Action plan for the implementation of the Sustainable Organic and Plastic waste Methodology

Final version of 31/12/2021

Deliverable number D.5.3.2

Project Acronym: NETWAP

Project ID Number: 10047692

Project Title: NETwork of small "in situ" WAste Prevention and management initiatives

Priority Axis: 3 Environment And Cultural Heritage

Specific objective: 3.3 Improve the environmental quality conditions of the sea and coastal area by use of sustainable and innovative technologies and approaches

Work Package Number: 5

Work Package Title: Pilot actions and sustainability evaluations

Activity Number: 5.3

Activity Title: Policy recommendations and action plan

Partner in Charge: ENEA

Partners involved: ENEA, Čistoća d.o.o., City of Zadar, GAL Molise Verso il 2000

Status: Final

Distribution: Public

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Executive summary

Traditionally, waste policy has tended to focus on how we treat the waste we produce and how to achieve the right balance between waste recycling, recovery and disposal.

However, waste policy can no longer be about the narrow consideration of how to treat the waste we produce, implicitly based on a linear or take-make-waste consumption model that cannot be sustained. Our policy focus must be broader, looking first at how we consume materials and resources, how we design the products that households and businesses use, how we prevent waste generation and resource consumption and how we extend the productive life of all goods and products in our society and economy. A transition to a circular economy offers the possibility of a sustainable alternative future and is a fundamental step towards achieving climate targets and United Nations Sustainable Development Goals (SDGs).

The 2020 Circular Economy Action Plan 'For a cleaner and more competitive Europe' from the European Commission recognises the need to accelerate this transition to the entire mainstream economy. It takes a multi-dimensional approach to the many challenges:

- A new sustainable product policy framework that will leverage change through design, purchasing power and a new industrial strategy.
- It identifies 7 key product value chains: electronics and ICT; batteries and vehicles; packaging; plastics; textiles; construction and buildings; and food, water and nutrients.
- It proposes 6 key actions on waste including waste reduction targets; harmonising collections; measures around substances of concern; scoping more EU-wide end-of-waste criteria; revising shipment rules.
- Strategic interventions across skills, social policy,
- Just transition, climate action, state aid and working globally.

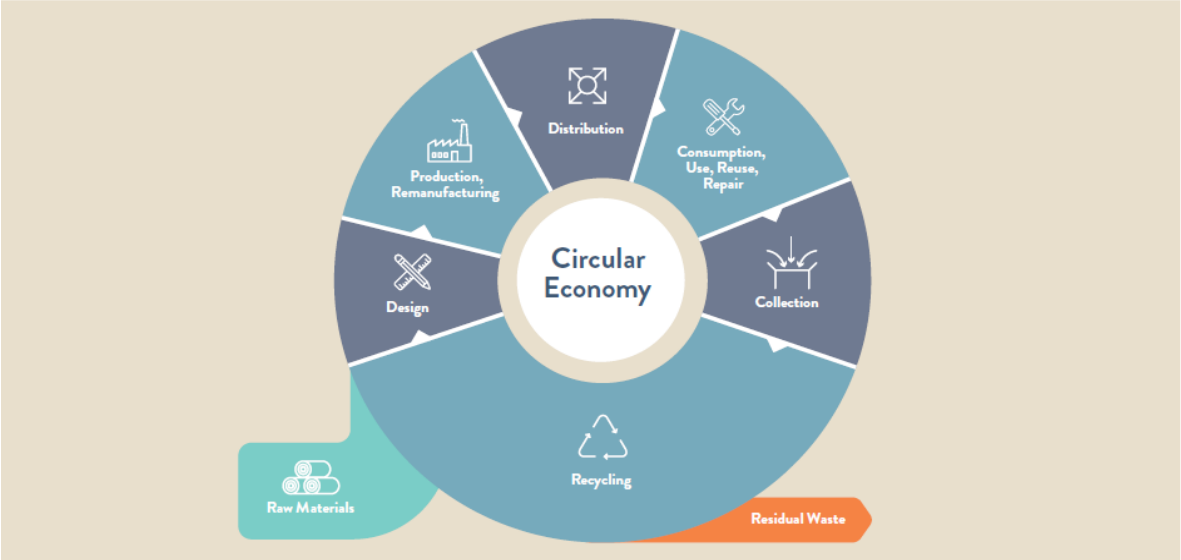


Figure 1 - The circular economy (source: national waste prevention programme)

The NETWAP project is aimed at testing and validating a methodology for sustainable waste management in small communities, also characterized by touristic pressure, in order to reduce the environmental impact of organic waste and plastics. The methodology is focused on four specific aspects (reduction of waste, recycling and recovery, innovative "in situ" transformation process, cost definition of proposed actions) particularly fitted for territories where small communities are settled, and aims at improving the capacity of the authorities and the citizenship to implement and to carry on a correct waste management hierarchy, also activating an effective mechanism for responding to seasonal increase of waste (related, for instance, to touristic flows).

This Action plan for implementation of sustainable Organic and Plastic Waste Methodology strives towards the achievement of the following **objectives**:

1. Reduction of the residual biowaste in municipal mixed waste;
2. Reduction of plastics from beach and marine litter.

The overarching objectives of this action plan are to:

- introduce schemes of small scale composting (autocomposting, community composting and local composting) at local level as a form of recycling at source for biowaste;

  - these schemes are supposed to be regulated by a municipal resolution which establishes obligations and benefits for joining subjects (households, associations, commercial activities);
  - these schemes are accompanied by action plans consisting of operating composters in two targeted territories measuring benefits in terms of sustainable management.
- introduce a collection of waste plastics from marine litter which is ready to be directed to effective recycling and not to landfill as it is the current case;
  - this method has been accompanied by field samplings and experimental work to demonstrate the recyclability of collected waste plastics.

Some of the measures in this document can be implemented immediately. Others require legislative or institutional change.

1. Introduction

1.1 Presentation of the project

NETWAP project is a cross border cooperation initiative included within the Priority Axis 3 “Environment and Cultural Heritage” of the Interreg Italy Croatia Programme, that aims to contribute to the specific objective 3.3 “Promoting innovative technologies to improve environmental protection and resource efficiency in the waste sector, water sector and with regard to soil, or to reduce air pollution”.

NETWAP project’s objective is to address potential environmental damage and improve the quality of the marine environment in selected territories of the cooperation area, by increasing the awareness, ability, know-how and decision-making activities of local communities towards a sustainable waste management methodology and a system based on innovative technologies and procedures. The project involves the development, verification and validation of a sustainable municipal strategy and a waste management model that promote the adoption of a cross-border approach based on effective cooperation and in harmony with the EU waste hierarchy and with the principles of circular economy. The problem of increasing tourist pressure on fragile cultural and natural sites, with particular attention to small and / or isolated communities, far from well-established collection and treatment services is addressed by the project. The project will address the challenges taking into account the governmental, technical, financial and environmental aspects of developing a cross-border waste management strategy and methodologies, training needs of technical staff and information needs on the political side. The approach is innovative as it aims to overcome the existing practice in the management of organic and plastic waste already in place, both in the Italian and Croatian coastal areas, supporting local authorities and economic operators

in the design of an effective methodology for small communities, tourists and citizens in gathering the required knowledge. The creation of an Italian-Croatian shared methodology requires an approach that capitalizes on established methods with the best waste management practices and innovative aspects related to the involvement, awareness and authorization of all the interested parties in the project areas. The NETWAP project will focus on human capital skills and skills development, involving all communities targeted in the management of organic waste and disadvantaged local groups in capacity building activities and daily work with a participatory approach.

1.2 Presentation of the strategy

The NETWAP methodology is aimed at defining a new approach for the autonomous and sustainable waste management in small communities – in general, intended as the ones with relatively small permanent population scattered across the reference territory, that lie quite away from the main logistic routes and which is characterized by a lack of main infrastructures for waste management – and foresees procedures for:

- stimulate waste reduction and boosting recycling;
- promoting local small scale composting and reducing the use of landfills;
- plastic waste collection using low technologies and subsequent proper treatment.

