designs should embrace the imperfections of the material as part of its storytelling.

Applications and Impact:

These products can be sold or distributed:

- As souvenirs in tourist information centres, museums, eco-lodges, or airports
- As part of incentive programs for tourists who participate in plastic collection or recycling activities
- Through subscription-based models or apps where travellers log their recycling activity and earn collectibles or discounts
- In educational workshops where visitors make their own object from local waste

By linking waste transformation to place-based identity and gamification, this model transforms the act of recycling into a memorable and repeatable experience, turning tourists into active participants in circular economy efforts across different destinations.

Human resources and technical expertise

The implementation and operation of a small-scale plastic recycling facility require a combination of technical skills, operational roles, and community engagement. While the technologies used are relatively accessible and open-source, proper training and task distribution are essential to ensure safety, efficiency, and impact.

Key Human Resource Profiles:

- **Technical Operator(s):** Responsible for handling the machinery (shredder, injection, extruder, compression, etc.), maintaining equipment, and ensuring correct settings for each material. Basic knowledge in mechanics, thermoplastics behaviour, and machine safety is required. Ideally, 1–2 full-time or part-time operators depending on production scale.
- **Design and Product Developer:** This role focuses on developing molds, object design, and ensuring that the recycled items meet aesthetic and functional goals. Knowledge of 3D modelling (e.g., Fusion 360, Blender) and familiarity with 3D printing and digital fabrication are advantageous.
- **Recycling Coordinator / Logistic Manager:** Oversees the collection system, relationships with local businesses, sorting logistics, and inventory management. This role also ensures alignment with waste management regulations and organizes storage areas.
- **Community and Educational Facilitator:** Especially relevant in tourism or educational contexts, this person runs workshops, guides visitors, manages public outreach, and creates awareness campaigns. Strong communication and pedagogical skills are key.
- **Project Manager / Supervisor:** Ensures the coordination between stakeholders, budget control, and project milestones. May also liaise with local authorities, tourism offices, and sustainability networks.

Required Expertise and Training:

While highly specialized knowledge is not mandatory, the team should receive initial training in:

- Safe handling of thermoplastics (e.g., dealing with fumes from ABS or PS)
- Operation and maintenance of recycling machinery
- Quality control of products
- Basic design for manufacturability (DFM)
- Environmental and circular economy principles

This training can be supported through online resources (e.g. Precious Plastic Academy), local fabrication labs (FabLabs, maker spaces), or partnerships with universities and vocational schools.

Opportunities for Inclusion and Employment:

Such micro-factories can offer employment or training for:

- Youth and students (in tourism, environmental sciences, design, or engineering)
- People in vulnerable situations, promoting inclusive circular economy initiatives
- Local artisans or craftspeople, integrating recycled plastic into traditional practices

By blending technical skills with creativity and local identity, the project not only recycles plastic—it builds human capacity and community ownership around sustainability.

Conclusions and recommendations

The implementation of small-scale plastic recycling and transformation facilities in tourism-heavy areas represents a high-impact, low-barrier opportunity to advance circular economy principles at the local level. By harnessing the value of thermoplastic waste, such as PET, PS, PP, and ABS; these micro-factories turn environmental challenges into tangible, community-driven solutions.

The proposed model demonstrates clear benefits: it contributes to environmental protection by diverting plastic waste from landfills and natural ecosystems, particularly in coastal and protected areas; it fosters social cohesion through education, local engagement, and potential job creation; and it offers economic potential by generating new products with market value and cultural relevance. Additionally, it adds a narrative layer to tourism, allowing travellers to connect with local sustainability efforts and bring home meaningful souvenirs with purpose.

To ensure long-term success, several key recommendations emerge. First, projects should start small and scale smart, focusing initially on one or two core transformation techniques (such as injection moulding and extrusion), and expanding as community interest and capacity grow. It's also important to leverage local identity in product design: creating items that reflect the culture, landmarks, or symbols of each destination increases both their appeal and their value as souvenirs or collectibles.

Securing a stable input of plastic waste is essential, and this can be achieved by forging partnerships with local businesses, festivals, accommodations, and restaurants. This approach not only ensures material flow but also reinforces a shared commitment to sustainability. Equally vital is a strong focus on safety and training, especially when working with heat-based processes or potentially hazardous materials like ABS and PS, clear operational protocols and basic technical education are non-negotiable.

Moreover, integrating recycling with tourist experiences and educational initiatives can enhance visibility and participation. Offering workshops, maker sessions, or reward-based systems for visitors who contribute plastic can transform a passive act of disposal into an engaging and memorable moment. Finally, by designing for replicability, the initiative can scale organically, through open documentation, shared learnings, and network-building, so that similar micro-factories can take root in other cities or tourist destinations with minimal adaptation.

In conclusion, the synergy between recycling, local craftsmanship, and sustainable tourism opens new paths to reduce waste, engage communities, and inspire behavioural change. With modest infrastructure and well-structured partnerships, plastic waste can become not only a challenge to overcome, but a valuable resource and storytelling medium for the places we visit and the future we want to build.

2.2. Value Chain 2 (PA): Protocol for recovering and valorisation of fishing nets

2.2.1 Introduction

Marine plastic pollution is increasingly recognized as one of the most pressing global environmental challenges. Among the different fractions of marine litter, abandoned, lost, or otherwise discarded fishing gear, commonly referred to as “ghost nets,” plays a particularly critical role due to its persistence, entanglement hazards, and contribution to the accumulation of microplastics in the marine environment. Earlier FAO/UNEP assessments estimated that around 640,000 tonnes of fishing gear are lost or discarded in the oceans each year^[1]. More recent analyses based on global surveys and quantitative modelling suggest that losses may be closer to 160,000–200,000 tonnes annually, equivalent to about 2% of all fishing gear put in use worldwide^[2].

The challenge is not only environmental but also economic and social. Coastal communities, fisheries, and aquaculture operators are directly affected by the accumulation of ghost gear, while governments and municipalities bear significant costs for clean-up and waste management. At the same time, these discarded nets represent a potential secondary raw material stream that is largely underexploited.

The primary objective of these guidelines is to define the technical and logistical pathway for the valorisation of PA nets into two high-value outputs: textile yarns for commercial clothing and reinforced pellets for structural composite materials. By integrating the field expertise of partners like SMILO and Palana Environment with the technological capacities of NTT and AITIIP, these guidelines ensure that marine residues are not merely disposed of, but upcycled into technical materials. This framework covers the entire journey: from the environmental impact assessment during recovery to the optimization of mechanical properties through mineral reinforcement.

2.2.2 Description of the recovered material

Types of fishing nets recovered

Within the framework of REMEDIES, SMILO interviewed the association Palana Environment, founded in 2016 in Marseille, in France, by professional diver Pablo Liger. The association works to preserve and restore marine ecosystems in southern France. Its core mission is to identify, recover and recycle abandoned fishing nets, which represent a serious threat to marine biodiversity in the Mediterranean. Palana Environment works in close collaboration with local fishers along the Mediterranean coast, from the Côte Bleue and Marseille to the Frioul Islands, and as far as Porquerolles.

The nets identified and recovered by the association originate predominantly from professional coastal fishing activities in the north-western Mediterranean. The recovered materials mainly include:

- Nets used in small-scale artisanal coastal fisheries;
- More occasionally, trawl-type nets, which are larger in size and present a high entanglement potential.

These nets are essentially composed of synthetic polymers. Depending on the fishing technique, ancillary components (ropes, floats, metallic elements) may be present and must be separated during the pre-processing stages.

Around Porquerolles (REMEDIES pilot site), a joint operation was carried out with Palana Environment, the Port-Cros National Park and local fishers to recover an abandoned artisanal fishing net. As the net was too severely damaged to be recycled, it was subsequently transported to a landfill facility.

Origin and geographical context

The fishing nets recovered by Palana Environment originate from the Mediterranean coastal zone of southern France, with a particular focus on:

- Porquerolles Island;
- The Côte Bleue;
- The Marseille area and the Frioul Islands.

These recovery operations, coordinated by the Marseille-based association, are conducted in close collaboration with:

- Local fishers;
- Managers of marine protected areas (notably the Port-Cros National Park);
- Local authorities and environmental organisations.

This field-based cooperation ensures a minimum level of traceability of the recovered materials and enables the collection of qualitative information regarding the type of net, its initial use and the estimated conditions under which it was lost at sea.

Recovery conditions and environmental assessment

Prior to any removal operation, Palana Environment systematically carries out an environmental impact assessment to determine whether the extraction of the net is ecologically appropriate.

Based on field experience:

- Approximately 90% of identified nets are removed;
- The remaining around 10% are left in place when they are too integrated into the environment (strong biological colonisation, entanglement in sensitive habitats), and when their removal would cause greater ecological damage than benefit.

Recovered nets are generally located:

- On rocky seabeds, often in interaction with gorgonians and coralligenous habitats;

- Or on sandy seabeds, where they may remain mobile and continue to fragment, releasing microplastics into the marine environment.

During recovery operations, divers also take part in ecological restoration actions, notably through the transplantation of damaged gorgonians to more suitable habitats.

Estimated time in the marine environment and degradation state

The degradation state of recovered nets strongly depends on their duration of submersion and their interaction with the marine environment.

Field observations allow the following phases to be identified:

- 0–6 months: the most critical period. Nets remain highly active in terms of ghost fishing, with significant accidental catches of fish and crustaceans.
- 6–12 months: progressive reduction in fishing efficiency, linked to algal colonisation.
- 1–2 years: nets generally no longer trap organisms, but remain mechanically hazardous and polluting:
 - On rocky substrates, nets may become heavily colonised by calcareous algae and partially stabilised;
 - On sandy substrates, they remain mobile and continue to degrade, contributing to the release of microplastics.

From a materials perspective, prolonged exposure to:

- UV radiation (for partially exposed nets);
- Saltwater;
- Mechanical stresses;
- Calcareous colonisation;

leads to polymer ageing, macromolecular chain scission, and an increase in contamination, directly affecting the suitability of the nets for high value-added valorisation routes.

Implications for valorisation pathways

Not all recovered nets can be directed towards the same valorisation pathways. Depending on their condition:

- Lightly degraded nets, which have spent a limited time in the marine environment and exhibit low contamination levels, may be directed towards textile applications (filament extrusion, yarn production);

- Heavily colonised or mechanically degraded nets could be more suitable for less mechanically demanding uses, or controlled disposal pathways.

For example, in July 2025, the ghost net recovered offshore from Porquerolles following a report by a recreational diver was assessed as too degraded to be recycled. It was therefore directed to a waste treatment facility.

Local reuse and emerging circular initiatives

Whenever possible, the fishing nets recovered by the French association are integrated into local circular economy initiatives, including:

- Direct reuse within the fishing community;
- Transformation into decorative or design objects by the association Sauvage Méditerranée (France);
- Exploratory collaborations with SAO Textile (France), aiming to recycle certain nets (notably trawl-type nets) into sustainable textile fibres.

These initiatives illustrate that, although the majority of fishing nets recovered from the sea are heavily degraded, a fraction can be valorised as secondary raw material when recovery takes place sufficiently early and under controlled conditions.

2.2.3 State of the art: opportunities and challenges in recycling PA6 from fishing nets

Fishing gears are typically made of synthetic polymers with good mechanical strength and chemical resistance, especially polyamides (e.g. PA6), polyethylene (PE), polypropylene (PP) etc. PA6 is commonly used due to its excellent tensile strength, abrasion resistance, and resistance to saltwater environments. It has been estimated that more than 75% of synthetic fishing nets are composed of PA6^[3]. While these properties make PA6 ideal for demanding marine applications, they also pose challenges for end-of-life management: long service life, exposure to UV, saltwater, mechanical abrasion, and biofouling lead to degradation, which complicates recycling and reuse.^{[4],[5]}

Recycling fishing nets into secondary raw materials represents both a waste management strategy and a resource efficiency opportunity, in line with the EU Circular Economy Action Plan^[6] and the EU Plastics Strategy^[7].

By transforming this waste stream into valuable products, it is possible to significantly reduce marine litter and its associated ecological impacts. Furthermore, the substitution of virgin PA6 with recycled feedstock contributes to resource efficiency, reducing dependency on non-renewable fossil-based inputs and promoting the use of secondary materials. From a climate perspective, the implementation of this process enables a measurable reduction in greenhouse gas emissions and overall carbon footprint throughout the value chain. In addition to the environmental and climate benefits, the valorisation of this waste stream creates new market opportunities and supports the development of innovative business models in strategic industrial sectors, including automotive, textiles, consumer goods, and construction.

Two of the most common recycling approaches for PA fishing nets are chemical and mechanical recycling. The key factor influencing the choice between these technologies lies in the effective removal of contaminants (such as salts, sand, and biomaterials) and in the extent of polymer degradation caused by prolonged exposure to UV radiation and marine hydrolysis.

These aspects strongly affect the feasibility and quality of mechanical recycling, often making chemical recycling a more suitable option. In fact, chemical recycling (depolymerization) is often celebrated for its ability to return PA6 to its original monomeric state, effectively creating a "virgin-quality" resin. The global leader in this field is the Italian company Aquafil, which produces ECONYL®, a regenerated nylon specifically manufactured from waste such as recovered fishing nets (both from aquaculture and recovered "ghost nets"), carpet fluff, and industrial plastic. However, this process is highly energy-intensive and requires massive industrial plants.

In contrast, mechanical recycling offers a more localized and low-carbon alternative. This method focuses on the physical transformation of nets through sorting, washing, shredding, and melt-extrusion into new pellets. Although it requires careful management of polymer degradation and contamination, several companies have successfully scaled this approach to create high-value secondary raw materials.