Specific details regarding the NETWAP methodology are presented in the Deliverable 3.4.1, anyway the rationales regarding each one of these aspects are the following.

1. Stimulate waste reduction and boosting recycling

According to the Waste Hierarchy, the methodology is based on measures basically regarding three different levels of involvement in waste reduction and boosting recycling of the different stakeholder in the territory:

- Information and awareness of inhabitants and tourists (societal level);
- Legislative acts by local authorities (political level);
- Incentives and disincentives (economic level).

2. Promoting local small scale composting and reducing the use of landfills

In order to promote small scale composting, that represents a potential major opportunity for managing biowaste in those geographical areas where remote and small communities (islands, mountain, rural villages, etc.) lie away from the main logistic routes and infrastructure, the methodology focus on:

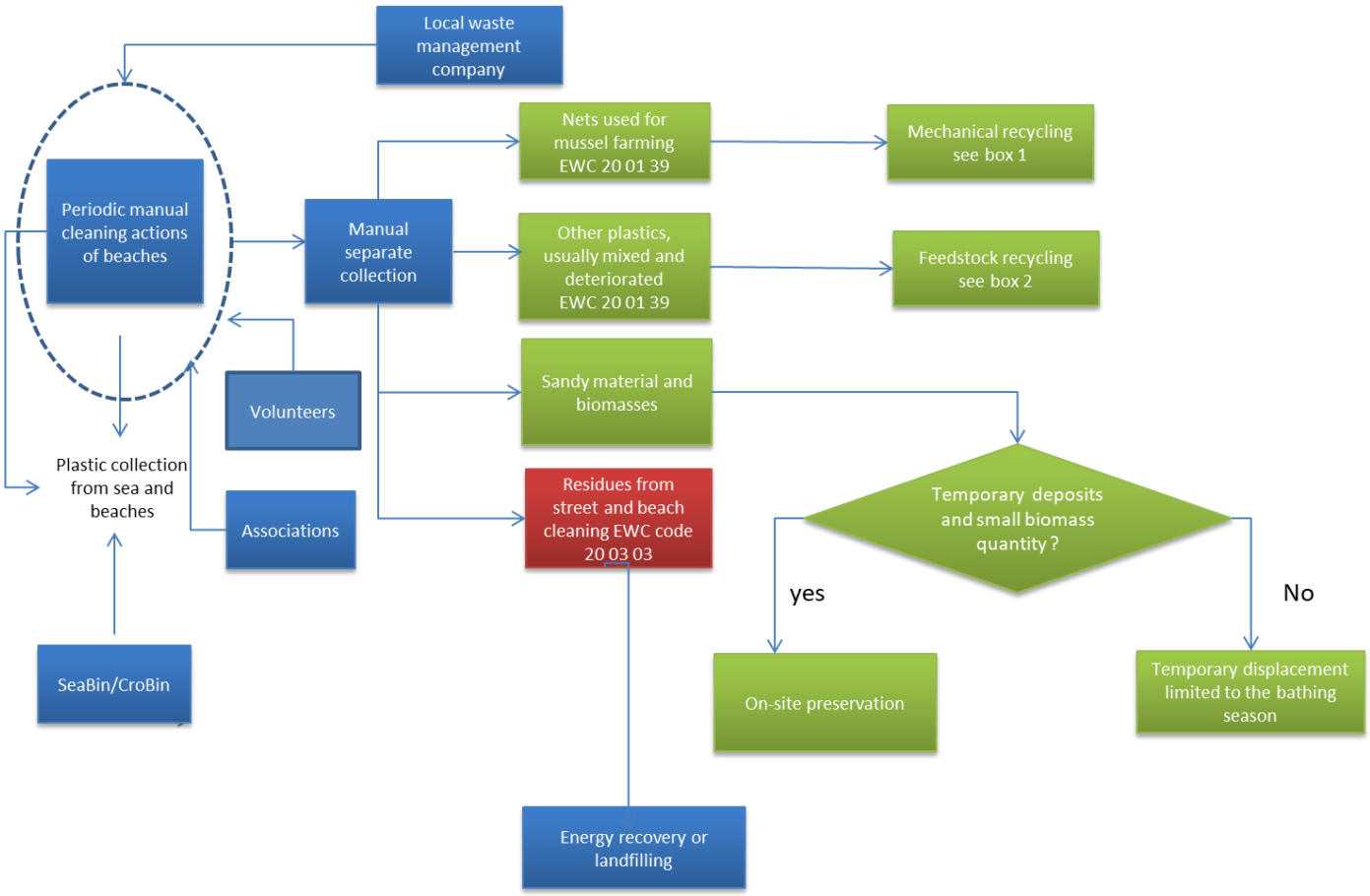
- Auto-composting;
- Community composting;
- Local Composting.

The application field of each one of these solutions is related to the amount of biowaste yearly treated and the administrative/legal/tax frameworks are different from one to another typology, with all the details given in Deliverable 3.4.1.

3. Plastic waste collection using low technologies and subsequent proper treatment

The NETWAP proposal mainly consists of taking advantage of the periodic initiatives of beach cleaning through the work of free associations of citizens, volunteers, waste management companies. Infact waste plastics which is collected from beaches, is currently classified with a European Waste Catalogue (EWC) referred to “residues from street and beach cleaning” and as such, is disposed of into landfill or energy recovery and cannot be directed to recycling. In the course of samplings and experimental work carried out by Ruder Boskovich and ENEA in the beaches, waste plastics were subdivided into two categories: one suitable for mechanical recycling and the other for chemical or feedstock recycling. Therefore, volunteers can be properly trained to recognize and properly separate these two categories to which a European Waste Catalogue (EWC) of “plastics” can be attributed. At the same time, instructions are given to properly manage the biomass and temporary deposits which are accumulated on the beaches in order to save the natural quality of the site. The experimental work is detailed in the following **Pogreška! Izvor reference nije pronađen.** paragraph and Deliverable 3.4.1, by describing in three example boxes the various steps of preparation to recycling, polymers identification, mechanical and chemical treatment. A concept scheme is illustrated in Figure 2.

Figure 2 - Supposed scheme for plastic marine litter management



2. Biowaste management

Waste management is one of the main environmental problems that municipalities have to address. The fulfilment of the recycling objectives imposed by the European Commission (or European Union) requires the segregation and treatment of the municipal bio-waste.

The municipal bio-waste management practices affect citizens: economic (waste collection fee) and environmental impacts (emissions and indirect system effects), but also more diffuse effects such as the physical connection with waste management through the design of the collection system and the psychological effect of the localization of waste management facilities. The management of municipal bio-waste must be improved in order to move towards more sustainable systems, in accordance with the criteria of circular economy and with the involvement of citizens [1].

Bio-waste is a valuable organic resource with a high potential for recycling and reuse, producing valuable products such as fertilizers or biogas. However, inefficient and neglected management can generate bio-waste breakdown and pollution, reducing the efficiency of subsequent treatment operations and generating human health and environmental impacts.

2.1 Targets set by the Circular Economy Package for Biowaste

Organic waste or Biowaste consists of food and garden waste and with 34% [2] is the largest component in municipal solid waste; as a consequence, biowaste is one of the main landfilled waste fractions, creates greenhouse gas emission [3] and costs households thousands of dollars each year. On the other side,

biowaste is a valuable resource that can be harnessed and returned to productive use, turned into compost to improve and fertilise soil, or rescued to provide food for people and animals.

National action is required by all levels of government, businesses and communities to reduce organic waste and improve how we collect and treat organic waste in all waste streams. The EU circular economy package introduced new targets and recommendations for the biowaste management. According to the 2018/851/EU Waste Framework Directive [4] imposes all Member States the following targets:

1. Setting up of the separate collection of biowaste not later than the 31st December 2023 onwards; alternatively, biowaste must be recycled at source by applying home or community composting.
2. The residual biowaste in municipal mixed waste must be halved before 2030;
3. Municipal waste recycling must achieve 55% by 2025, 60% by 2030 and 65% by 2035. These objectives are impossible to be addressed without the contribution of biowaste.
4. From 2027 onwards compost derived from mixed municipal waste will no longer count towards achieving compliance with recycling target
5. Reduction of municipal waste directed to landfilling down to 10% by 2035.

2.2 Biowaste management in Europe

Data uniformly collected by the European Environment Agency throughout the EU-28 (28 EU Member States) go back to 2017 [5]. Municipal waste production was 249 Mt while biowaste production amounted to 86 Mt. This estimation includes the biowaste both separately collected (43%) and the fraction inside the mixed municipal waste (57%) which is directed to landfill or energy recovery treatments. Concerning this last figure, one can conclude that there are large margins of improvement for the correct valorisation of biowaste. This is the reason why the European Commission pushes a policy of diverting- so much biowaste as possible –from the residual municipal waste which is directed to landfilling to the recycling at source by home or community composting or to a separate collection where biowaste can be transformed into a soil improver by composting treatment or into biogas by anaerobic digestion treatment. It is important to state that the accuracy of the figures related to biowaste management depend on the quality of investigations carried out in the single Member State among which significant differences can be found. The European countries have only limited data available on their waste management structure. This is particularly true for home and community composting for which a systematic work of data collection is lacking and just a few experiences were thoroughly surveyed. Table 1 reports some meaningful examples of these activities described in international literature.

A complete knowledge of the total treatment capacity of biowaste in Europe is far to be achieved as 20 Member States which account for only 59% of the total amount of generated biowaste, provide information about this topic. In 2017 the capacity is equal to 38 Mt, 21 Mt of which is composted and 17 Mt anaerobically digested. Biowaste also includes sewage sludge, waste from food industry and manure. Countries with a very efficient biowaste management system offer a treatment capacity higher than the volume of municipal biowaste generated.

Table 1 – List of meaningful experiences of home and community composting in Europe

Program/project	Municipality/Country	Action	Source
REVITALIZA	Pontevedra/Spain	Small composting facility Home composting Awareness raising Training of a composting master	[6]
Decisive	Spain Lyon/France	Demonstrative project of decentralised systems	[2]
Community composting program	Bratislava/Slovakia	Cooperation among stakeholder and citizens. Biowaste management and reduction	[2]
Platform of sharing experiences in home and community composting	National French Environment Protection Agency (ADEME) France		[2]
Project of a private company	Fiumicino Airport of Rome/ Italy	Small composting facilities for the treatment of food waste of catering services 1000 t/y capacity	[7]
Project of volunteers to trainee citizens of small villages	Flanders/Belgium	Awareness raising – home composting and gardening	[8]
Municipal project for a small village	Allariz/Spain 6000 inhabitants	Modular composter of 1000 L at the service of the village	[9][9]
Project for a housing estate of 89 apartments	Ballymum/Ireland	Electromechanical composter with capacity of 26 t/y at the service of a housing estate	[11]
Project of a private company	Dublin/Ireland	Electromechanical composter of 2 m^3 at the service of catering company	[12]

Project of a catering company	Lithuania	Batch composter of capacity of 10 t/y	[13]
University Project	Barcelona/Spain	Composter for the treatment of Leftovers of raw fruit and vegetable and pruning wastes	[6]

2.3 Existing policy and regulations

As already mentioned, the European Circular Economy Package, which includes the waste directive 2008/98/EC, regulates all waste streams in the EU and paves the way for better biowaste management and for placing recycled bio-waste materials on the European market as products. The main objectives of the EU Circular Economy, in fact, are to reduce the waste production in Europe, to promote recycling, to save primary resources, and to establish markets for secondary products. With the adoption of the revised Waste Framework Directive [14], Landfill Directive [15] and the EU Fertilizer Regulation [16] the legislative framework for achieving these objectives has been set.

The production and use of quality compost obtained from the treatment of organic waste represents a strategic action in this framework, since it makes possible to return organic matter to the soil, improving its quality and protecting it. To achieve this goal, the indications summarized below provided by the Italy Towards Zero Organic Waste in Landfill strategy, promoted in 2016 by the Kyoto Club and the Foundation for Sustainable Development, could be adopted:

- ✓ Encourage the separate collection by ensuring that the waste is not mixed with other types of waste also making the users to be responsible for the sorting through the introduction of tariff systems and periodic communication campaigns.
- ✓ Allocate funding for the development of plant for composting and anaerobic digestion alongside other innovative solutions aimed at increasing the use of the organic fraction as a resource for obtaining new products and intermediates with high added value.
- ✓ Guarantee the high quality of the organic fraction by organizing monitoring and surveillance systems with respect to the use of compostable bags according to the law.
- ✓ Support agronomic practices or use of products in agriculture that allow to bring back organic carbon in the soil to restore its fertility.

2.4 About composting

The term composting is defined as biological degradation of waste under controlled aerobic conditions. The waste is decomposed into CO_2, water and the soil amendment or mulch. In addition, some carbon storage also occurs in the residual compost.

Three industrial composting techniques that are available to compost bio solids are windrow, aerated static pile, and in-vessel composting [17]. Each technique varies in procedures and equipment needs. Other variations between the technologies are issues such as air supply, temperature control, mixing, and the time required for composting.

Windrow composting is the production of compost by piling organic matter or biodegradable waste, such as animal manure and crop residues, in long rows (windrows). This method is suited to producing large volumes of compost. These rows are generally turned to improve porosity and oxygen content, mix in or remove moisture, and redistribute cooler and hotter portions of the pile. Windrow composting is a commonly used farm scale composting method.

Aerated Static Pile composting, refers to any of a number of systems used to biodegrade organic material without physical manipulation during primary composting. The blended admixture is usually placed on perforated piping, providing air circulation for controlled aeration. Keeping in mind the complexity and cost, aerated systems are most commonly used by larger, professionally managed composting facilities, although the technique may range from very small, simple systems to very large, capital intensive, industrial installations. Aerated static piles offer process control for rapid biodegradation, and work well for facilities processing wet materials and large volumes of feedstock. ASP facilities can be under roof or outdoor windrow composting operations, or totally enclosed in-vessel composting, sometimes referred to tunnel composting.

In-vessel composting is an industrial form of composting biodegradable waste that occurs in enclosed reactors. These generally consist of metal tanks or concrete bunkers in which air flow and temperature can be controlled, using the principles of a "bioreactor". Generally the air circulation is metered in via buried tubes that allow fresh air to be injected under pressure, with the exhaust being extracted through a biofilter, with temperature and moisture conditions monitored using probes in the mass to allow

maintenance of optimum aerobic decomposition conditions. This technique is generally used for municipal scale organic waste processing, including final treatment of sewage biosolids, to a safe stable state for reclamation as a soil amendment. In-vessel composting can also refer to aerated static pile composting with the addition of removable covers that enclose the piles. There have been other techniques and methodologies also small scale aerobic compositing such as.

Given the current situation in Fossalto and Ist island with regard to development and diffusion of composting as a technology of recycling at source , in the course of project several barriers have been identified. These barriers have been categorized as economic barriers and non-financial barriers. While economic barriers primarily include high cost and low scale of composting plants, the non-financial barriers are mostly those associated with the limitations of the current institutional structure, the current policy and regulatory framework and those associated with information and awareness with regard to composting. In the specific cases of the targeted territories, it is important to point out that Croatia did not develop any regulatory framework for any form of small scale composting. This implies that the activities which have been carried out in Ist island are not subject to any law, whether local or national, and are conducted under the full accountability of Zadar County under which the island is administrated. Based on the success of this initiative, Croatian authorities will decide whether it is opportune to convert this experience into a model associated to a regulatory framework to be extended to the whole country. In the case of Fossalto instead, the municipal administration can rely on a national law for small scale composting which contains all procedures for obtaining authorisations, fiscal benefits and obligations. The municipality is requested to present a plan of activities to the regional environmantal protection agency in compliance with the aforementioned national law to ask for an official opinion. After the issue of this opinion, activities can freely start. ENEA prepared for both local administrations of Zadar and Fossalto drafts of regulation models, local laws and procedures onto which a regulatory framework can be developed for Croatian authority from one side, and the guidelines for the municipal administration of Fossalto to obtain the opinion of the regional environmental protection agency from the other side.