Bureo^[8], a company settled in Chile and USA, has developed the NetPlus® program, an initiative focused on the collection and mechanical recycling of discarded nylon fishing nets across coastal communities in South America. This material is used to manufacture recycled pellets, which are now integrated into the premium product lines of global brands such as Patagonia, Yeti, and Humanscale. In fact, NetPlus® material is used to produce a wide array of products, ranging from yarn for high-performance apparel fabrics to durable injection-molded hard goods such as skateboards, sunglasses, and office furniture components.

In Europe, Plastix^[9] is a Danish cleantech company focused on the mechanical transformation of maritime fibers, especially used fishing nets and ropes, into high quality Green Plastic. Their technology is specifically designed to handle the contamination typical of used fishing gear, converting it into standardized pellets for industrial plastic components and furniture.

Another example is Circular Ocean, a Portuguese initiative and cleantech project, turning discarded fishing nets into a high-performance recycled raw material called PENYLON™^[10]. The material is an example of fully r-PA6 made from ocean-bound nets with traceable supply chain, claiming ≈ 92% CO₂ reduction relative to virgin PA6 production. The material is offered to designers, manufacturers, and companies that intend to use it in finished products—for example in large-scale 3D printing processes or to produce sustainable components and furniture.

Companies are also already using PA6 from recycled fishing nets in visible trim parts in automotive applications via injection moulding. For example, BMW has integrated about 30% marine plastic waste recycled into visible automotive trim components in its Neue Klasse series^{[11],[12]}. Similarly, DSM/Envior markets Akulon® RePurposed, a recycled PA6 derived from fishing nets, which is used in automotive components^{[13],[14]} and reinforced consumer goods such as gardening tools^[15].

These cases demonstrate that recycled PA6 is not only a research topic but also an emerging industrial reality.

A recent review^[16] addresses recent advances for synthetics nets, including regeneration of discarded nets made of PA6, biodegradable alternatives, reinforced blends etc. The study highlighted recycled PA6 from fishing nets as a key contributor to sustainable netting materials for marine and agricultural applications, alongside bio-based and biodegradable alternatives.

Yet, several technical barriers remain. The recycling of PA6 from discarded nets is technically feasible but presents several material and process-related challenges. Furthermore, the choice of recycling technology (mechanical or chemical) is driven by the purity of the input raw material and the required quality specifications for the final application.

- **Degradation and variability:** Exposure to UV light, seawater, and mechanical stresses during service life leads to chain scission, oxidation, and reduction in molecular weight^[3].
- **Moisture sensitivity:** Like virgin PA6, recycled PA6 is hygroscopic, requiring strict drying to avoid hydrolysis during melting processing^[17].
- **Contamination:** Nets often contain sand, biofouling residues, pigments, and traces of metals (from attachments or ropes), which affect melt stability and product quality.
- **Processability:** Fibre spinning and filament extrusion are technically possible but more challenging, due to reduced viscosity and drawability. Studies show that without stabilisation or blending, the resulting fibres exhibit lower tensile strength and tenacity.^[18] Reduced melt flow stability complicates filament extrusion and fibre spinning, leading to filament breakages and defects^[19].
- **Mechanical performance:** A study^[4] compares injection moulded specimens from recycled PA6 fishing nets with commercially available extruded PA6 plates, assessing mechanical, physical (tensile, impact), hardness, density etc. The results confirmed the feasibility of producing injection moulded components from mechanically recycled fishing nets, though recycled PA6 shows reduced tensile strength and impact resistance, restricting high-performance applications unless blended with virgin PA6 or reinforced with fillers.

Despite these challenges, mechanical recycling through processes such as pelletizing, injection moulding, and melt spinning remains a promising route. Moreover, recent studies have demonstrated that performance can be enhanced through additive strategies.

For example, the study of Belmokhtar et al.^[19] demonstrates that adding natural fibers (switchgrass) up to ~30 wt% improves tensile strength ($\approx +23\%$) and Young's modulus ($\approx +126\%$) compared to the neat recycled PA6. However, higher fiber loadings reduce processability (e.g. mold filling problems, reduced melt flow rate). There is also recent work^[20] modifying recycled PA6 (from fishing nets) with biochar fillers (rice husk, lignocellulosic biochar). These modifications improve stiffness, reduce water uptake, and improve fire resistance (higher activation energy for combustion), though there may be trade-offs in terms of cost, mechanical toughness etc.

2.2.4 Processability of recycled commercial materials

Considering the background, NTT and AITIIP agreed to carry out laboratory scale test activity to demonstrate the recycling of a PA coming from fishing net waste, through two different manufacturing routes: injection moulding, carried out by AITIIP, and melt spinning, carried out by NTT. Pre-cleaned and disassembled PA fishing gear was not available from the project partners, due to difficulties in sharing net waste across countries. Therefore, the laboratory tests were carried out using commercial recycled PA granules purchased by NTT. Several companies offering commercial PA compound recycled from fishing net waste were contacted by NTT (Table 5).

Table 5 List of companies offering commercial recycled PA compound, obtained from fishing net waste recycling.

Company	Website	Product	Location
Fil & Fab	https://www.fil-et-fab.fr/	Nylo®	France
Aquafil	https://www.aquafil.com/it/	ECONYL®	Italy
Nurel	https://nurel.com/en/	Recomyde®	Spain
Ocean Material	https://oceanmaterial.com/	PA6 - fishing nets	Germany/Hong Kong
Envalior	https://www.envalior.com/	Akulon® RePurposed	Global
Reborn Plas	https://www.rebornplas.com/en	A2040NC	Taiwan

Nylo® product was selected by NTT to be purchased for testing. The choice was driven by different positive factors: the availability of small samples (25 kg), the fast feedback provided by the company Fil&Fab, the material's European origin, aligning with supply-chain and compliance requirements, as well as its versatility.

In fact, the product is not designed for a single specific transformation process but instead appears suitable for multiple applications. Fil&Fab does not explicitly list the full range of applications, but it does provide several suggestions, such as surfboard fins, eyewear frames, and 3D-printing filaments. These references

highlight the material suitability for various transformation processes and end-use markets, representing an attractive material for the evaluation.

Fil & Fab recycled PA: material description

The material under study consists of commercial recycled PA6 (r-PA) granules derived from discarded fishing nets, purchased from Fil&Fab (www.fil-et-fab.fr), a French company that recovers used fishing nets and transform them into 100% r-PA 6 compound, known as Nylo®.

The Technical Data Sheet (Annex 4) reports on the main physical and mechanical properties of the compound. According to it, Nylo® is composed of 99,4% r-PA 6, derived from fishing net waste, and 0,6% of an antioxidant additive.

The production of Nylo® relies fundamentally on a thermomechanical recycling process. Fil&Fab has made an explicit strategic choice to follow a mechanical recycling strategy, rejecting alternative processes like chemical depolymerization. The justification for this choice is rooted in the company core values: minimizing environmental impact.

In fact, their process begins with careful collection and sorting of end-of-life fishing nets, separating nets from ropes and floats to avoid contamination with other plastics. The nets are cleaned, shredded into small fibre fragments, and then melted down and extruded with small amounts of non-polluting additives (less than 2%) to preserve the mechanical properties and colour stability of the material.^[21] Mechanical recycling typically involves melting and compounding the material with stabilizing compounds, or masterbatches, to ensure adequate final performance. It also includes a filtering phase to remove any remaining physical impurities that may have bypassed manual sorting, followed by final granulation to produce standard pellets.

This stage generally requires significantly less energy and fewer chemical inputs than the energy-intensive and complex depolymerization processes. This method is therefore positioned to achieve a lower process carbon footprint. However, the technical viability of this lower impact recycling route is entirely dependent upon the preceding success of the localized value chain in delivering exceptionally clean, segregated PA 6 waste, mitigating the primary technical vulnerability of mechanical recycling, the contamination.

The supply chain established by Fil&Fab is designed as a local circular economy ecosystem: from the original fishing ports (mainly in Brittany) to the final granulate production and onward to manufacturers who turn Nylo® into new plastic products. This “re-valorisation” (rather than simple recycling) emphasises traceability, regional collaboration among maritime, public, financial and technical stakeholders, and the transformation of marine waste into a high quality, technically reliable material, thus helping to reduce waste, avoid incineration or landfill, and give new value to discarded nets.

The supplied sample consists of opaque cylindrical granules showing dark green to brown color variations, which are characteristic of recycled fishing net residues (Figure 13). The manufacturer states that the recycling process is designed to preserve, to the greatest possible extent, the intrinsic properties of the incoming materials and no specific additives are added unless explicitly requested by the customer. Consequently, as the fishing nets used as feedstock may exhibit a wide range of colors and no pigments

are added in compounding, the resulting granules may display chromatic variations within a single batch. These variations do not affect material performance and do not constitute evidence of contamination or degradation.

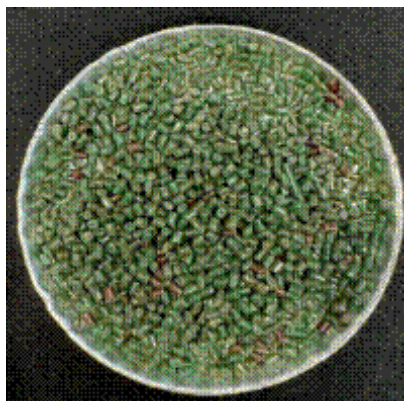


Figure 13 Nylo® granule sample (Fil & Fab)

Technical Data Sheet reports pre-processing requirements. Due to intrinsic moisture sensitivity of PA 6, Nylo® is recommended to be stored in a dry place and dried minimum 6 hours at 80°C prior extrusion.

Melt spinning trials

NTT performed spinnability trials aiming to assess the suitability of Nylo® compound to multifilament melt spinning process. Tests were carried out to meet two target objectives: achieving the highest possible tenacity and the lowest possible linear density.

Spinnability tests were carried out on a lab scale melt spinning machine (Figure 14), equipped with monocomponent configuration, a 36-filament spinneret (0.35 mm diameter), one feed godet, three drawing godets, one relaxation godet and a final winder. Considering the configuration scheme showed in Figure 14, the main parameters are listed below:

- V_0 : Extrusion Speed (g/min);
- V_1 : Feed Roll Speed (m/min);
- V_2 , V_3 and V_4 : Drawing Roll Speeds (m/min);
- V_5 : Relaxation Roll Speed (m/min);
- MDR: Melt Draw Ratio (V_1/V_0);
- DR: Draw Ratio (V_4/V_1).

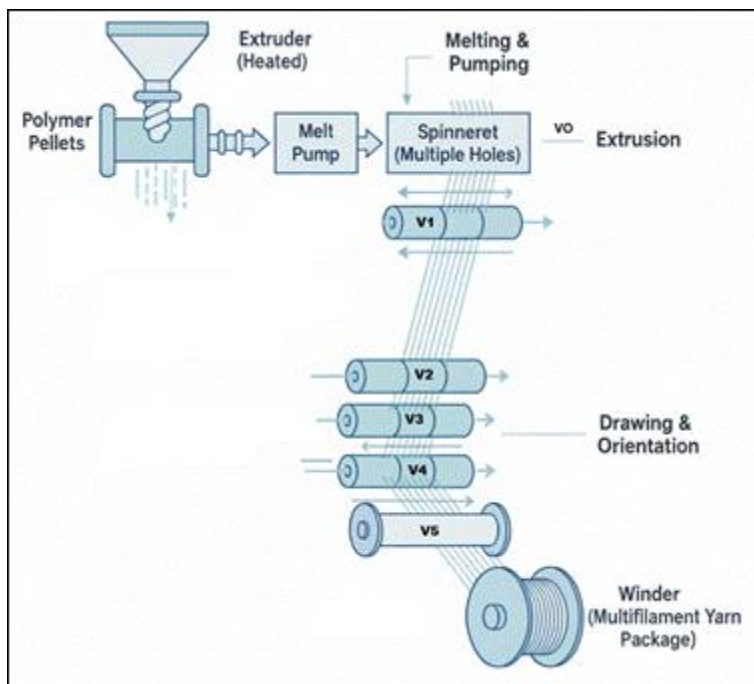


Figure 14 Lab scale melt spinning equipment configuration

The material was tested according to the following steps:

- establishing a temperature profile (TP);
- studying several extrusion speeds;
- applying appropriate drawing ratios to meet target requirements:
 - highest tenacity: [MDR(–), DR(+)]. Godet V_1 is set at minimum velocity (200 m/min.), reaching the lowest value of MDR and achieving the DR maximization.
 - lowest linear density: [MDR(+), DR(+)]. Godet V_1 is set at highest velocity to reach the MDR and DR maximization.

Considering this last point, it is important to underline that MDR describes the extent of filament stretching in the molten state. While high MDR values (MDR⁺) promote fibre thinning and reduced linear density, lower MDR values (MDR[–]) improve filament stability, particularly for heterogeneous materials. (DR⁺) is the maximum draw ratio achievable under a given MDR regime before filament breakage or instability occurs. In such cases, applying high draw ratios (DR⁺) under (MDR[–]) conditions can result in improved tenacity, whereas (MDR⁺) combined with (DR⁺) mainly leads to finer fibres with lower linear density but limited drawability.

Prior processing, the material was dried at 60°C overnight and then at 80°C for 6h as recommended. Humidity analysis after drying showed a moisture content of zero.

Spinning trials were carried out testing four different temperature profiles (TP) as listed in Table 6. Since the spinning speeds weren't satisfactory at TP1, other temperature profiles (TP2, TP3 and TP4) were attempted. At each TP, it was possible to collect at least one filament, tuning extrusion speed (throughput cc/min). Several extrusion speeds were studied for TP1: 20, 30 and 40 rpm (12 cc/min, 18 cc/min and 24 cc/min). At 30 and 40 rpm, the process became unstable, and it wasn't possible to obtain any fibers.