2.5 Current status of organic management in the Netwap pilots

2.5.1 Organic waste management in Croatia

Eurostat source [5] reports a production of municipal waste in Croatia in 2018 equal to 1.768 Mt; bio-waste accounts for 600 thousands of tonne. In Croatia bio-waste separate collection is still to be fully developed. It is limited to a few areas of the country, overall involving 96 municipalities. Bio-waste composition consists of 75% of food waste, 23% garden waste and 2% of other origin [5], [1]-[18][27].

According to data concerning biowaste treatment which go back to 2015, 27 thousands tonne were directed in 2015 to composting and 5,6 thousands tonne to anaerobic digestion [1]-[27].

2.5.1.1 Target territory of Ist

Figure 3 - Panorama on Ist bay, Croatia

Ist is a tiny Island of just 9.73 km^2 surface and 182 residents, belonging to the Dalmatian Archipelagus before the coast of Zara to the administration of which is dependent. The number of people on summer increases up to 4000-4500. Biowaste separate collection does not exists and residents owning a garden backyard or poultry animals give them their kitchen waste. Tourists dispose of their biowaste into municipal mixed waste which accounts yearly around 65 t. Mixed waste is collected by a single employee of the county waste management company, which is named Čistoća, and transferred to the landfill of Diklo in homeland by ferry, twice a month on spring, autumn and winter and four times a week on summer. Waste collection costs 40.000 € which includes the salary of the person in charge of the services and the transportation costs by ferry. Each resident is charged with 10 € for collection and transport costs.

2.5.2 Organic waste management in Italy

According to the Italian Environmental Protection Agency [3], in Italy, around 9 Mt of Biowaste – out of 30 Mt of Municipal waste - has been generated in 2018, 7.3 Mt of which has been separately collected. This biowaste consists of food waste (67.7% and 4.9 Mt), garden waste (27.8% and 2 Mt), home composted waste (3.7%, 267 thousands of tonne) and market waste (0.8%, 60 thousands of tonne). The treatment capacity is based above all on composting and for a small fraction on anaerobic digestion. In fact, composting facilities are 281 with an overall capacity of 6 Mt and in 2019 treated 4 Mt of biowaste

separately collected; anaerobic digesters are 23 with an overall capacity of 1 Mt. In 2019 this option transformed just 328 thousands of tonne of biowaste separately collected.

As previously mentioned, no systematic work on the diffusion of home and community composting exists. However, we can cite some interesting experiences that have been some years ago investigated in partial work of literature ([18], [19]) and reported as a synthesis in Table 2.

Table 2 – Experiences of community composting in Italy

Municipality	Management company or institution	County town	Composter manufacturer	Origin of biowaste
Rosola	Gruppo Loccioni	Ancona (central Italy)	Joraform	Food waste from canteen
Capannori	Council	Lucca (central Italy)	Joraform	Food waste from canteen
Fenestelle (Praticanat)	Piemonte Region	Torino (Northern Italy)	Comar	Food waste from canteen
Villa San Giovanni in Tuscia	Council	Viterbo (Central italy)	Bighanna	Door-to-door separate collection
Cuccaro Vetere	Council	Salerno (Southern Italy)	Joraform	Citizens are free to drop off their own biowaste
Roma (*)	ENEA	Roma (Central Italy)	Bighanna	Food waste from canteen
San Antonio Susa	Council	Torino (Northern Italy)	Joraform	Food waste from canteen
Barone Canavese	Council	Torino (Northern Italy)	Joraform	Door-to-door separate collection

2.5.2.1 Target territory of Ist

Fossalto is a little hilltop village located at the foot of the mountain chain named “The Appenines” about 50 km far from Adriatic Sea. Fossalto belongs to Campobasso county in Molise region. The municipal territory extends 28 km^2 with a total population of 1258 inhabitants. Fossalto owns an historical center and rural district which is settled 2 km far from it.

Figure 4 - Panorama of Fossalto, Italy

The waste management is directly organised by the municipal administration and not through a municipal or private company. Biowaste separate collection is door-to-door organised; residents use single-use compostable bags which are distributed by shops to customers doing shopping. Compostable bags must possess a printed declaration of compliance to standard UNI EN 13432 which confirms their compostability. Biomass from wood cutting and prunings (EWC 200201) is not collected. The involved households in Fossalto historical centre are 187 with 401 residents and in the rural district are 57 with 140 residents. Then, the municipal separate collection of biowaste concerns only some households. The rest of households settled in the countryside use compostable waste partly as feed for pets and poultry animals partly as feed in a domestic composter. Various fractions are transported to the facility of Montagano (CB) in the locality of Colle Santo Ianni; the facility encompasses the following treatments for 60 municipalities in Molise: composting, mechanical and biological treatment (MBT), landfilling. The composting plant has an input capacity of 14.400 t/y with a biocell technology. The MBT has an input capacity of 55.000 t/y, while the Landfill 39.000 m3/y. Montagano facility is located 30 km far from Fossalto.

In 2019 according to the report of Arpa Molise, the regional environmental protection agency, Fossalto produced a total amount of 278.49 t of urban waste achieving a separate collection rate of 53%. The mixed waste fraction was equal to 128.84 t. Figures of year 2020 were communicated directly by the major of Fossalto. Both figures of years 2019 and 2020 are reported in Table 3.

Table 3 – Figures of waste production (t) and waste separate collection (t) in Fossalto in years 2019 and 2020

Year	Organic waste (EWC 200108)	Paper and cardboard (EWC 200101)	Glass (EWC 150107)	Mixed packaging (EWC 150106)	Mixed waste (EWC 200301)	Total collected waste	Separate collection rate (%)
2019	45.46	27.1	40.49	36.60	128.84	278.49	53
2020	43.14	17.7	43.68	43.54	133.8	281.86	52

By comparing data of Table 3, it is possible to draw that residual biowaste in mixed waste is around 40 t y^{-1}, almost as much as the total biowaste separately collected. This means that an initiative of recycling at source such as home and community composting can push forward the valorisation of biowaste and significantly reduce the residual fraction in mixed waste.

2.6 The challenge

In both targeted territories there is the need to reduce the residual biowaste in mixed municipal waste. In Ist the presence of tourists on summer season increases the number of inhabitants from the current 182 residents up to 4500; this in turn overcomes as double as much the municipal waste production in July and August where 46% of the yearly production is concentrated. Therefore the challenge consists of setting up an effective biowaste separate collection directed to tourists who visit the harbour, the four restaurants and three apartements of the island. If this model proves to be successful , small scale composting could be officially introduced in Croatia for all localities which experience the same difficulties with touristic pressure and waste management. In this case, it will be advisable to introduce a set of regulations with incentives for users (autocomposting and community composting) who accept this practice.

In the case of Fossalto, the challenge consists of:

1. Reducing the amount of residual biowaste in mixed municipal waste which is estimated as much as the amount separately collected;
2. Cancelling the transportation of biowaste 30 km far from Fossalto to the local composting facility.

2.7 Measures to achieve optimum results

Pilot actions in both territories consisted of installing an electromechanical composter performing an input capacity of 30 t y^{-1}. This composter is managed through a local composting scheme as previously

described (paragraph 1.2.1). ENEA prepared drafts of regulations (reported in Deliverable 3.4.1) containing obligations and benefits for citizens involved in any of the three schemes of small scale composting (autocomposting, community composting and local composting). In the case of Fossalto, local composting is enacted by the municipalty admnistration, which has voted and issued a regulation on the basis of the mentioned draft, while in the case of Ist, by Cistoca, the local waste management company. In order to fully treat the biowaste totally produced in Fossalto (about 45 t y^{-1} coming from the separate collection and 40 t y^{-1} to be found in the residual municipal waste), two more electromechanical composters of the same input capacity of 30 t y^{-1} will be necessary. In the future, it is foreseen to enforce the local composting by adding the autocomposting for households; however it is important to keep in mind that 100 people which corresponds to 25 households of 4 members each, can treat with a domestic composter 4 t y^{-1} of biowaste.

A useful indicator to monitor the succesful impact of the electromechanical composter consists of measuring the organic fraction in the waste composition of municipal mixed waste. This purpose can be achieved in Ist Island by introducing a biowaste separate collection coupled with the putting into operation of the electromechanical composter. The biowaste separate collection should be above all addressed to tourists which will be informed by all touristic operators and providers of catering services.

In Fossalto the challange can be addressed by improving the biowaste separate collection. In future it is advisable that citizens will be allowed to drop autonomously their biowaste every time they need to the composter. In this way, the municipality will be able hopefully to lower the burden of separate collection costs .

3. Plastic waste management

Reducing waste overall is important, but particular resources and materials deserve extra attention, including plastics and packaging. Plastic litter is one of the most insidious forms of pollution. Around 80% of marine litter is plastic. It is estimated that by 2050, there will be more plastic in the ocean than fish by weight. We need to act now to identify and stop using the plastics that we can't manage effectively. The sound management of chemicals and hazardous wastes throughout their lifecycle is also intrinsic to this approach, to minimise the materials that could harm us and the environment.

3.1 European context and relevant future targets

According to Eurostat [5] world plastic production has reached over 368 Mt/year in 2019; about half of it is used only once and recycling is less than 5 %. In Europe the packaging sector generate the largest

production (The majority are disposable products and they become waste within a year after distribution on the market or after a single use.

In Europe, the recycling rate of waste plastics reached 31% for the first time in 2016, overcoming the disposal into landfill (27%). However, it is important to highlight that only a part of the collected plastics are reintroduced into the market. Polymers with an established recycling market are few and composed by polyethylene (PE), polypropylene (PP) and polyethylene terephthalate (PET) among packaging and polymethyl methacrylate (PMMA) among electrical and electronic waste (WEEE).

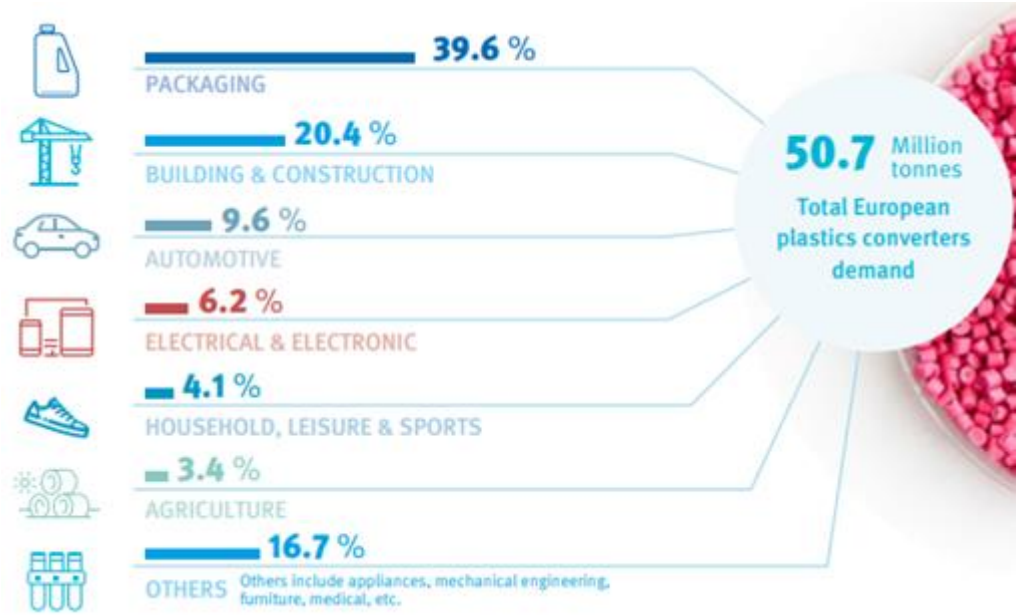


Figure 5 - Distribution of the plastics market by sectors. Source: Plastics – The Facts 2020 [21].28

3.2 Existing policy and regulations

The number of regulations and legislation focused on plastic use and disposal has risen sharply, impacting companies across the value chain and driving change upstream and downstream. Only policies and regulations that have a direct impact on the plastic value chain, in terms of reducing production and consumption and for better waste management, are considered in this section. Other related regulations, such as on food safety contact and hazardous chemical use (REACH, the EU's Registration, Evaluation, Authorisation and Restriction of Chemicals) are not included.

INTERNATIONAL LEVEL

Plastic is covered under various international fora. The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (in this report covered in the section on disposal) now considers the trade of plastic waste. Within the Sustainable Development Goals, plastic falls under SDG 12, to: "Ensure sustainable consumption and production patterns". Certain targets within this goal also align with the circular economy model, to: "Substantially reduce waste generation through prevention, reduction, recycling and reuse"4 by 2030. The Paris Climate Agreement is also relevant given its target to limit the increase in global temperature to 1.5 degrees.

As the previous paragraph has shown, the packaging sector accounts for the greatest producer of waste plastics (like other packaging wastes) because this type of disposable items last a very short time period in comparison with other durable goods. In order to introduce a virtuous circle, a Directive on Packaging and Packaging Waste was for the first time issued in 1994 (94/62/EC) introducing the Extended Producer Responsibility (EPR) principle, imposing recycling and recovery obligations to the producers of packaging and of packaged products. In this framework the Packaging Recovery Organisation Europe established the Green Dot symbol under which every European Member State created a compliance scheme which collects the financial contributions of all stakeholders involved in the production and retail of plastic packages. According to the compliance scheme adopted in most European countries among which France, Italy and Spain, this financial contribution cover the costs of collection and recycling management of waste packaging plastics. Therefore, plastics stakeholders pay the municipal waste management company which has the task to organise and carry out the waste separate collection. Collected waste plastics is delivered to packaging plastics stakeholder joined together under a single consortium which establishes waste selection and recycling facilities. In Germany, producers and retailers are obliged to setting up the scheme of collection and recycling themselves, without the intermediation of local municipal companies. The last version of the Packaging and Packaging Waste directive, known as (EU) 2019/852 [22] and bound to the Package on Circular Economy, set recycling targets of 50% by 2025 and 55% by 2030, together with a new calculation method of recycling performances. This new method started to be applicable for data of the year 2020. Intact until now, Member States were allowed to calculate in 4 different ways recycling rate, all based on input waste streams which overestimated the results. The new methodology imposes to take into account waste treatment outputs from material recovery facilities. The output of any sorting operation can be counted as recycled when it is sent to a final recycling process and when the waste streams for disposal or incineration remain below 10%. An average loss rate "is subtracted from the separate collected fractions. It differs from type of waste and treatment process. All 3 to 4 years a new average loss rate" will be estimated.

In addition to the legislation of waste management directed to plastics, in 2019 a new directive of single use plastics was issued (EU 2019/904) [23] which imposes limits and prohibitions to the commercialisation of single plastic disposal items, in order to reduce the effect of waste plastics into the environment. Some single use items will not be allowed to be sold such as: cotton bud sticks, cutlery, plates, straws, stirrers, balloon sticks and polystyrene drink and food vessels. Moreover, plastic bottle of capacity up to 3 litres should have a recyclable content of 25% by 2025; a recycling rate (calculated with respect to the quantity put on the market) of 77% by 2025 and 90% by 2029 for plastic bottles must be achieved. In order to obtain this result, compliance scheme specific for Plastic bottles collection according to the EPR Principle are allowed to be set up.