Table 7 provides the extrusion parameters set for the trials and the fiber linear density. As reported, two extrusion speeds were used to produce the fibers: 12 cc/min (S1) and 18 cc/min (S2). Fiber TP4-S2_02 was obtained under an unstable stretching process, and further optimization should be required.

Table 6 Temperature profiles

Fibre reference	Temperature Profile	Extrusion Temperatures (°C)						Godet Temperatures (°C)			
		Zone 1	Zone 2	Zone 3	Melt pump	Transfer Line	Spinhead	V ₁	V ₂	V ₃	V ₄
TP1-S1_01	TP1	232	265	272	274	255	250	70	100	100	100
TP2-S1_02	TP2	230	266	270	273	254	255				
TP3-S2_01	TP3	227	263	269	275	255	260				
TP3-S2_02		223	266	271	275	253	260				
TP4-S2_01	TP4	224	265	270	279	267	280				
TP4-S2_02		224	265	270	280	265	280				

Table 7 Spinning parameters and fibre linear density

Fibre reference	Temperature Profile	Throughput (cc/min)	Pressure (bar)	MDR	DR	Spinning speed (m/min)	Linear density (Dtex)	Notes
TP1-S1_01	TP1	12	104	58	1.39	272	390 ± 14	MDR(−) DR(+)
TP2-S1_02	TP2		110	115	1.31	515	200 ± 12	MDR(+) DR(+)
TP3-S2_01	TP3	18	141	38	1.39	272	587 ± 17	MDR(−) DR(+)
TP3-S2_02			139	106	1.31	707	210 ± 0	MDR(+) DR(+)
TP4-S2_01	TP4		108	173	1.30	1147	133 ± 9	MDR(+) DR(+)
TP4-S2_02			108	38	2.10	395	337 ± 9	MDR(−) DR(+)*

* Unstable stretching process, optimization required.

Figure 15 shows the collected spools.



Figure 15 Collected spools

Figure 16 shows the condition of the spinpack filter after the trials. The spinpack filter is a key component of a melt spinning extruder, located just before the spinneret. Its function is to retain solid particles, gels, and other contaminants present in the molten polymer, ensuring a consistent and uniform flow through the capillaries. By stabilizing the melt quality, the spinpack filter helps protect the spinneret and supports the production of continuous, defect-free filaments. In the image the presence of impurities trapped in the filter is clearly visible, indicating that the material still carries a certain level of contamination. Despite this, none of the tests carried out reported issues related to flowability, and the process remained stable throughout the trials. The observed contamination levels and particle size were therefore not significant enough to hinder the spinnability of the material.



Figure 16 Spinpack filters after trials

Mechanical tests were performed according to ASTM D 3822:07 - Standard Test Method for Tensile Properties of Single Textile Filaments, using a universal mechanical test machine (Shimadzu AGX-V 50 kN, Figure 17), with a 100 N load cell. Tests were carried out 4 days after production on 10 specimens for

each spool, test speed was set at 250 mm/min and gauge length at 25 mm. Elongation at break and force at break have been registered to determine the filament tenacity.



Figure 17 Shimadzu universal mechanical test machine.

Figure 18 shows a comparison of elongation at break and tenacity values of all the produced multifilament. The table in the figure lists all the registered values related to linear density (dtex), maximum force at break (cN), elongation at break (%) and tenacity (cN/dtex).

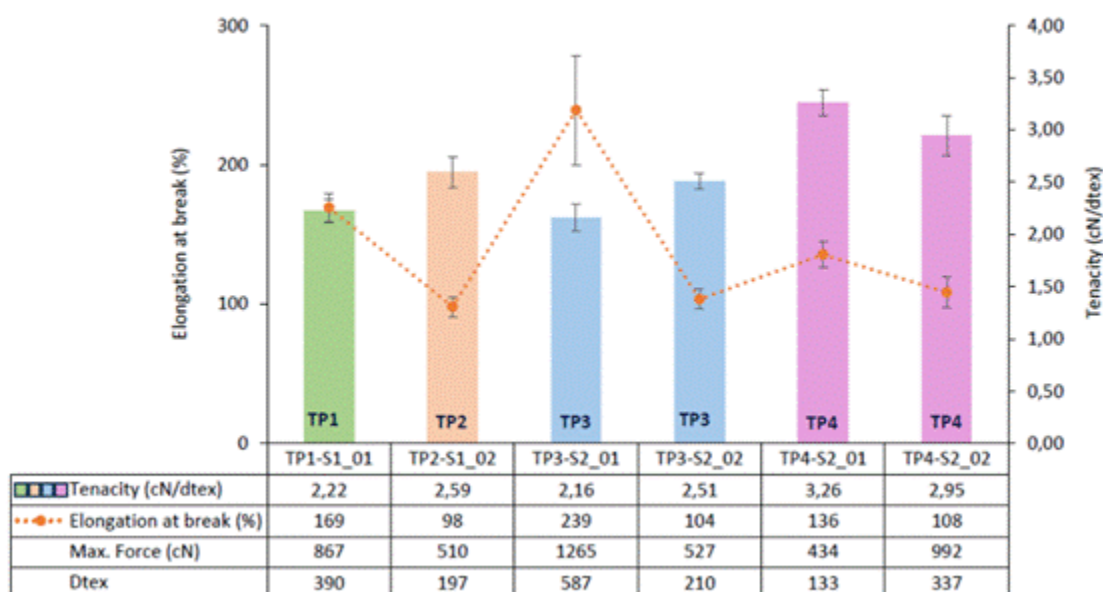


Figure 18 Mechanical characterization results of the different obtained fibres

Discussion

The following considerations are directly connected to mechanical results and data presented in Table 6 and Table 7. High DR^+ values are generally expected for homogeneous materials under controlled melt drawing and optimal drawing conditions. Conversely, the presence of impurities and excessive melt stretching can limit drawability, resulting in reduced DR^+ values. The maximum draw ratio (DR^+) achieved

for Fibers obtained under TP1, TP2 and TP3 conditions was found to be around a value of approximately 1.3.

At these temperatures this behaviour indicates that material limitations play a dominant role in defining the maximum achievable draw ratio, while the influence of the drawing regime becomes secondary once a DR^+ of about 1.3 is reached. This behaviour suggests that the maximum achievable draw ratio is mainly governed by intrinsic material limitations rather than by the drawing conditions alone.

An exception to this general trend was observed for filaments produced under TP4 conditions, which showed an enhanced response in terms of drawability compared to the other samples.

While similar DR^+ values under MDR^+ and MDR^- conditions initially suggested a material-imposed limitation, increasing the processing temperature significantly enhanced chain mobility and stress redistribution. Under MDR^- conditions, where filaments are less stressed and thicker, this resulted in a substantial increase in drawability, leading to DR^+ values up to 2.1. In contrast, under MDR^+ conditions, the combined effect of high melt stretching and material heterogeneity continued to limit the achievable DR^+ .

At higher processing temperatures (TP4) and at a throughput of 18 cc/min, a substantial increase in tenacity was observed. This improvement is associated with the possibility of applying higher stretching ratios, which promoted more effective molecular orientation and structural consolidation within the filaments. Consequently, the TP4-S2_01 and TP4-S2_02 samples exhibited better mechanical properties compared to filaments produced under lower-temperature conditions, highlighting the positive role of elevated processing temperatures on filament performance.

As observed in Figure 18, elongation at break values are relatively low for all the multifilaments, with minimum values around 100%. This indicates that, from a polymer matrix perspective, the material could potentially be stretched further. The inability to reach higher elongation values is probably related to the presence of impurities within the material (Figure 16). In particular, the size of impurity particles may act as stress concentration points, limiting homogeneous deformation and preventing further stretching of the filaments. As a result, both the achievable draw ratio and the elongation at break are limited, even under favourable thermal and processing conditions.

Table 8 reports range of values of tenacity, elongation at break, maximum force at break, and linear density of r-PA multifilaments obtained during the spinning trials (Figure 18), compared to range of values of High Tenacity (HT) multifilament generally used for fishing net production^[22].

Table 8 Comparison of r-PA Multifilaments and Standard High-Tenacity PA for Fishing Nets

	r-PA multifilaments	HT PA Multifilament for fishing nets
Tenacity [cN/dtex]	2,16 – 3,25	7,8
Elongation at break [%]	98 – 239	20 – 22

Max Force [cN]	434 – 1265	7522
Linear Density [dtex]	133 – 587	935 - 1880

As observed, the range of values of the r-PA multifilaments does not match the specifications required to produce new fishing nets. The fibers exhibit medium to low tenacity, suggesting they are more suitable for general textile applications, such as knitting, hosiery, or soft reinforcements, rather than high strength industrial uses like ropes or belts.

As explained in Section 2.2.3, mechanically recycled PA6 derived from sources such as discarded fishing nets or post-industrial waste, significantly influences the final material characteristics. While scientific literature confirms that r-PA6 retains thermal stability (melting temperatures comparable to virgin PA6), the mechanical recycling process induces a slight degradation of the polymeric structure. Specifically, r-PA6 yarns typically exhibit reduced tenacity and breaking strength, attributed to polymer chain scission during the melting and re-extrusion phase^[18]. On the other hand, this same phenomenon can lead to an increase of elongation at break compared to virgin counterparts. According to polymer science literature the generation of these shorter chains increase free volume and chain mobility within the polymer matrix, allowing the material to stretch further compared to the more rigid virgin structure and observing improvements by up to 50%^[23].

As a further step, Fibre TP3-S2_02 was selected to produce a jersey knitted structure, using a lab-scale knitting machine with the main purpose of producing socks. In principle, all produced samples are compatible with the knitting machine, resulting in softer or coarser jerseys.

Depending on the intended application, PA socks are generally manufactured using yarns with a linear density of 200 dtex or below. This choice is mainly driven by the need to balance comfort, flexibility, and durability in hosiery products. In particular, fine or moderately fine PA multifilament yarns are commonly employed as main or plating yarns in knitted sock structures to ensure adequate softness, elasticity, and wear resistance without compromising breathability and fitting. Recent research on commercial sock samples reports the use of textured PA 6.6 yarns with linear densities in the range of approximately 156–220 dtex, indicating that yarn counts close to or below 200 dtex are representative of typical hosiery applications^[24].

Based on these considerations, Fibre TP3-S2_02 was selected, as it falls within the desired range of linear densities and exhibits the lowest standard deviation in linear density among the samples (Table 7). Figure 19 shows the sample of jersey knitted structure, confirming the potential use of a r-PA multifilament in sock manufacturing.

It is important to note that Fibre TP3-S2_02 was used as it for knitting trial. PA6 yarns used for hosiery on knitting machines are almost exclusively Draw Textured Yarns (DTY). This texturing process imparts the necessary bulkiness and high elasticity required for the comfort and fit of the socks, often in a blend with elastane. In fact, as detailed in the literature^[25], original flat synthetic filaments possess inherent

limitations for apparel use, specifically regarding transparency, slipperiness, and an unpleasant glassy sheen. Without texturing, these yarns lie flat against the skin, inhibiting air entrapment and resulting in a 'clammy' sensation due to poor moisture management. The texturing process was introduced specifically to overcome these defects by imparting bulk, opacity, and warmth, thereby giving the synthetic fiber a natural-like hand suitable for next-to-skin applications such as hosiery.

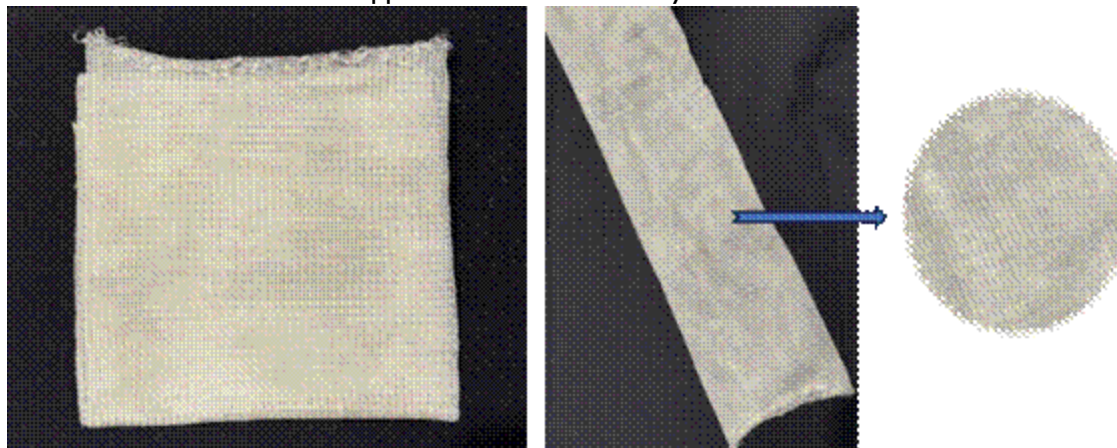


Figure 19 Jersey knitted structure with TP3-S2_02 multifilament

Guidelines and recommendations

The study demonstrates that recycled PA6 derived from discarded fishing nets represents a viable feedstock for filament extrusion. However, compared to virgin materials, the valorisation of recycled material presents specific challenges linked to material heterogeneity. To ensure process stability and final product quality, adherence to a rigorous pre-processing and processing protocol is mandatory.

- **Systematic Characterization:** Due to the intrinsic variability of waste materials, systematic characterization of each recycled PA6 batch is essential to predict processing behavior and adjust parameters accordingly.
- **Moisture Management:** Strict moisture control is fundamental to prevent hydrolysis and the consequent reduction of molecular weight. While standard drying at 80–90 °C is effective, the optimal protocol identified involves a two-step drying process: 60 °C overnight followed by 6 h at 80 °C. This ensures a moisture content approaching zero prior to processing.
- **Contaminant Removal:** Mechanical sieving and filtration steps are strictly necessary. These processes not only remove solid contaminants inherent to marine debris but also homogenize the granulometry, reducing feed variability.
- **Additives and Blending:** To recover mechanical properties and processability, the formulation should be optimized. This includes the evaluation of specific stabilizers and compatibilizers. Furthermore, blending with virgin PA6 is highly recommended as a strategy to enhance flowability and mechanical stability, bridging the gap between recycled sustainability and industrial performance standards.

Injection molding and compounding

This part of the document is focused on the development of structural composite materials. This route investigates the mechanical enhancement of rPA6 through the incorporation of mineral fillers (CaCO_3) to produce technical parts such as fittings, housings, or rigid components for marine cleaning technologies. Nylo® material from Fil&Fab was used for injection molding and thermoplastic compounding. The objective is to establish a performance baseline that correlates the “marine history” of the waste with its behavior during melt processing.

The following subsections detail the experimental results obtained to date, starting with the mechanical validation of injection-grade compounds, while the preliminary results of the spinning tests define the limits of the material’s ductility and tensile performance for textile applications.

The valorisation of recycled Polyamide 6 (rPA6) from end-of-life fishing nets presents a significant opportunity for the circular economy, yet the mechanical performance of the recycled polymer can often be compromised by previous thermal degradation and the presence of residual impurities. Incorporating calcium carbonate as a mineral filler is a strategic approach to address these limitations for several reasons. Primarily, it acts as a cost-effective reinforcing agent that enhances the structural stiffness and dimensional stability of the polymer matrix, counteracting the potential loss of properties during the recycling process. Furthermore, CaCO_3 serves as a nucleating agent, potentially improving the crystallization rate and shortening injection molding cycles, which increases industrial efficiency. From a sustainability perspective, the use of mineral fillers reduces the overall carbon footprint of the final component by substituting a portion of the polymer volume with a natural, abundant mineral, thus aligning with the project goals of high-value plastic waste upcycling.

In this section we evaluate the processability and mechanical performance of recycled rPA6 sourced from end-of-life fishing nets and we assess the impact of a 5% CaCO_3 mineral filler reinforcement.

Both formulations underwent a strict dehumidification protocol (4 hours at 90°C) to prevent hydrolytic degradation during processing. The specimens were produced via injection molding, using the neat rPA6 parameters as a baseline for the CaCO_3 compound to evaluate process stability and compatibility.

For the neat rPA6 material, test specimens were produced using a 25T injection molding machine. Once manufactured, these specimens were tested in a universal testing machine to study their mechanical properties, providing a baseline for the recycled material’s performance.

For the reinforced formulation containing 5% CaCO_3 , the process begins with extrusion compounding in a twin-screw extrusion machine to ensure the mineral filler is homogeneously dispersed within the polymer matrix. Following this compounding stage, the resulting pellets are processed using the same methodology as the neat PA6: they are injected into test specimens using the 25T injector and subsequently analyzed in the universal testing machine.

Table summarizes the comparative mechanical properties of the neat rPA6 and the reinforced compound:

Table 9 comparative mechanical properties of the neat rPA6 and the reinforced compound

Property	Recycled PA6	rPA6 + 5% CaCO ₃	Variation (%)
Tensile Modulus (Et)	1938±132MPa	2007±140MPa	+3.5%
Tensile Strength (σm)	51.2±0.7MPa	53.19±4.63MPa	+3.9%
Flexural Modulus (Ef)	2036±21MPa	1876±29MPa	-7.8%
Flexural Strength (σfM)	91.2±0.7MPa	82.50±0.97MPa	-9.5%
Charpy Impact Energy	18.87±0.59kJ/m ²	13.28±0.37kJ/m ²	-29.6%

Discussion of compounding and injection results

The results indicate that the addition of 5% CaCO₃ led to a moderate increase in both tensile modulus and strength, confirming a successful reinforcement effect of the mineral filler within the recycled matrix. This improvement aligns with the potential for performance enhancement through additives mentioned in the State of the Art (Section 2.2.3), despite the challenges posed by environmental exposure. However, an unexpected decrease in flexural properties was observed, deviating from standard industrial trends where mineral fillers typically increase stiffness across all loading modes. This suggests a potential localized heterogeneity or a modification in the crystalline structure of the PA6 under bending stresses, likely exacerbated by the polymer chain scission and reduction in molecular weight previously identified as technical barriers.

Furthermore, a significant reduction in impact resistance (approximately 30%) was recorded. The CaCO₃ particles act as stress concentrators within the recycled polymer matrix, representing a common trade-off when increasing stiffness in post-consumer polyamides that have already suffered from oxidative and mechanical degradation. Regarding ductility, the tensile elongation at break for the 5% CaCO₃ samples showed high statistical dispersion ($73.34 \pm 66.72\%$), suggesting potential experimental artifacts or slippage during the process. Consequently, these specific values have been excluded from the definitive trend analysis to maintain data integrity and focus on statistically significant results.

Processability and Manufacturing Insights

- **Injection Stability:** The neat rPA6 displayed excellent processability. Weight consistency across specimens was high, indicating that the commercial recycled material (Fil&Fab) maintains a level of homogeneity suitable for industrial-scale injection molding.
- **Compound Behavior:** The rPA6 + 5% CaCO₃ compound was processed using the same parameters as the neat material without technical issues. A consistent increase in specimen weight was observed, directly correlating with the higher density of the mineral filler, confirming a stable dosage and distribution of the additive during the melt phase.

Guidelines and Recommendations for Compounding and Injection Molding

Following the laboratory trials, the following technical guidelines are established for the development of structural components using recycled PA6 from fishing nets:

- **Process Parameter Synchronization:** To ensure industrial scalability, use neat rPA6 injection parameters as a reliable baseline for mineral-filled compounds. This approach facilitates a smooth transition from neat to reinforced materials without requiring extensive machinery reconfiguration.
- **Density Monitoring as Quality Control:** Implement systematic weight measurement of injected specimens. Consistent specimen weight serves as a real-time indicator of stable mineral dosage and homogeneous distribution of the CaCO₃ filler during the compounding phase.
- **Application-Specific Performance Balancing:** When designing technical parts, perform a careful trade-off analysis between stiffness (gained through CaCO₃ addition) and impact resistance (lost through reinforcement). High-stiffness applications are ideal for mineral fillers, whereas components subject to dynamic mechanical stresses may require lower filler loadings or toughening agents.
- **Homogeneity Verification:** Given the observed flexural variations, ensure high-shear mixing in twin-screw extruders. This minimizes localized heterogeneities and prevents the formation of stress-concentrating filler agglomerates within the recycled polymer matrix.

The recycled PA6 from fishing nets demonstrates high technical maturity and processability. The incorporation of 5% CaCO₃ is a viable valorisation route to tune the material's stiffness, although it requires careful consideration of the impact strength requirements for the final application. The material's behavior confirms that rPA6 from the REMEDIÉS project scope is a robust candidate for replacing virgin polymers in technical components.

2.2.5 Success case: Sauvage Méditerranée association/SAO

Sauvage Méditerranée – transforming marine litter into eco-design products

Sauvage Méditerranée is a non-profit organisation based in Aix-en-Provence, in France, dedicated to recovering and recycling marine waste collected along the Mediterranean coast. The organisation works in partnership with a network of local environmental organisations that clean beaches and coastlines,

collecting a range of marine debris, including plastics, polished glass, sails and, most importantly, abandoned fishing nets supplied by Palana Environment. These are therefore, as explained in previous Section mainly nets from small-scale fishing.

At the heart of Sauvage Méditerranée's activities is the artisanal transformation of recovered waste into eco-designed products. In its workshop, volunteer artisans and staff upcycle fishing nets and other materials into jewellery, decorative items and bespoke trophies, blending creative design with environmental advocacy. These products are sold through the association's online platform and partner outlets, and a share of proceeds is reinvested in supporting beach clean-up efforts and associated environmental NGOs.

Fishing nets constitute one of the primary raw materials for the association's creations, reflecting their dual role as a major source of marine pollution and a valuable feedstock for upcycling initiatives. By giving discarded nets a second life as meaningful, desirable objects, Sauvage Méditerranée contributes to raising awareness of plastic pollution and promotes creative, local solutions to marine waste problems.

SAO Textile – from fishing nets to recycled textile fibres

SAO Textile is a mission-driven French start-up founded in February 2023 with the specific aim of transforming used fishing nets into sustainable textile fibres. Headquartered in Bessan, in the Occitanie Region, SAO Textile is the first initiative in France dedicated to mechanically recycling end-of-life fishing nets into 100 % recycled polyamide yarn, without the addition of virgin material.

The company's process begins with the collection of used nets directly from fishermen in key Mediterranean ports such as Sète, in the Occitanie Region. After preliminary cleaning and preparation, the nets are mechanically processed into polyamide granules, which are then melted and extruded into continuous filaments. These filaments are further texturised and cut to produce recycled textile fibres suitable for knitting or weaving into new materials.

By valorising fishing nets in this way, SAO Textile contributes to both marine pollution reduction and the development of a circular, local textile industry in France. The initiative aligns with broader climate and circular economy goals, as fishing nets account for an estimated 10 % of underwater plastic pollution and can take centuries to break down naturally.

In 2025, SAO Textile received recognition for its innovative approach, and is actively working on industrialising its production process and expanding its workforce to support waste collection and fibre manufacturing. Several local fishing cooperatives are already participating by supplying used nets, and early commercial interest has emerged from sportswear, workwear and fashion sectors interested in high-quality recycled polyamide yarns.

Together, Sauvage Méditerranée and SAO Textile represent complementary examples of how marine plastic waste, including fishing nets, can be redirected from pollution pathways to creative, circular and industrial value chains, from artisanal eco-design to advanced textile recycling.

2.3 Value Chain III: Recycling approach of plastics recovered in marine environment

2.3.1 Introduction

Plastic waste is estimated to account for between 40% and 80% of all marine debris, with polyethylene (PE) and polypropylene (PP) being the most common polymers. Once in the marine environment, plastics undergo physical, chemical, and biological degradation processes, fragmenting into smaller particles and contributing to the generation of secondary microplastics, with long-term impacts on ecosystems, biodiversity, and human health.

The recovery and recycling of marine plastic debris is therefore crucial to reduce environmental pollution and limit the formation of secondary microplastics.

In this context, valorisation pathways for plastics recovered from the marine environment are essential components of circular economy strategies. However, marine plastic waste presents unique challenges compared to post-consumer or industrial plastic streams. Materials are typically highly heterogeneous, degraded by environmental exposure, and contaminated with inorganic residues such as sand, salts, and biological matter. These characteristics significantly affect processability, material performance, and the feasibility of conventional recycling routes.

Within the REMEDIES Project, CNR investigated the technical feasibility of mechanically recycling a polyethylene-rich plastic fraction (PE-rf) recovered from marine environments. Different pretreatment techniques, such as cryogenic grinding and planetary ball milling, were tested by CNR, along with blending strategies involving recycled polyethylene (R-PE) and compatibilizing agents (maleated polyethylene: MAPE). The influence of these approaches on the thermal, mechanical, and morphological properties of the resulting materials was systematically assessed to understand the potential and the limitations of mechanical recycling for this challenging waste stream.

The outcomes highlight both opportunities and constraints for the valorisation of marine plastic waste. While pretreatment, blending, and compatibility can partially improve material homogeneity and performance, they cannot fully overcome the intrinsic variability and contamination associated with plastics recovered from the marine environment. As a demonstration of potential application pathways, selected formulations were processed into filaments and evaluated in the fabrication of cast filaments, confirming their basic suitability for 3D printing, providing practical insights into downstream valorisation options.

This Value Chain III builds on these findings to provide operational guidance for stakeholders involved in collection, pretreatment, recycling, and application development. It aims to support informed decision-making on realistic valorisation routes for marine plastic waste, bridging experimental evidence with practical recommendations for circular and sustainable plastic management.

2.3.2 Description of the recovered material

Floating and sinking macroplastics were detected in the Demo Site Sinis-Mal di Ventre Marine Protected Area (Sinis MPA) (western Sardinia, Italy) through specific monitoring activities conducted between spring and summer (March-July) by CNR. The sampling approach combined fixed-point underwater assessments

and vessel-based transects to describe macroplastic debris both on the seabed and at the surface in representative coastal zones of the MPA.

Underwater observations were performed by pairs of divers who conducted standardized point counts along predefined depth lines on rocky and sandy seabeds, up to a maximum of 10 meters. During each dive, operators visually examined the surrounding seabed, retrieved all detectable plastic objects (e.g., bags, bottles, large fragments) within a defined search radius, and recorded the sampling point using the support vessel's GPS. Recovered items were placed in net bags, brought to the surface at the end of the dive, and transferred on board for initial sorting and documentation. Additional vessel transects focused on floating plastic debris. The research vessel traveled at a constant speed of approximately 5 knots along 20-minute visual transects, with observers scanning a standardized area ahead and along the bow for floating macroplastics such as plastic bags, cling film, bottles, and various consumer items. For each transect, all observed items were netted where possible, and their location, time, and environmental parameters were recorded, allowing for subsequent normalization of macroplastic quantities based on effort measures (e.g., items per transect or per kilometer). At the end of each survey day, all materials were rinsed, sorted by item category, and labeled with sampling information (date, GPS coordinates, method, transect or dive ID). A portion of PE-rf was separated from the recovered macroplastics using FTIR spectroscopy. The resulting fraction consisted primarily of polyethylene in the form of small plastic pieces of various sizes or entire objects. FTIR results qualitatively confirmed that PE fragments represented the majority (73%), followed by smaller percentages of polypropylene (PP) (14%) and other polymers (13%).

Sampling also indicated the presence of slight contamination from other plastics, such as polyamide and acrylonitrile butadiene styrene (ABS).