Finally the European Directive 2015/720/EU [26] about the reduction of single use plastic bags was anticipated in 2012 and implemented by the Italian Legislation which established a complete replacement of plastic shopping bags with compostable single use plastic bags complying with the European technical standard EN 13432 since the 1st of January 2018.

CIRCULAR ECONOMY LEVEL

Society needs to move away from the current linear “take, make and dispose” approach to producing and consuming plastic to one where materials are used, and their value maintained, for as long as possible – a circular economy. In 2019, the EU Technical Expert Group on Sustainable Finance released a classification system, the Taxonomy,6 for environmentally-sustainable economic activities. The Taxonomy presents technical screening criteria for climate change mitigation objectives, adaptation objectives and “do no significant harm” to other environmental objectives in the legislative proposal. Relating directly to plastic, one of the environmental objectives is labelled as “transition to a circular economy, waste prevention and recycling”. This objective is currently only considered under “do no significant harm” by the mitigation and adaptation objectives. The EU also has an Action Plan for the Circular Economy, launched in 2015,7 which considers product life cycles and encourages partnerships and collaboration across the value chain and sectors. Most member states have since developed their own national strategies, which have been adopted or are due to be implemented in line with the action plan. Regulatory actions include revised European legislation for waste management, adopted in 2018. These legislative changes set plastic recycling targets at 50 percent of plastic waste by 2025 and outline the minimum requirements of Extended Producer Responsibility (EPR) schemes. Plastic is also one of five priority sectors that led to the EU Strategy for Plastics in a Circular Economy, which aims to transform how plastics and plastic products are designed, produced, used and recycled. Among its targets is that all plastic packaging should be reusable or recyclable by 2030.

3.3 About plastic recycling

Demand of recycled plastics is strongly related to the properties of materials, closely dependent on the price of oil which influences the cost of the raw material. In Europe, during 2014, about 13% of the total volume of packaging plastics allocated to recycling (44%), entered the European market, while 30% were exported with no information about its final destination.

Nowadays, the recent ban of 2017 on the plastic waste import by the Chinese government has deeply affected the recycling market, especially for those fractions with a low quality and an unstable market such as polypropylene (PP), plastic films, polyolefin blends for packaging or acrylonitrile butadiene styrene (ABS) and styrenic polymers from WEEE. As a consequence, in 2017, the price of small films in Italy collapsed to the symbolic price of 2 €/ton.

At the same time, saturation of incineration plants is causing a worrying and increasing storage of plastic waste into unauthorised deposit. In Italy, for example, there has been an emergency due to more than 300 fires in 2017-2018 of these saturated plastic deposits. Due to the lack of available land and the high cost for the society, landfill is an unsustainable solution. So, it is mandatory to focus on the suitable and complementary alternative to traditional recycling methods.

3.4 Current status of plastic management in the Netwap pilots

Information on how Waste plastic management is carried out in both countries Croatia and Italy has been drawn by investigating the following sources:

- For Croatia ([24],[25]) :
  1. Decision on the adoption of the Waste management plan of the Republic of Croatia for the period 2017-2022 (OG No. 3/17) available at the website: https://www.mzoip.hr/en/waste/strategies-plans-and-programmes.html
  2. Waste management in Croatia: Factsheet, available at the website: http://ec.europa.eu/environment/waste/framework/pdf/facsheets%20and%20roadmaps/Factsheet_Croatia.pdf[27]
  3. Answers provided by Čistoća to a questionnaire prepared by ENEA (mr. Lorenzo Cafiero) and DRIOPE (Mr. Vanja Lipovac)

- For Italy:
  1. The Municipal Waste Report concerning the waste management at national level published by ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale. The Italian Institute for Environmental Protection and Research) in 2020 [28].

2. Answers provided by Saverio Nonno, major of Fossalto Council to a questionnaire prepared by ENEA (Mr. Lorenzo Cafiero) and GAL Molise (Ms. Giuseppina De Castro)

3.4.1 Plastic waste management in Croatia

Over a population of slightly more than 4 million inhabitants, the plastic waste production amounts to arount 350 thousands of tonnes. According to the Croatian Factsheet, municipalities (in legal terms, usually referred to as 'local selfgovernment units', hereinafter LSGUs) are responsible for waste collection. Waste management in Croatia applies an Extended Responsibility Producer (ERP) scheme which involves among various packaging materials, plastic packaging; other plastic durable objects are excluded from the separate waste collection. This is also confirmed by Čistoća (The company responsible for waste management in Zadar County). Waste collection is physically performed by companies owned by the Municipalities. These companies are competent to set fees for their services, and also collect them. Fees are usually dependent on the size of waste containers and the frequency of their collection. € 7 per month for a household is a typical fee level for collection and management of municipal waste. A very efficient refund scheme concerning PET beverage containers exists since 2006. It applies for volumes > 0.2 l and amounts to 0.5 kuna (= ca. €0.07). A return rate of bottles is given as 94%, with more than 70% of the returned bottles being PET.
In table a list of "environmental contribution fees" established for each waste category in the framework of Extended Responsibility Producer (ERP) schemes is reported.

Table 4 - Environmental contribution fees payed by the consumer for each category originating from packaging waste and belonging to ERP schemes (€ t^{-1}) (Source: Croatian Factsheet [20])

Material		Charge per t (ca.)
PET		€ 54
Aluminium cans		€ 54
Iron cans		€ 30
Paper, cardboard		€ 50
Multi-layered packaging with dominant paper/cardboard component	For beverages:	€ 54
	For other purposes:	€ 99
Plastic bags		€ 198
Wood		€ 20
Textile		€ 20
Other polymer materials		€ 99
Glass		€ 20

3.4.2 Plastic waste management in Italy

The separate collection of waste plastics in Italy concerns the packaging sector for which official data are provided by the Italian National Agency of Environment Protection. A quantity of 1.5 Mt of waste packaging plastics were collected in 2019 following an increasing trend of 3-7% since 2015; in the only case of 2019 we saw an exceptional increase from 2018 to 2019 of 12.5%. The quantity of packaging plastics put on the market accounts for 2.4 Mt in 2019 with a slight increase of 23000 t in comparison to the previous year. Data are provided by Packaging Plastics Consortia established according the EPR principle: COREPLA for packaging plastics in general, CORIPET for PET bottles, CONIP for food and pallets containers. Recycling of plastics is awkward for a number of reasons, at the top of which is the consideration that plastics can be successfully recycled only if they are made up of the same polymer. Plastic items in the largely diffused kerbside collection are combined with other different materials in order to keep costs down and this leads to contaminations and difficulties of separation in the selection facilities. In conclusion, separately collected plastics is 50% destined to recycling and 50% to energy recovery. Most recent data say that in 2019, 1.05 Mt were recycled and 1.03 energy recovered.

3.4.3 Marine Litter

Monitoring programme, carried out for the implementation of the Marine Strategy, revealed distribution and quantity of marine litter on the sea surface, seabed and beaches. Preliminary data[1] suggest that waste distribution is not yet completely exhaustive but it can be roughly estimated as follow [29]:

- 3-600 items per 100 m of beach;
- 1-1,000 items per km^2 of floating waste (depending on the distance from river mouths);
- <1,000 per km^2 on the seabed;
- 90-200,000/km^2 of microplastics (and their transfer to the food chain, is still not homogeneous).

The amount of waste potentially present in the areas of interest is reported by the European Commission's Decision 2017/848/EU.

[1] Data of Italian Institute for Environmental Protection and Research (ISPRA) submitted to the European Commission under the Marine Strategy framework activities such as EU project DEFISHGEAR, MEDSEALITTER; ML-REPAIR, INDICIT

It is well known that micro-plastics are capable of transporting and spreading different kinds of pollutants with them. Recently, research projects carried out by National Research Council (CNR) and *Legambiente* association characterised the bacterial colonies that populate the biofilm attached to micro-plastics. A correlation was highlighted between the state of degradation of polymers and the bacterial population.