2.3.3 Thermomechanical recycling and transformation approach

To grind and homogenize the PE-rf, two different pretreatments were applied. First, the PE-rf was cryogenically ground by immersing the fragments in liquid nitrogen and then processed in a Retsch ZM 1 centrifugal mill (Retsch GmbH, Haan, Germany), using a 1 mm mesh sieve to generate a fine powder. The cryotreated PE-rf was labeled G PE-rf. Second, the PE-rf was subjected to a preliminary grinding step in a PM100 planetary ball mill (Retsch GmbH, Haan, Germany), equipped with a 125 ml steel bowl and four 10 mm balls. The mill was operated at 500 rpm for 30 min and then at 600 rpm for another 30 min. The resulting powder was designated BM PE-rf. The resulting materials were then processed under various conditions, as described below:

- **Direct melt blending:** All samples (raw PE-rf, PE-rf G, and PE-rf BM) were melt-processed in a twin-screw extruder (Thermo Haake MiniLab) at 190°C in recirculation mode, for a total

processing time of 5 minutes. Prior to processing, the thermal stability of the materials was assessed by TGA on selected fragments, demonstrating that degradation only began around 250°C. The materials were produced with the following formulations: 100% raw PE-rf, 100% PE-rf G, PE-rf G/R-PE 50/50, PE-rf G/MAPE 95/5, 100% PE-rf BM. A 100% R-PE sample was also processed as a reference.

- Cold mixing: To evaluate the feasibility of a cold mixing method, an additional blend containing 40% PE-rf and 60% R-PE was prepared by manually mixing G-PE-rf powder with R-PE pellets before compression molding.

After the mixing procedures, the resulting materials were compression molded using a hydraulic press (Collin P200E, Ebersberg, Germany) at 190°C for 5 minutes at 50 bar. Films with a thickness of 0.5 mm were produced.

2.3.4 Realisation of new materials

As shown in Table I, tensile tests performed on unblended and molded PE-rf revealed a relatively high elastic modulus, consistent with values typically associated with HDPE ⁽¹⁹⁾. However, this high stiffness is associated with low strength and extremely limited elongation at break, approaching 1%. This behavior may be related to the presence of rigid impurities and inorganic matter within the PE-rf, as preliminarily indicated by FTIR analyses, which limit the deformation of the polymer matrix and result in a brittle mechanical response ⁽²⁰⁾.

To improve the properties of the PE-rf, part of the material was subjected to cryogenic grinding (G PE-rf). Grinding allowed for a more uniform distribution of inclusions and contaminants within the sample, improving its homogeneity. This treatment resulted in a slight improvement in mechanical performance, with increases observed in all measured parameters. To evaluate the effectiveness of a polymeric compatibilizer in improving properties, a formulation containing 5% maleated polyethylene and 95% ground PE-rf was prepared. However, the addition of MAPE did not result in a significant improvement compared to ground PE-rf (Table I). Although MAPE is generally recognized as an effective compatibilizer for PE-based systems containing inorganic particles, in this case the high amount of such impurities, combined with the presence of several types of polymers whose adhesion to the PE-rich phase cannot be improved with MAPE, resulted in the limited performance achieved.

In contrast, the combination of ductile R-PE with PE-rf resulted in a significant increase in elongation (from 3% to 30%), while the elastic modulus decreased by up to 80%. These results are consistent with the fact that R-PE is a recycled blend composed primarily of low-density polyethylene, a highly ductile polymer with very low stiffness. It is worth noting that the tensile strength of the G PE-rf/R-PE 50/50 formulation is nearly identical to that of pure R-PE. For the material produced by cold mixing, the presence of R-PE

still improved the ductility of the blend; however, the measured strength was significantly lower, confirming the key role of the melting process in improving dispersion and overall uniformity. In both materials containing R-PE, the high standard deviation affecting the elongation values can be attributed to the impact of solid impurities, which caused premature failure in some samples.

To evaluate the feasibility of an alternative homogenization strategy, a planetary ball mill (BM) pretreatment was applied to the pure PE-rf. The strong mixing action generated by the BM is theoretically suitable for the homogenization of heterogeneous materials. The BM process was conducted at room temperature and, in line with a sustainable approach, no solvents or additives were added. However, the treatment failed to improve the mechanical behavior of the treated materials. These results indicate that the presence and distribution of rigid contaminants play a dominant role in controlling the mechanical response of recycled PE-based systems.

Table I. Results of mechanical testing: elastic modulus (E), tensile strength ($\sigma_{\max}$), elongation at break (ϵ_R)

Sample ID	E (MPa)	$\sigma_{\max}$ (MPa)	ϵ_R (%)
Neat PE-rf	1100 $\pm$ 100	7.6 $\pm$ 1.1	1.1 $\pm$ 0.3
G PE-rf	1400 $\pm$ 50	11 $\pm$ 0.5	3.2 $\pm$ 0.1
G PE-rf/R-PE 50/50	440 $\pm$ 70	12 $\pm$ 1.2	31 $\pm$ 23
G PE-rf/R-PE 40/60	310 $\pm$ 20	7.6 $\pm$ 1.5	34 $\pm$ 14
G PE-rf/MAPE	1300 $\pm$ 70	9.4 $\pm$ 1.9	1.2 $\pm$ 0.5
BM PE-rf	1300 $\pm$ 120	6.7 $\pm$ 1.4	0.7 $\pm$ 0.1
R-PE	140 $\pm$ 40	10 $\pm$ 0.2	380 $\pm$ 120

Thermogravimetric and calorimetric analyses were performed on the blends to study the effects of R-PE addition on thermal properties. Thermogravimetric analysis (TGA) results indicate that all samples exhibit a single-step thermal degradation process, typical of polyethylene-based materials. The onset of weight

loss occurs around 450°C; this temperature was determined based on the onset of a 5% weight loss. The thermal stability of the blends (PE-rf/R-PE) is comparable to that of the individual components (PE-rf and R-PE), suggesting that the incorporation of recycled fractions does not significantly compromise the material's thermal resistance. Slight differences in onset temperatures between the curves may reflect subtle variations in composition and crystallinity, but overall, the degradation profiles confirm the compatibility of recycled and reprocessed polyethylene grades within the blends. Differential scanning calorimetry revealed the presence of different grades of PE within PE-rf, as evidenced by the presence of multiple melting peaks. Melting peaks at 108–114 °C indicate the presence of LDPE, while those at 131 °C indicate HDPE with a probable predominance of the latter ⁽²⁰⁾. In films obtained with the cold-blending approach, double melting peaks are observed, one comparable to that of R-PE and the other to that of PE-rf; these suggest incomplete mixing of the two components in the blend. Films with 50% PE-rf and 50% R-PE and prepared by extrusion show a melting peak at an intermediate temperature between the melting peaks of the two components, indicating that melt-blending is effective in producing homogeneous blends. The occurrence of a melting peak around 123 °C in samples containing R-PE suggests the presence of LLDPE within the recycled polymer matrix ⁽²¹⁾. The presence of LLDPE within the recycled polyethylene fraction appears to play a significant role in improving the homogenization of the blends. This effect can be explained by the structural characteristics of LLDPE, which exhibits a linear structure with short-chain branching, resulting in intermediate crystallinity and density between LDPE and HDPE. These characteristics allow LLDPE to act as a physical compatibilizer, reducing interfacial tension and promoting better dispersion of different polyethylene grades and minor polyolefin components. Consequently, the incorporation of LLDPE contributes to the formation of a more uniform polymer matrix, which is expected to improve the mechanical performance and thermal stability of the recycled formulations. Literature data support this hypothesis. Van Belle et al. (2020) ⁽²²⁾ reported that LLDPE/LDPE and LLDPE/HDPE blends exhibit a strong interphase due to the miscibility of their amorphous phases, leading to mixed-phase interfacial regions and improved phase adhesion. Similarly, in LLDPE/HDPE blends, the linear structure of both polymers facilitates chain alignment, reducing entanglement and contributing to more uniform deformation and work hardening in intermediate compositions ⁽²³⁾. These results, combined with mechanical test results, indicate that the presence of LLDPE in recycled polyethylene fractions can significantly improve mechanical performance, supporting its role as a physical compatibilizer in multigrade polyethylene systems.

Filaments produced from the G PE-rf/R-PE 50/50 blend were fabricated to preliminarily evaluate the recycled blend's suitability for fused filament (FFF) production. This evaluation was designed as a proof-of-concept, focusing primarily on the filament's extrusion capability and basic printability, rather than optimizing filament quality or achieving high-performance printed parts.

Filament extrusion was performed using a single-screw extruder equipped with a circular die, with a nominal filament diameter of 1.75 mm. Several extrusion trials were conducted to determine the operating conditions that would allow for stable extrusion and satisfactory dimensional consistency. The temperature profile during extrusion proved essential for regulating melt viscosity and filament formation ⁽²⁴⁾. At low temperatures, irregular flow and filament breakage occurred, while excessively high temperatures caused inadequate dimensional control due to excessive melt flow ⁽²⁵⁾. The optimized process conditions selected for filament production are listed in Table 2.

Table 2 Filament fabrication parameters

Processing Parameter	Value
Nominal filament diameter	1.75 mm
Temperature profile [°C]	190-225-220-188
Screw speed [rpm]	3
Cooling mode	Air cooling
Filament monitoring	Inline diameter control

Using these parameters, continuous filament extrusion was achieved; the filament exhibited an overall uninterrupted structure and a reasonably uniform diameter along its length. However, localized diameter variations and surface defects were still visible, even under the optimized regime. These imperfections arise from the inherent heterogeneity of the recycled blend, the presence of residual inorganic contaminants, and the complex crystallization characteristics of polyethylene-based materials. The filament was then used in fused filament fabrication. During FFF testing, rapid crystallization of the material resulted in limited interlayer adhesion and a tendency to warp. To partially address these issues, 20 wt% calcium carbonate was incorporated to slow crystallization and improve dimensional stability during deposition. In this case, the printed samples showed continuous extrusion paths and satisfactory adhesion between consecutive layers, enabling the fabrication of dimensionally stable objects with uniform infill. However, surface roughness, small voids, and localized imperfections at interlayer interfaces were consistently present, indicating that, while the material is adequate for initial 3D printing demonstrations, further improvements in formulation and processing conditions are needed to achieve print quality comparable

to that of commercial filaments. Overall, these results illustrate the technical feasibility of converting polyethylene-rich plastic waste recovered from the marine environment into FFF filaments, while also highlighting current limitations related to material heterogeneity and crystallization dynamics. Future efforts will focus on improving filament uniformity, surface finish, and mechanical properties of printed components through formulation refinements and better process control. Figure I shows the process for making the material, from the extrusion process to the production of the filament for 3D printing.



Figure I. Thermomechanical recycling and transformation approach

2.3.5 Cold mixing approach

To create a protective bottle band, we used plastic materials recovered from the marine environment, as discussed in the previous sections. The collected fragments were preliminarily characterized by FTIR spectroscopy, selecting a fraction rich in polyethylene, a material deemed suitable for the band due to its sufficient flexibility. The material was cryogenically ground using a centrifugal mill, achieving a particle size suitable for the subsequent processing steps.

The resulting mixture was subjected to a cold mixing process and then compression molding, obtaining a compact sheet of recycled material. The molded piece was then shaped according to the project dimensions, derived from the bottle's technical drawing. The band was also manually engraved with the project name.

Finally, the semi-finished product was closed into a cylinder and heat-sealed, obtaining the final band shown in the figure 2. The final result demonstrates the possibility of transforming selected and appropriately treated marine plastic waste into a functional and customized product.

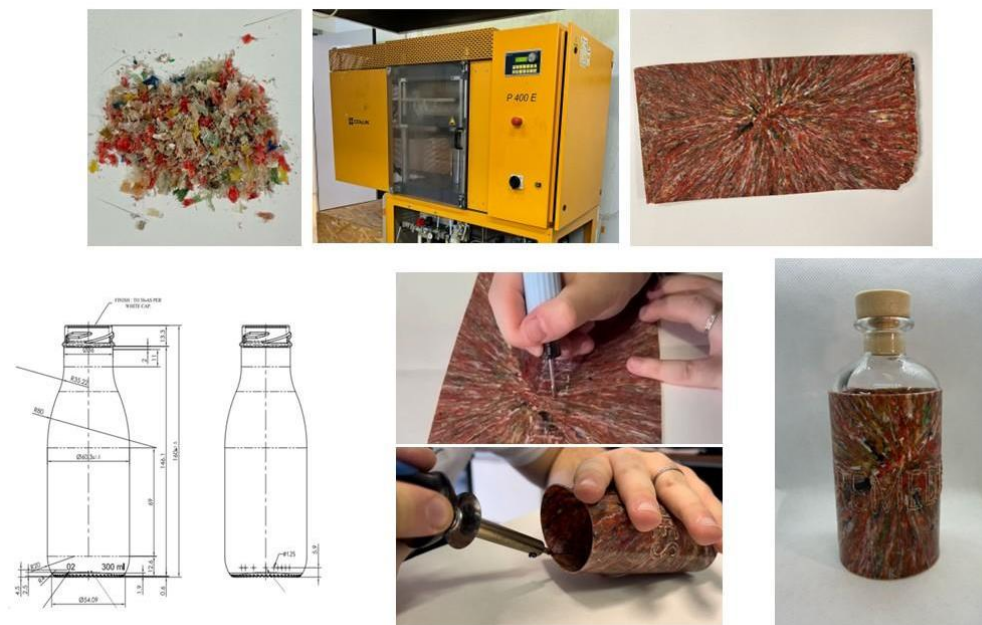


Figure 2. Development of the recycled polyethylene band from marine plastic: fragment selection, cryogenic grinding, compression molding, forming, engraving and heat sealing until the final product is applied to the bottle.

2.3.6 Conclusions and Recommendation

The activities carried out within Value Chain III by CNR demonstrate that plastics recovered from the marine environment can be valorised through thermomechanical recycling, although it has limitations linked to material heterogeneity and contamination. As reported above, the recovered macroplastics were dominated by polyethylene-rich fractions, with relevant contributions from polypropylene and minor polymer contaminants. This composition reflects real-world marine litter streams and confirms that recycling strategies must be designed for mixed and degraded materials rather than ideal, single-polymer inputs.

Mechanical recycling of the polyethylene-rich fraction (PE-rf) is feasible from a processing standpoint, as thermal stability is compatible with conventional extrusion and compression molding temperatures. However, the intrinsic presence of inorganic residues and rigid inclusions strongly governs the mechanical response of the recycled materials. Neat PE-rf exhibits high stiffness but very low ductility and strength, resulting in brittle behavior. Mechanical homogenization by cryogenic grinding improves dispersion of

contaminants and leads to modest improvements in tensile properties, while planetary ball milling does not provide measurable benefits. This confirms that mechanical pretreatments alone cannot overcome the performance penalties imposed by contamination and compositional variability.

Chemical compatibility with maleated polyethylene (MAPE) showed limited effectiveness, as adhesion between the PE-rich matrix and heterogeneous impurities or non-polyolefin contaminants cannot be sufficiently enhanced by a single compatibilizer. In contrast, blending PE-rf with recycled polyethylene (R-PE) substantially improves ductility and processability, particularly when melt-blending is applied. The presence of different polyethylene grades, including LLDPE in the recycled fraction, contributes to improved physical compatibility and matrix homogeneity, supporting the role of multigrade PE blends as a practical pathway for valorisation.

Downstream transformation routes further confirm technical feasibility. The production of films and filaments suitable for fused filament fabrication (FFF) demonstrates that marine plastic-derived materials can be shaped into semi-finished and functional products. Nevertheless, rapid crystallization of polyethylene, residual contamination, and blend heterogeneity limit interlayer adhesion, dimensional stability, and surface quality in 3D-printed parts. The successful realization of a demonstrator product (protective bottle band) via cold mixing and compression molding highlights that low-complexity, low-performance applications represent a realistic and immediately implementable valorisation route.

Overall, this value chain confirms that marine plastic recycling is technically possible but structurally constrained by feedstock quality. High-value or performance-critical applications are currently out of reach without substantial upgrading of sorting, cleaning, and formulation strategies.

Effective valorisation of plastics recovered from the marine environment depends strongly on the quality of the collected feedstock and on the robustness of the downstream processing chain. Enhanced washing and decontamination procedures should be implemented to remove inorganic residues such as sand, salts, and biofouling, which have been shown to exert a dominant negative influence on mechanical performance and product reliability.

In terms of product design and application development, valorisation efforts should focus on low- to medium-performance applications that can tolerate variability in material properties. Suitable targets include non-structural components, packaging accessories, protective elements, and demonstrator products developed for awareness-raising and circular economy showcases.

2.4 Value Chain IV (bio-plastics)

The valorisation of bio-based polymers represents a critical step toward closing material loops and reducing dependency on fossil resources. Unlike conventional plastics, bio-based materials exhibit unique thermal and mechanical sensitivities, requiring adapted mechanical recycling strategies that preserve their

molecular integrity. Successful valorisation is not merely about mass recovery but about maintaining processability for high-value secondary applications, such as technical injection molding or large-format additive manufacturing.

By optimising shredding, drying, and reprocessing stages, it is possible to mitigate thermo-oxidative degradation, transforming end-of-life products - such as bio-based cups - into competitive secondary raw materials.

It is important to note that the following results and guidelines are specifically derived from the study of cups manufactured from PBS and PHBV blend. While these findings provide a robust framework for the mechanical recovery of bio-polyesters, they should not be generalised to all bioplastics (such as PLA, bioPE, or starch-based compounds), which may possess different melting points and degradation kinetics. This section serves as a technical bridge, translating general circular economy principles into a specialised valorisation protocol for this high-performance matrix, ensuring its successful reintegration into secondary manufacturing streams.

Based on the experimental results obtained during the project, the following directives are defined for the transformation of recovered material:

2.4.1. Phase 1: Pre-processing and size reduction

To ensure consistent feeding into transformation machinery, the material must be mechanically conditioned:

- Shredding strategy: use a blade mill equipped with a 4mm to 6mm mesh screen. This flake size provides the optimal balance between bulk density and screw intake efficiency.
- Fines removal: a dust extraction system is highly recommended after shredding. Bio-based plastic dust (fines) has a high surface-to-volume ratio and tends to degrade thermally before the larger flakes, leading to black spots or color variations in the final part.

2.4.2. Phase 2: Optimised conditioning (Drying)

Bio-based materials are inherently hygroscopic. To prevent hydrolytic degradation during reprocessing:

- Low-stress dehumidification: Dry the flakes at a reduced temperature for a shorter duration compared to virgin resin protocols
- Rationale: Excessive residence time in the dryer can trigger thermal degradation before the material even reaches the melting stage in the extruder.

2.4.3. Phase 3: Direct injection molding of flakes (Short-loop recycling)

This is the preferred route for energy efficiency as it bypasses the pelletisation stage:

- 4-Zone thermal profiling: A decreasing temperature profile toward the nozzle should be employed (e.g. 180/185/190/185°C). This stabilises the melt and prevents excessive shear.

- Hopper management:
 - Maintain a low material level in the hopper to prevent “bridging” and ensure a steady gravitational feed into the screw.
 - Avoid high screw RPMs; excessive rotation generates frictional heat (shear heating), which negatively impacts the polymer’s viscosity and final coloration.
- Dosing: Use minimal backpressure to reduce mechanical stress on the polymer chains.

2.4.4. Phase 4: Re-pelletisation for Advanced Manufacturing

For processes requiring ultra-precise dosing, such as pellet-fed 3D printing, reprocessing via twin-screw extrusion is recommended to produce pellets with consistent bulk density. This eliminates the pressure fluctuations that raw flakes might cause in specialized 3D printing deposition heads.

4. Conclusions

After evaluating the four value chains, the following transversal conclusions have been established to guide future circularity initiatives.

- Material history as a process determinant: The environmental exposure of the plastic (UV radiation, saltwater hydrolysis, and biofouling) is the primary constraint for high-value recovery. Mechanical recycling is technically viable across all streams, but applications requiring high tenacity or transparency must be replaced by structural parts (compounding) or aesthetic upcycling (eco-design).
- The decontamination performance trade-off: Across all value chains, inorganic residues (sand, salts, and organic matter) act as “stress concentrators”. Chemical compatibilisers have limited efficacy when contamination levels are high. Valorisation efforts must prioritise aggressive cleaning and mechanical filtration (melt-filtering) to ensure process stability, especially for sensitive routes like textile melt-spinning or 3D printing.
- Moisture Management: A recurring technical barrier is the hygroscopic nature of both technical and bio-based polymers. Both PA6 (fishing nets) and PBS/PHBV (cups) require strict, low-temperature dehumidification protocols. Preventing hydrolysis during the second melt cycle is the single most important factor in preserving the molecular weight and mechanical integrity of the recycled material.
- Processing softness: To successfully reprocess degraded or bio-polymers, the project trials suggest a shift towards “material preservation” parameters:
 - Thermal control: using 4-zone profiles with slightly lower temperature than virgin benchmarks prevents further thermo-oxidative damage.

- Mechanical care: Reducing screw RPM and backpressure across all chains helps manage “shear heating”, which is the main cause of discoloration and viscosity loss in recycled plastics.
- Advanced manufacturing as a high-value outlet: the successful production of 3D printing filaments and knitted textiles proves that marine and bio-based waste can enter the Industry 4.0 workflow. While direct injection from flakes is energy-efficient, re-pelletisation via twin-screw extrusion is essential for advanced manufacturing to ensure the constant bulk density required by automated deposition heads.

The synergy between the four value chains proves that even the most challenging marine debris can be reintegrated into the economy. The transition from "plastic as a pollutant" to "plastic as a resource" requires a localized approach, where technical parameters are fine-tuned to the material's specific state of degradation, as detailed in these practical guidelines.

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III Conclusion

This deliverable presents the operational framework through which REMEDIES translates citizen engagement into coordinated action against marine litter. By combining structured clean-up methodologies with emerging plastic valorisation pathways, the guideline demonstrates how local environmental action can contribute simultaneously to pollution reduction, knowledge generation and circular-economy experimentation. The experiences documented across the REMEDIES demonstration sites confirm that community-based clean-ups can serve as powerful entry points for environmental stewardship, mobilising citizens, municipalities, NGOs and educational institutions around the shared goal of protecting coastal and riverine ecosystems.

A central achievement of this deliverable is the establishment of a **harmonised operational approach** to organising clean-ups across diverse geographical and socio-environmental contexts. The guidelines presented in this deliverable ensure that activities are conducted safely, consistently and in alignment with European monitoring frameworks. By adopting common procedures for site selection, waste separation, volunteer coordination and data recording, partners are able to generate comparable information while maintaining flexibility to adapt to local conditions. The integration of digital tools, such as the REMEDIES monitoring and citizen-science applications, further strengthens the reliability and accessibility of data collected through community-driven initiatives.

Beyond the direct removal of marine litter, the deliverable highlights the importance of **linking clean-up activities with awareness, education and communication efforts**. Each clean-up event becomes a moment of learning and engagement, allowing participants to better understand the sources and impacts of plastic pollution while contributing to a wider movement for environmental responsibility. Through training initiatives, knowledge-exchange workshops and public campaigns, the project has created a learning ecosystem that empowers citizens and local organisations to replicate and scale these actions.

Equally important is the introduction of **plastic valorisation pathways**, which demonstrate how collected materials can be redirected into circular processes rather than treated solely as waste. By exploring low-tech community-based solutions alongside more advanced recycling routes, the deliverable outlines practical opportunities for transforming plastic litter into new products, materials or educational tools. These approaches help illustrate the broader circular-economy potential embedded within marine litter management, encouraging communities to see waste not only as an environmental challenge but also as a resource that can support innovation and behavioural change.

The experience of the REMEDIES demo sites and associate regions shows that successful anti-litter initiatives rely on a combination of **community mobilisation, scientific monitoring, institutional collaboration and communication outreach**. When these elements operate together, clean-ups evolve from isolated volunteer events into structured programmes that generate lasting environmental and social impact. The replication examples presented in this deliverable demonstrate that the REMEDIES model can be successfully adopted by municipalities, research institutions, NGOs and citizen groups across different regions.

Looking ahead, the Clean-up and Valorisation Guideline provides a solid foundation for the continued expansion of citizen-driven marine litter initiatives within the Mediterranean and beyond. By offering practical tools, clear methodologies and replicable practices, the deliverable supports the broader ambition of building a coordinated network of communities working together to reduce plastic pollution. In doing so, it contributes directly to the goals of the EU Mission “Restore our Ocean and Waters”, reinforcing the role of citizens, science and innovation in creating cleaner, healthier and more resilient marine environments.

IV Annexes

Annex I – Beach Litter Monitoring and Clean-Up at a Glance: Do's and Don'ts (VLPPF)



BEACH LITTER MONITORING AND CLEAN UP AT A GLANCE

do's and don'ts

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HOW TO ORGANIZE BEACH LITTER MONITORING

TOOLS NEEDED:

- Local map and GPS localizer (i.e smart phone)
- Camera (i.e smart phone)
- REMEDIES shoreline litter monitoring app
- Printing Items Classification List (G and J codes) as a back up
- Pen/pencil
- 4 movable signals (wood sticks, flags, others - If you do not use the app)
- open reel surveyors tape 100 mt

TO REMEMBER:

- Define the date of the monitor in clear weather and don't carry it out after an exceptional weather events (i.e. storm surges, floods, etc.)
- Preserve the environment and be mindful about the wildlife present in the hot-spot areas
- Plan your activity in coordination with the waste management entities and other relevant local authorities for authorization and data sharing
- Take always an insurance for the planned activity

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DON'T DO IT

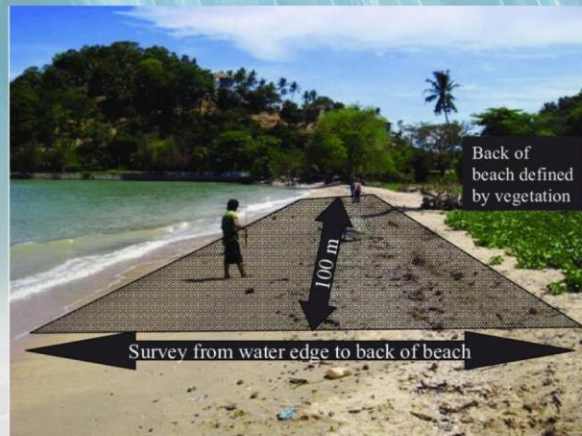
- The 100-meter transect on the beach must be representative (do not select the most polluted part of the beach).
- Stick to the selected beach and its transect for the seasonal beach litter monitoring rounds. Do not shift the survey time: if a month is set, adhere to it periodically (October 2023 - October 2024).
- Monitor only what is naturally stranded and visible on the surface of the beach—do not dig to search for litter or look for other litter accumulated by other means.



WHERE MONITORING

- Sometimes it is difficult to identify the width of the beach to monitor.

Useful tip: monitor only from the water edge to the back of the beach defined by stable-consolidated vegetation





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WHERE MONITORING



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TO DO IN MONITORING



- Monitor all the litter > 2,5 cm
- If you are not able to assign the specific G/J code, take a picture and share it with the organization(s) in charge for validation or that can help validation
- The single wood eligible for monitoring is the processed wood
- After the monitoring activities remember to properly remove and dispose the litter



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INFORMATION IN MONITORING

- If a plastic bottle has a cap, you should count only the bottle and not add the cap (caps should be counted only if found alone).
- If you find fragments of the same item, you should count each fragment, not as a single item.