3.5 The challenge

Environmental protection in seaside resorts cannot be separated from sustainable land management. Particular attention must be paid to the sustainable development and to the reconciliation of fishing, tourism and the environmental conservation. This need takes on a specific meaning in the case of the smaller islands and villages on the coastside. Here the ecosystems are fragile and can be altered by significant seasonal tourist flows.

With this contribution we want to offer a simple, flexible and shareable tool for stakeholders in order to promote good practices aimed at preventing waste production. The objective of the present methodology is the implementation and adoption of a best practice focused on prevention of urban waste production. Marine litter is increased during Anthropocene. As a consequence, beach cleaning is becoming an emerging issue on environmental management because mixing of different material can increase waste production and loss of natural resources (sand and vegetal biomasses in particular).

With the present methodology we have implemented a simple procedure to coordinate manual cleaning operation by both volunteers and municipal company responsible for the local waste management, in order to allow recycling of waste collected on beaches and coastal areas. A great deal of this waste consists of plastics; in particular, plastic nets used by aquaculture are an emerging and increasing component. Unfortunately, these plastics, being collected in the beaches, are classified with an EWC (European Waste

Catalogue) 20.03.03 of “cleaning street residues” and as such, they are landfilled without any possibility of recovery.

The activities introduced by the NETWAP project provide fundamental elements for the resolution of recurrent problems in coastal areas, increasingly afflicted by the emergency of marine litter. The growing problem of marine litter has exacerbated the impact on local communities and the environment on a global scale and, in particular, in the Mediterranean Sea. The increasing number of wastes washed ashore during storm surges or near the mouths of rivers, favours the spread of bad management practices, such as mixing and disposal.

The main purpose is to provide highly replicable case studies, so as to provide Public Administrations, in particular those of small islands and coastal areas, with experiences, technical and scientific knowledge, indications but also, hopefully, practical and effective tools for the management and resolution of common problems.

ENEA's experience, accumulated over the last decades, starting from the local scale to the national one, has allowed to reach the definition of models and systems for analysis. In this way it is possible to implement remediation and policy interventions at central and regional level. The holistic and systemic approach adopted in the interventions on the territory allows to define, plan and implement territorial projects based on criteria of environmental and economic sustainability, also in order to develop strategies to support tourism that, alone, contributes to more than 10 % of the national GDP.

3.6 Measures to achieve optimum results

1) In order to separate different types of plastics and, therefore, increase the separate collection of plastics in beached waste, the collection of waste from coastal areas should be carried out manually. Therefore, it is suggested to collect 3 categories of materials:
   a) Nets used for mussel farming may be mechanically recycled according to the experimental treatment specifications outlined in the chapter “Mechanical recycling of mussels net”, reported in Deliverable 5.1.4; this category has an EWC 20 01 39 code;
   b) Other plastics, usually mixed and deteriorated, cannot be mechanically recycled, but must be treated according to the schematic description in the chapter "Chemical recycling of plastic marine litter" reported in Deliverable 5.1.4); for their management also this category has an EWC 20 01 39 code;

c) The remaining material will be classified as "residues from street and beach cleaning" with EWC code 20 03 03

2) Complementary services can include selective waste collection along the coast. Coordination of periodic cleaning actions operated by volunteers, associations and the services provided by local authorities that periodically collect and transport waste should be promoted. All events that involve volunteers should also include and promote the value of informal and non-formal education which can be implemented through these events.
3) During the cleaning events, volunteers and workers can drop off the material to "green islands" specifically distributed along the beach during the summer months (Figure 6), in order to avoid problems of EWC code attribution to the collected waste. Alternatively, operators can deliver the collected material to the nearest collection point or beach resort. Both the options described above could increase the percentage of separate/recycling collection of non-domestic users.
4) Volunteers should be trained to collect the different fractions of waste and separate them. If necessary, they may perform some preparation work such as washing or separation from the sand. Sediments must not be removed from the beach.
5) All sandy material and vegetable biomasses that should be recovered during the treatment must be separated, preserved and they are a common asset owned by the community and not by the management body of the treatment plant. Therefore, at the end of the process, they must be returned to the beaches with no cost for the public administration and without additional income for the owner of the treatment plant.

The following actions have been carried out during the NETWAP Project:

- ✓ ENEA implemented a beach cleaning procedure.
- ✓ The draft of proposal has been shared with all partners of NETWAP Project in order to be reviewed and discussed with possible common implementations.
- ✓ Guidelines for beached marine litter have been implemented and approved among all project partners and stakeholders involved in the project. An example of good practices, useful for the prevention of waste production in the coastal marine environment, has been disseminated through presentation and webinar of 27th May 2021.

Specific details regarding the NETWAP project actions/results are presented in the Deliverable 5.1.4.

Figure 6 - Bins of "green islands" or “recycling banks” on the beach

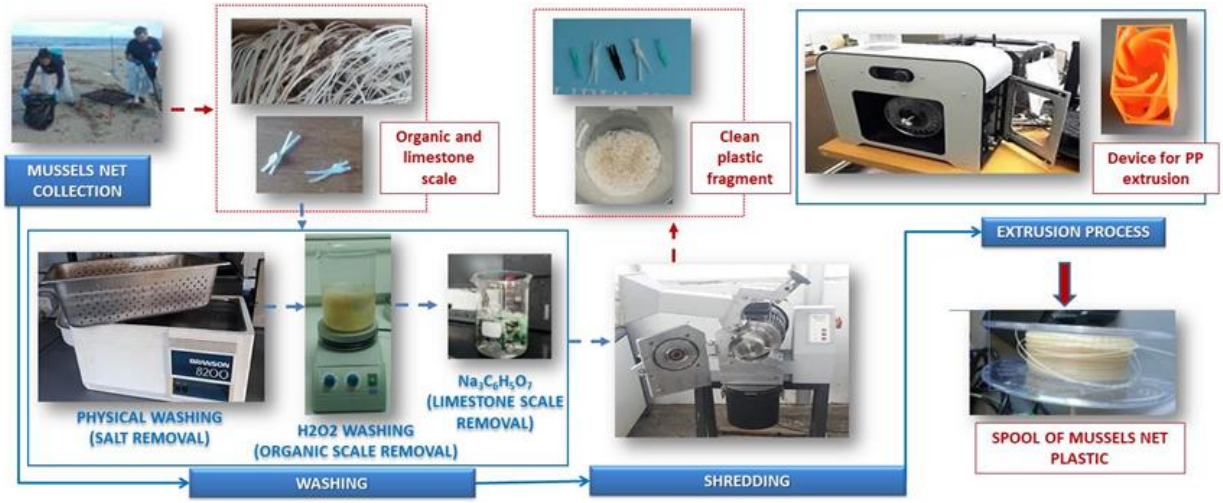
3.7 Concluding remarks

Many concluding remarks can be made on the basis of the procedure implemented within the framework of NETWAP project. Most of them are reported as follow:

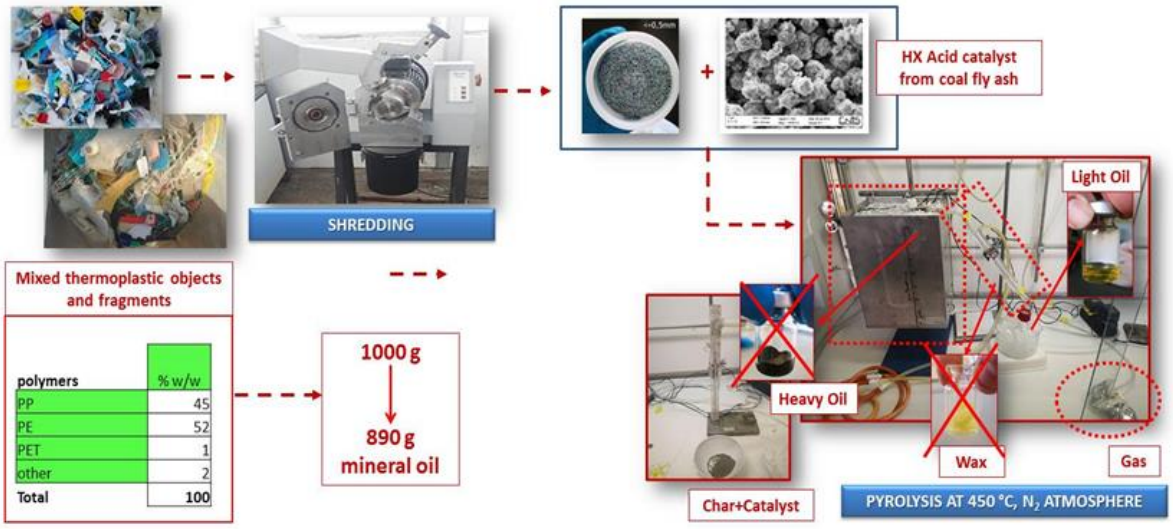
- ✓ The cleaning of coastal areas could be affected by actions of separate waste collection in analogy to the separate collection applied to domestic and non-domestic users;
- ✓ Two different kinds of plastics should be collected during beach cleaning and their treatment should follow the processing chain described in BOX 1 (Mechanical recycling: collection, washing, extrusion tests of mussels net) and BOX 2 (Chemical recycling: mineral oil from the heterogeneous and deteriorated plastic fraction) of the present report;
- ✓ Management of beached vegetal biomasses should be rapidly adopted by European countries according to the model of ecological beaches described in BOX 3 (ecological beach model);
- ✓ Extra cost of these waste separation services should be covered by contribution of the central governments or subtracted from the burden of state concessions;
- ✓ Tax credits, reduction of the state fee, rewards in the scores of tenders or environmental certification (such as blue flag), or non-refundable other incentives should be foreseen for those operators who separate the waste collected along the coast and manage the beached vegetable biomass instead of disposing them;

- ✓ To promote an ecological transition across Europe, specific regulatory action should be implemented and rapidly adopted by EU countries in order to reduce marine litter and waste production derived from beach cleaning operation.

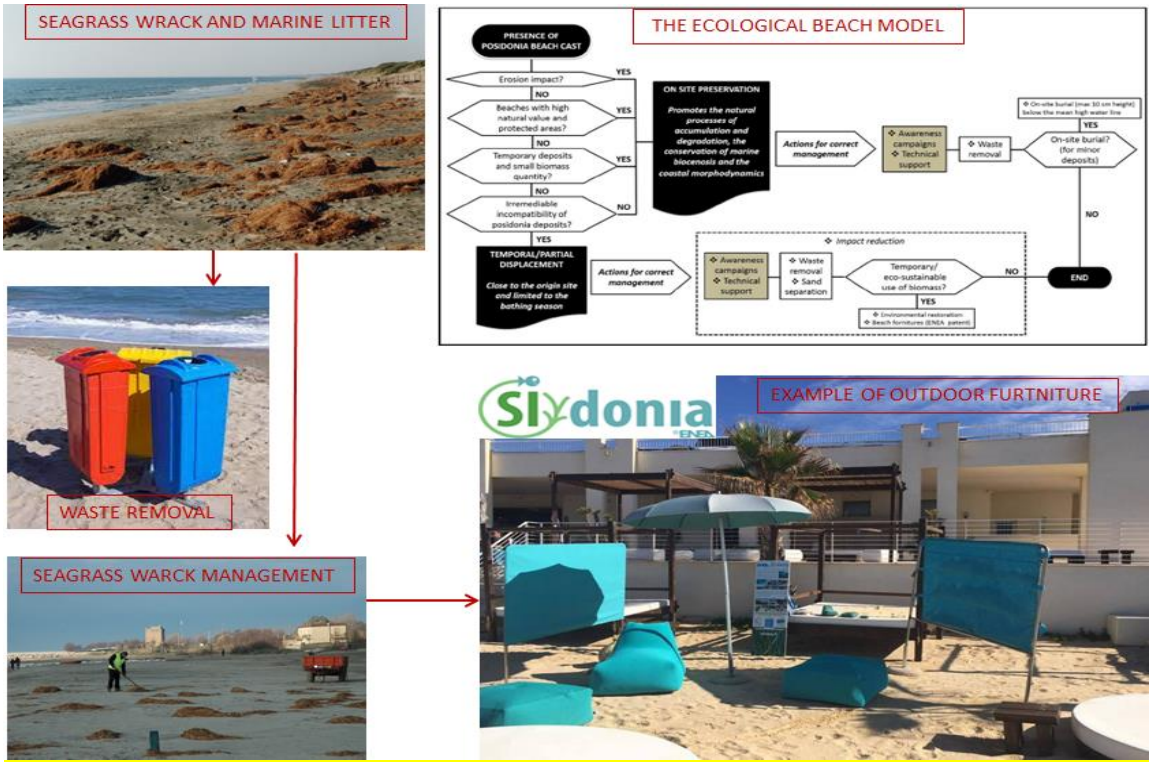
BOX 1: BOX FOR MECHANICAL RECYCLING: COLLECTION, WASHING, EXTRUSION TESTS OF MUSSELS NET



BOX 2: BOX FOR CHEMICAL RECYCLING: MINERAL OIL FROM THE HETEROGENEOUS AND DETERORATED PLASTIC FRACTION



BOX 3: BOX FOR MANAGEMENT OF VEGETAL BIOMASSES AND ECOLOGICAL BEACH MODEL



4. Taking Action

Everyone has a role to play to reduce of the residual biowaste in municipal mixed waste and the plastics from beach and marine litter.

In this document the following overarching strategic actions have been identified: each of these strategic action is briefly discussed together with Čistoća, Ruder Boskovich Institute, ENEA and Gal Molise Verso il 2000

Priority Action 1: introduce schemes of small scale composting (autocomposting, community composting and local composting) at local level as a form of recycling at source for biowaste.

Priority Action 2: involve households, touristic activities and free associations of citizens to participate in the management of the small scale composting, changing the perception of organic matter from waste into a resource.

Priority Action 3: build a regulatory framework at local level which recognizes the committment of the aforementioned subjects through fiscal benefits and the promotion of a participative model.

Priority Action 4: introduce a collection of waste plastics from marine litter by involving volunteers, citizens associations, public services of waste collection.

Priority Action 5: attribute an European Waste Code to waste plastics collected from beach litter in order to avoid the disposal into landfill.

Priority Action 6: promote recycling technologies which are able to valorise plastics from mussels nets (one of the most spread and typical waste plastics in adriatic coasts) and mixed deteriorated thermoplastics from beach litter.

Figure 7 - Strategic Action

5. Summary of Actions

Čistoća, Ruder Boskovich Institute, ENEA and Gal Molise Verso il 2000will work with stakeholders and other interested parties in the development and implementation of the following actions.

Table 5 – Summary of actions

Actions	Accomplishment date
1.Introduce schemes of small scale composting at local level as a form of recycling at source for biowaste	
• Provide support to develop distributed infrastructure solutions (composting) to process biowaste	
•	
•	
2. Involve stakeholders to participate in the management of the small scale composting	
• Provide effective and efficient municipal waste collection service	
•	
•	
3. Build a regulatory framework at local level	
•	
•	
•	
•	
4.Introduce a collection of waste plastics from marine litter	
• Coordinate community campaigns to reduce and clean up waste on our coastlines	
• Implement measures to reduce ship-sourced waste in accordance with the XXX	
•	
5.Attribute an European Waste Code to waste plastics collected from beach litter in order to avoid the disposal into landfill	

• Develop a national plastics plan to increase recycling rates and reduce plastic pollution	
• Identify problematic and unnecessary plastic packaging to provide an evidence base for industry to take coordinated action	
•	
6.Promote recycling technologies	
•	
•	
•	

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