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WARNINGS!

TO REMEMBER

- Make sure that the activities will not pose any threat to endangered or protected species and their habitats, such as sea turtles, sea birds or shore birds, marine mammals or sensitive beach vegetation; in many cases this would exclude protected areas, but it depends on local management arrangements. Always consult protected areas conservational management authorities before going operational with clean up or beach litter monitoring activities.
- Try to avoid conducting beach surveys during the summertime in areas with touristic presence, as beaches are cleaned by bathing facility managers for the tourist season. It is advised to organize monitoring surveys between the end of February and April (to minimize the impact on breeding bird species that generally colonize the beaches from April to May) or in the second half of September on.



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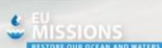


BEACH LITTER CLEAN-UP MANAGEMENT GUIDELINES

P. Franceschetti- D. Poletto- G. Toso



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1. IDENTIFICATION OF THE SITE FOR BEACH LITTER CLEAN-UP

BEACH IDENTIFICATION PHASE:

TOOLS NEEDED:

- Local map GPS localizer (i.e smart phone)
- Camera (i.e smart phone)

HOW TO DEFINE THE BEACH:

1. Define the macro-area of investigation (i.e. Venice coasts)
2. Identify the spot(s) that has to:
 - a) Have a free entrance during the year (no private areas)
 - b) Easy access and way to remove the litters
 - c) Be characterized by a low to moderate slope ($\sim 1-45^\circ$), which excludes very shallow tidal mudflat areas;
 - d) Get a beach with open shorelines to walk through (not obstructed by breakwaters or jetties);
 - e) close to a street,
 - f) with a car park or public transports close by
 - g) with a high presence of litter accumulation hot spots.



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1. IDENTIFICATION OF THE SITE TO BE CLEANED-UP

OPERATIONAL STEPS

1. Scouting areas
2. Identify the hot-spot(s);
3. Take note of the geographical coordinates with GPS localizer of the hot-spot to clean;
4. Take pics or video clips of the entire investigated area and in particular of the hot-spots for advocacy and clean up impact maximization communication.



2. HOW TO ORGANIZE BEACH LITTER CLEAN-UP

PRE-EVENT COMMUNICATION:

- The communication should be flexible enough to address different stakeholders with variable communication strategies.
- To have the highest participation from volunteers the pre-communication has to start a couple of weeks before the date of the clean-up event.
- The information to give to the participants have to be clear, easy to understand and straightforward
- The best tentative days to set a clean-up is on Saturday or Sunday if you wish higher number of participants.
- The “meeting/information point” for the volunteers has to be close to the clean-up site and easy to spot, close to public transportation stop or car park.





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2. HOW TO ORGANIZE IT

WHAT TO COMMUNICATE:

- Time of the clean-up, including the date, the starting and final time hour
- The site of the clean-up and the identification of a specific "meeting point"
- A contact person with phone number and email
- Partners/organisers/sponsors of the event
- Basic operational recommendations in terms of equipment and other (gloves, shoes, caps, etc.)

PREPARATION:

1. Contact the city departments-authorities in charge of any necessary authorization(s)
2. Contact the waste management authority to arrange:
 - a. Removal and final disposal and treatment of all litter collected, providing location(s), timetable of the event and final pick up point(s)
 - b. Any other logistic and organisational support you deem necessary (special requests, distribution of material to roll out clean up etc.
 - c. Authorisation to use logos and synergies at the communication level
3. Design and create an appealing event flyer with logistics and time schedule details to rely volunteers to share in all communication channels (issued before clean up 10-14 days)
4. Provide REMEDIES C&D leading partner with suitable communication outputs



3. HOW TO IMPLEMENT THE CLEAN-UP

TOOLS NEEDED:

- Table
- Tokens (t shirts, flags, caps, posters, etc.) that may identify the implementing organization(s), the project (REMEDIES), the donor (EU)
- Marketing flyers/gadgets of REMEDIES Project (always with the project and donor logo displayed)
- Smart Phone
- Dynamometer scale
- Camera (i.e. smart phone)
- Pencil and papers with printed clean up sheet (VLPP format)
- Gloves
- Pickers (not indispensable but useful)
- Coloured waste bags for litter collection to separate plastics from non-plastics material that need to be reported separately
- First aid kit





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3. HOW TO IMPLEMENT THE CLEAN-UP



STEPS:

1. The organizer have to meet at least one ½ hour before the communicated clean-up starting time required to set out all is required for the activity.
2. When the participants arrive, remember to explain the following :
 - a. The area that has to be cleaned
 - b. The safety information about the clean-up (i.e. don't pick too heavy litters, stay off dangerous areas, etc.) and to respect the environment/animals (if present)
 - c. Check if each team-participant is adequately equipped (glove, waste bag etc).
 - d. Provide a reminder of clean up ending time
 - e. Ask to use two different waste bags: one only for plastics an the other for the rest of litters
 - f. Say where all the waste will be collected and leave the waste bags
3. During the clean-up leave at least one of your team at the "meeting/information point" to welcome late volunteers.
4. Provide constant assistance and supervision to all volunteers during the activity (as organizer you are liable at the penal and civil level)
5. Half hour before the end of the clean-up, prepare the participants to the closure of the event leading them to the waste collection area for the clean up.
6. At the end of the clean-up, be sure that all the participants leave the area and that all the litter has been properly disposed in line with the waste management authority provisions



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3. HOW TO IMPLEMENT THE CLEAN-UP



DATA COLLECTION:

Before the removal of the litters by the waste management authority, it is necessary to record the following information:

- Number of participants
- Weight of plastic litters collected using the dynamometer-scale
- Weight of no-plastic litter collected using the dynamometer-scale
- Pictures of the overall waste bags collected

All data must be recorded, saved and added in the REMEDIES app when available.

POST EVENT COMMUNICATION:

After the clean up is valuable to communicate its impact. It might be useful to :

- Date and area of the clean-up,
- The number of participants and partners involved in the clean-up
- The weight of the plastic removed
- significant images of the clean-up event (photo gallery)
- Any further follow up



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Meet Us!



@Remedies_eu



@Remedies_EU



@Remedies.eu



@remedies_eu



@REMEDIES-EU



remedies-for-ocean.eu



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Annex 2 – REMEDIIES Citizen Science Protocol – Beach Litter Clean-Ups

Beach Litter Clean-Up: Citizen Science Action for the REMEDIIES Project

Introduction

Marine litter, especially plastics, poses a significant threat to coastal and marine ecosystems, biodiversity, and the social and economic value of coastal areas. Beach clean-ups are a practical, visible, and inclusive citizen science action that mobilises communities to remove litter while documenting the impact of their effort.

This protocol provides step-by-step guidance for planning and implementing a safe and effective Beach Litter Clean-Up within the REMEDIIES project. Citizens play a key role by participating in the clean-up, separating collected materials, and documenting results (e.g., participants, weights, photos) using the REMEDIIES Citizen Science tools.

The activity supports REMEDIIES objectives by raising awareness, enabling structured citizen engagement, and contributing to local actions that reduce plastic pollution and advance the Mission Restore Our Ocean and Waters targets.

Objectives

- Remove beach litter in a safe, organised, and environmentally respectful way.
- Engage and empower citizens and local stakeholders to take action against marine litter.
- Ensure basic, harmonised documentation of clean-up outputs (participants, weights, photos) to support communication and impact reporting.
- Promote source-reduction awareness by highlighting common litter types and local drivers of pollution.

Target Group

This activity is suitable for organised citizen groups and the general public, including youth groups, schools (with supervision), coastal communities, NGOs, local authorities, and company volunteer teams. Participation should be adapted to local conditions and safety requirements.

Materials & Tools Needed

Core equipment and materials for a beach clean-up:

- Table (for organising materials and registration).
- Smartphone(s) for documentation and optional use of the REMEDIES Citizen Science App.
- Camera (smartphone acceptable).
- Dynamometer scale (or equivalent) for weighing collected waste.
- Printed clean-up data sheet (VLPF format) as a backup.
- Protective gloves of different sizes for all participants.
- Litter pickers (optional but useful).
- Coloured waste bags to separate plastics from non-plastics (reported separately).
- First aid kit.
- Visibility/identification items (optional): t-shirts, flags, caps, posters, etc., with REMEDIES and EU donor logos where relevant.

Digital tools:

- REMEDIES Citizen Science App (for recording types of collected litter, uploading photos, and entering bag weights). Download the app [here](#).

Step-by-Step Process

Preparation

Preparation is essential for participation, safety, and effective waste handling. Before confirming the date and location, coordinate with relevant authorities and consider weather, tourism seasons, and biodiversity sensitivity.

Site identification (recommended criteria):

- Public access all year (no private/closed areas).
- Easy and safe access for participants and for waste removal logistics.
- Low to moderate beach slope (approx. 1-45°), avoiding shallow tidal mudflat areas.
- Open shoreline sections that are walkable (not obstructed by breakwaters/jetties).
- Close to a street and with nearby parking or public transport.
- Visible litter accumulation hot spots.

Operational scouting steps:

1. Scout the area and identify litter hot spots.
2. Record the geographical coordinates of the selected hot spot(s) using a GPS- enabled smartphone.

3. Take photos and/or short video clips of the overall area and hot spots (useful for impact communication).

Authorisations, logistics, and safety:

1. Contact the city/local authority departments for any required authorisations.
2. Coordinate with the waste management authority to arrange removal, final disposal, and any special logistics (provide location, timetable, and final pick-up point).
3. Secure appropriate insurance for the activity (as required locally).
4. Identify and brief a responsible safety focal point (first aid kit, risk awareness, incident response).
5. Ensure the clean-up will not threaten endangered or protected species or sensitive habitats; consult protected area management authorities where relevant.

Pre-event communication (start approx. 2-4 weeks before):

1. Date, start and end time of the clean-up.
2. Exact location and a clearly visible meeting/information point (easy to reach, near transport/parking).
3. Contact person (phone and email).
4. Partners/organisers/sponsors (if applicable).
5. Basic recommendations for participants (closed shoes, gloves, sun protection, water, etc.).
6. Event flyer with logistics and time schedule (recommended release 10-14 days before).

Clean-Up Implementation

On the day of the clean-up:

1. Organisers arrive at least 30 minutes before the announced start time to set up materials and the meeting point.
2. Welcome participants and deliver a short briefing covering: (a) the area to be cleaned; (b) safety rules (do not lift heavy items; avoid dangerous areas); (c) respect for wildlife and the environment; (d) confirmation that everyone has gloves and bags; (e) reminder of end time; (f) where waste bags will be gathered for collection.
3. Ask participants to use two different bags: one for plastics and one for non- plastics.
4. Keep at least one organiser at the meeting/information point to welcome late volunteers.
5. Provide a presentation/training on the different types of plastics found on the beach, with the support of the REMEDIATION Flag on the Different Types of Plastics.



REMEDIIES Flag on the Different Types of Plastics

6. Provide continuous assistance and supervision during the activity.
7. About 30 minutes before the end, guide teams towards the waste collection point to close the event smoothly.
8. Ensure all participants leave the area safely and that collected waste is stored/disposed of according to the waste management authority's instructions.

Documentation and Data Recording

Before the waste is removed by the waste management authority, record the following minimum information:

- Number of participants.
- Total weight of plastics collected (kg).
- Total weight of non-plastics collected (kg).
- Photos of the overall collected waste bags (and group photo, if appropriate).

Record and store this information using the REMEDIIES Citizen Science App whenever possible. If needed, enter bag types and weights via the REMEDIIES web portal after the event.

Using the REMEDIIES Citizen Science App:

1. Download the REMEDIIES Citizen Science App from Google Play or the Apple App Store.
2. Organiser: log in to the web portal and create a new clean-up campaign (name, date/time, location, description).

3. Organiser: create one or more groups and assign a coordinator to each group (email required).
4. Coordinator/participants: log in or sign up via the mobile app and join the correct group.
5. During the clean-up: add collected litter in the app using the available categories.
6. End the clean-up session and upload group photos and bag photos (coordinator).
7. Record bag types and weights (kg) per bag either in the portal (Bags Details table) or in the mobile app (Cleanup > Manage Bags).

GDPR and data privacy:

The REMEDIES citizen tools follow GDPR principles (consent, transparency, and data control). Participants should be informed about data processing and photography practices according to local requirements.

Post-event communication (recommended):

- Share date and area cleaned, number of participants/partners, weights collected (plastic and non-plastic), and a short photo gallery.
- Highlight any follow-up actions or next clean-up dates to maintain engagement.

Additional Materials

- Download the REMEDIES Citizen Science App, created by Infordata, [here](#).
- REMEDIES Citizen Science App - User Manual (step-by-step guide for organisers, coordinators, and participants), created by Infordata, [here](#).
- REMEDIES Citizen Science App - Video Tutorial, created by Infordata, [here](#).
- REMEDIES Citizen Science App - Infographic, created by Infordata, [here](#).
- REMEDIES Flag on the Different Kind of Plastics ([vertical](#) and [horizontal](#)), created by Impact Hub Athens, University of Maribor, and Venice Lagoon Plastic Free.
- REMEDIES Citizen Science Manifesto, created by Impact Hub Athens, [here](#).
- The recording of the PLASTIC FANTASTIC webinar on plastic identification and beach litter monitoring, with educational content from Venice Lagoon Plastic Free and University of Maribor, [here](#).
- REMEDIES Beach Litter Monitoring and Clean up At a Glance - Do's and Don'ts, created by Venice Lagoon Plastic Free, [here](#).

The present protocol was drafted by [NIC](#) and [Impact Hub Athens](#) with the support of [Venice Lagoon Plastic Free](#), [Infordata](#) and [VITO](#).

Contributors/Authors: Vesna Kuralt, Violetta Tsitsiliani, Davide Poletto, Elazem Abdelhamid, Milica Velimirovic, Marko Petelin

Annex 3 – Clean-up & monitoring photographs per country

Albania



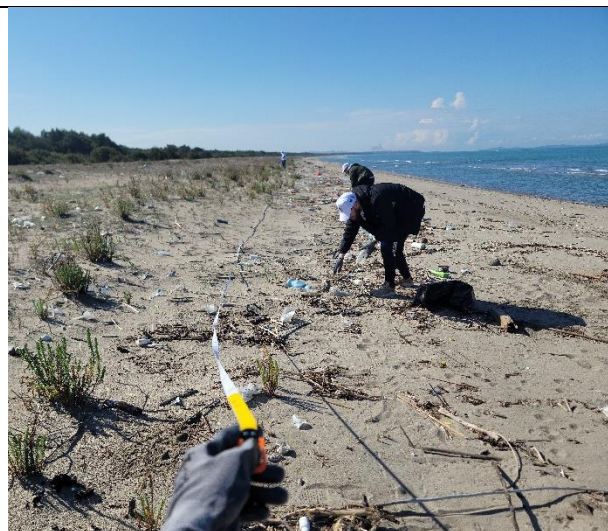
Albania - Ishmi River Mouth -2025-09-25 -Clean-up



Albania - Spille Beach - 2024-12-18 - Clean-up



Albania - Ishmi River Mouth -2025-09-25 - Clean-up



Albania - Hamallaj beach - Beach - 2024-03-17 - Clean-up



Albania - Ishem rivermouth - 2023-09-16 -
Cleaning I



Albania - Hamallaj Beach -2025-11-16-Clean-up &
Monitoring 3



Albania - Hamallaj Beach -2025-11-16-Clean-up
& Monitoring I



Albania - Hamallaj Beach -2025-11-16-Clean-up &
Monitoring 2

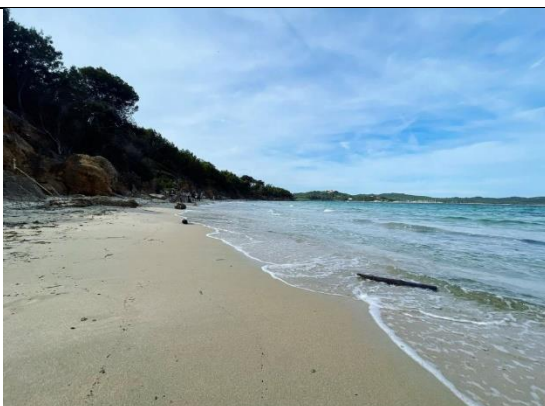
France



France - 3ème Courtade Porquerolles - 2024-07-03 - Clean-up & Monitoring 1



France - 3ème Courtade Porquerolles - 2024-07-03 - Clean-up & Monitoring 2



France - 3ème Courtade Porquerolles - 2024-07-03 - Clean-up & Monitoring 3



France - 3ème Courtade Porquerolles - 2024-04-06 - Clean-up & Monitoring 1



Copy of France - 3ème Courtade Porquerolles - 2024-07-03 - Clean-up & Monitoring 4



France - 3ème Courtade Porquerolles - 2024-01-13, Clean-up & Monitoring 1



France - 3ème Courtade Porquerolles - 2024-01-13, Clean-up & Monitoring 2



France - 3ème Courtade Porquerolles - 2024-04-06 - Clean-up & Monitoring 2



France - 3ème Courtade Porquerolles - 2024-04-06 - Clean-up & Monitoring 3



France - 3ème Courtade Porquerolles - 2024-04-06 - Clean-up & Monitoring 4



France - 3ème Courtade Porquerolles - 2024-04-06 - Clean-up & Monitoring 5

Greece



Greece - Tam Toom Beach - 2024-06-08 - Clean-up I



Greece - Merchia Beach Mykonos -2025-01-29 - Cleaning & Monitoring



Greece - Palaion Faliron - 2023-11-18 - Clean-up



Greece - Asimaki beach - 2024-1-12 - Clean-up



Greece - Mykonos Mertia beach - 2024-01-29-
Clean-up & Monitoring



Greece - Rinia, island - 2024-06-04 - Clean-up



Greece - Edem Beach Palaio faliro - 2024-06-05 -
Clean-up



Greece - Kalami - 2024-05-25 - Clean-up



Greece - Tam Toom Beach - 2024-06-08 - Clean-
up 2



Greece - Kremasti beach Rhodes - 2025-03-13 -
Clean-up



Greece - Ftelia Beach, Mykonos- 2024-05-29 -
Clean-up



Greece - Merchia Beach Mykonos -2024-10-30-
Clean-up & monitoring

Italy



Venice - Sacca San Mattia - 2024-06-01 - Clean-up



Venice - Alberoni Oasi WWF - 2025-04-13 - Clean-up & monitoring



Venice - S. Piero in Volta - 2023-04-27 - Clean-up & monitoring



Sardinia - San Giovanni di Sinis - 2024-06-02 - Clean-up



Venice - Alberoni Oasi WWF - 2024-09-22 -
Clean-up & monitoring



Sardinia - Torregrande - 2024-04-15 - Clean-up &
monitoring



Sardinia - Torregrande - 2023-04-17 - Clean-up
& monitoring - 25 volunteers - 4,6 kg plastic -
3,08 kg other litter 1



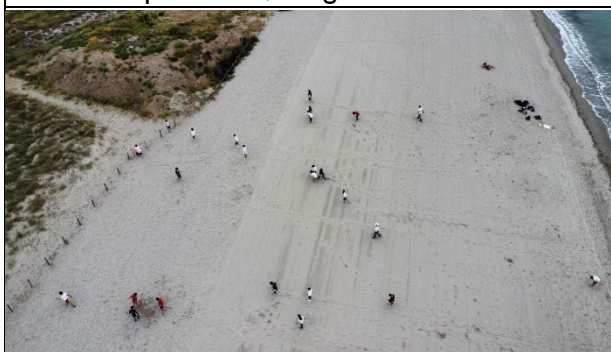
Sardinia - Torregrande - 2023-04-17 - Clean-up &
monitoring - 25 volunteers - 4,6 kg plastic -3,08 kg
other litter 2



Sardinia - Is Arenas Beach -2024-11-26 - Clean-up & monitoring - 30 volunteers - 16,88 kg plastic - 16,88 kg other litter



Sardinia - San Giovanni di Sinis - 2024-07-25 - Clean up



Sardinia - Poetto - 2024-05-24 - Clean-up & monitoring



Sardinia - San rocca turda - 2023-08-01 - Clean-up & monitoring - 56 volunteers - 17,9 kg plastic - 12,7 kg other litter I



Sardinia - Perd'è Sali - 2024-05-18 - Clean-up 2

Montenegro



Montenegro - Ada Bojana beach - Donji Štoj -
Clean-up 1



Montenegro - Ada Bojana beach - Donji Štoj -
Clean-up 2



Montenegro - Ada Bojana beach - Donji Štoj -
Clean-up 3



Montenegro - Ada Bojana beach - Donji Štoj -
Clean-up 4

Morocco



Morocco - Saidia -2024-10-26 - Clean-up &
Monitoring 1



Morocco - Saidia -2024-10-26 - Clean-up &
Monitoring 2



Morocco - Saidia - 2025-01-25 - Clean-up & Monitoring 1



Morocco - Saidia - 2025-01-25 - Clean-up & Monitoring 2



Morocco - Saidia - 2025-01-25 - Clean-up & Monitoring 3



Morocco - Saidia - 2025-01-25 - Clean-up & Monitoring 4



Morocco - Saidia - 2025-01-25 - Clean-up & Monitoring 5



Morocco - Saidia - 2025-01-25 - Clean-up & Monitoring 6



Morocco - Saidia - 2025-01-25 - Clean-up & Monitoring 7



Morocco - Saidia - 2025-01-25 - Clean-up & Monitoring 8



Morocco - Saidia - 2025-01-25 - Clean-up & Monitoring 9



Morocco - Saidia - 2025-01-25 - Clean-up & Monitoring 10

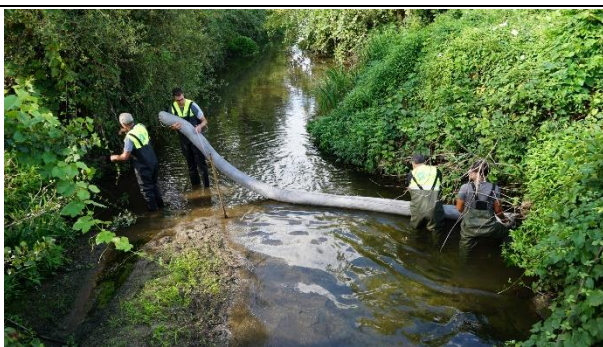


Morocco - Saidia - 2025-01-25 - Clean-up & Monitoring 2



Morocco - Saidia - 2025-01-25 - Clean-up & Monitoring 1

Portugal



Portugal - Selho River Guimarães - 2024-08-13 - Clean-up & Monitoring 1



Portugal - Selho River Guimarães - 2024-08-13 - Clean-up & Monitoring 2



Portugal - Selho River Guimarães - 2024-08-13 -
Clean-up & Monitoring 3



Portugal - Selho River Guimarães - 2024-07-29 -
Clean-up I



Portugal - Selho River Guimarães - 2024-07-29 -
Clean-up 2



Portugal - Selho River Guimarães - 2024-07-29 -
Clean-up 3



Portugal - Selho River Guimarães - 2024-07-29 -
Clean-up 4

Slovenia & Croatia



Croatia - Obala Josipa Broza Tita -2023-12-12 -
Clean-up



Slovenia - Bele Skale Beach - 2025-11-15 - Clean-
up - Clean-up & monitoring



Slovenia - Strunjan beach-2024-04-20 - Clean-up



Slovenia - Koper beach - 2023-09-16 - Clean-up
3



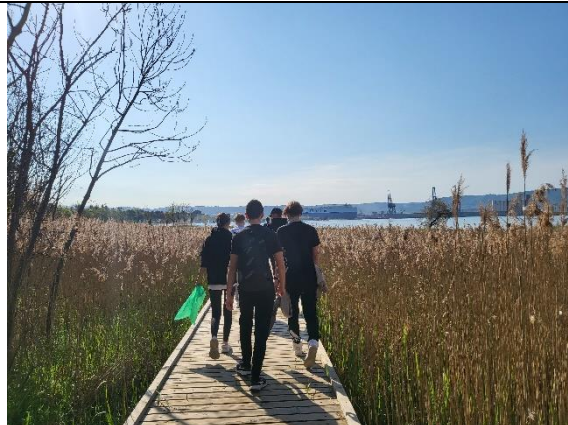
Slovenia - Koper beach - 2023-09-16 - Clean-up 2



Slovenia - Fiesa beach - 2023-04-21 - Clean-up &
Monitoring



Slovenia - Koper beach - 2023-09-16 - Clean-up
I



Slovenia - Debeli rtič -2024-04-06 - Clean-up



Slovenia - Bele Skale beach - 2023-04-15 - Clean-up & Monitoring 2



Slovenia - Bele Skale beach - 2023-04-15 - Clean-up & Monitoring I

Annex 4 – Technical Data Sheet of FIL&FAB NYLO®

		Technical Data Sheet		
		Product designation : NYLO®		
		Product codification : AA-GRa		
		Date : 10/12/2021		
Contact				
Address : FIL&FAB SAS - ZA Toul Ibil - 29217 - Plougonvelin				
Web : www.fil-et-fab.fr				
Tel : +33(0) 6 69 99 74 11				
Product designation				
chemical designation : rPA6 - recycled polyamide 6- 99,4% from fishing nets				
Adjuvant : Antioxydant 0,6%				
The fishing nets we recycle may be of very different colors. Since our recycling process maintains as much as possible the properties of the products received, and since we do not add any color pigments unless requested by the customer, the granules obtained may be of different colors within the same batch.				
This is in no way a source of dispersion of properties, nor the result of any kind of pollution.				
Recommended settings				
Drying : min 6 hours at 80°C		Process temperature : 235°C-280°C		Mould temperature : 80°C
We strongly recommend storing granules in a dry place,				
Values				
Physical properties	Factor	Value	Unit	Norm
Density	/	1,13	g/cm ³	ISO 1183
MFI	275°C / 2,16 kg	37	g/10min	ISO 1133
MFI	275°C / 5 kg	69	g/10min	ISO 1133
Water absorption - 24h	/	1,2	%	Protocole IDC
Water absorption - 48h	/	1,61	%	Protocole IDC
Processing shrinkage	/	2,06	%	Protocole IDC
HDT	1,8 Mpa	45,2	°C	ISO 75
Mechanical properties	Factor	Value	Unit	Norm
Tensile/young modulus	/	2463	Mpa	ISO 527
Max stress	/	58	Mpa	ISO 527
Stress at break	/	45	Mpa	ISO 527
Stress at elastic limit	/	55	Mpa	ISO 527
Elongation at break	/	30	%	ISO 528
Elongation at elastic limit	/	3,7	Mpa	ISO 528
Flexural Modulus	/	1690	Mpa	ISO 178
Charpy impact (notched)	/	4,2	Kj/m ²	ISO 179
Charpy impact (unnotched)	/	30	Kj/m ²	ISO 179
Shore hardness	/	75	Shore D	ISO48
Laboratory reference				
Innozh - 18 rue Wallon - 22000 St Brieuc - France				
The data and indications given reflect the current state of our knowledge and are intended to provide information about our products and their applications.				
They are not contractual and do not represent any assurance or guarantee of chemical resistance, product quality and their commercialization.				

