Neighbourhood composting systems in Fossalto (Italy) and Ist Island (Croatia)

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1 The pilot action concerning the small scale composting

Most recent European policies require a sustainable and integrated management of energy and, water and material resources. Waste should not be considered like something to be ridden off but like a resource from which one can recover materials and energy, and where landfilling concerns the residual waste fraction from recycling according to an economical and sustainable way.

National action is required by all levels of government, businesses and communities to reduce biowaste and improve how we collect and treat it 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 (WFD) 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

A small scale composting action like that one that is described in this deliverable is considered as “recycling at source” and as such allows to achieve the first target of EU WFD.

1.1 The electromechanical composter

The electromechanical composter for both targeted territories of Fossalto and Ist is delivered by the company DIZIOINOXA SR, registered and operational office: Via Maiella, 73 65010 Spoltore (PESCARA) VAT: 01576920688 TEL: ++39.085.497521 web www.dizioinoxa.it. The model is EcoKompos.T30.30GG and has an input capacity of 30 t y^{-1}. This capacity should completely cover the needs of biowaste production in Ist, where mixed municipal waste in 2019 accounted for 68 t.

Technical data of the composter are reported in Table 1

Table 1. – Technical data of the electromechanical EcoKompos.T30

Volumetric capacity	m^3	**3.75**
Diameter	mm	**1050**
Wideness x height	mm	**1300x2000 ca.**
Length	mm	**4500**

Total length	mm	**5000 ca.**
Residence time	giorni	**30 ca.**
Electrical power for mechanical components which allow the turning of biowaste	kW	**1,1**
Weight	kg	**2000 ca. +/- 5%**
Input capacity	t/anno	**25,5 biowaste + 4,bulky agent= 30 ca.**
Biofilter		**yes**
Maximum electrical power, 3Ph+N+T	kW	**6**
Voltage /frequency		**380 V / 50 Hz**

1.2 The geographical location in Ist

The pilot experience is carried out in the Dalmatian island of Ist, in the center-northern area of the archipelago, as one can see from **Figure1**

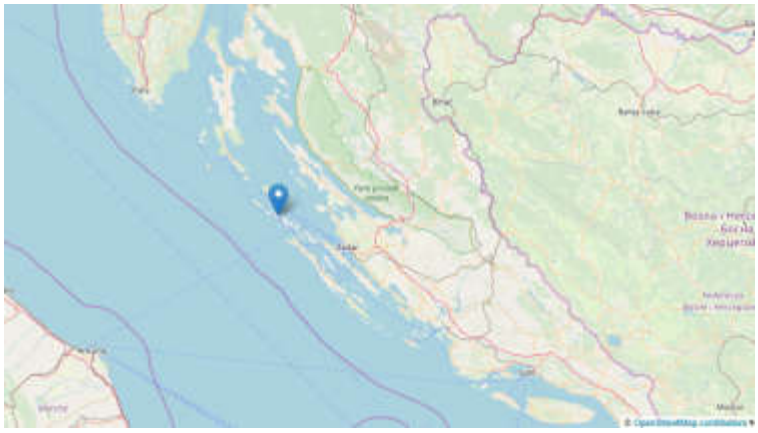

Figure1 – Position of Ist island in the Dalmatian archipelago

The island has barely 182 residents but its population does sensitively increase on summer up to 4.500 because of the presence of tourists. Figure 2 shows a satellite image of the Island where the residential area is highlighted.

Figure 2 – A satellite image of Ist Island where the residential area is shown.

From the resident area the composter is placed around 20 minutes by foot uphill. The road is a bit rocky but clear, and overall it's not a location suitable for everyday casual walks to dispose of waste. Instead, an employee of the Waste Management Company of by ČISTOĆA uses a tractor with a carriage to get there.

After the road, a former military complex is placed, with a good overview of the island and the composter is placed here for several reasons: firstly, further investment was planned at this locality, specifically regarding the electricity. Secondly, it has buildings where material and equipment can be placed and secured. Finally, it's a wide location approachable for trucks to enter, pick up waste and manoeuvre easily around the location. The composter itself is placed in a tiny hangar as mentioned, can be easily approached with a tractor, has a clearing in front to place any residuals or anything else. The location of the composter on the map (Figure 2) is marked as #2.

In the future, waste management on island is planned to be placed to a more suitable location, closer to the port entrance and the residential area (about ~5 minutes walk from the center of resident area).

Waiting for the realisations of electrical net, the composter is powered by a mobile diesel generator of 10 kW electrical power.

Figure 3. – The electromechanical composter installed under a roof in Ist Island

1.2.1 The management of the composter

In Ist the electromechanical composter is directly managed by the ČISTOĆA, the waste management company with site in Zadar. A trained employee is responsible for the biowaste separate collection and the management of the composter (daily loadings, organic output withdrawals, stockpile preparation for the curing phase, data recording). This person is trained by Dizio Inoxa company.

As in Croatia., the small scale composting is not regulated by any national nor local law, this activity has a mere experimental appearance. If it is possible to make a comparison with the situation in Italy, the adopted scheme resembles the local or municipal composting where the municipal administration of Zadar through the action of its waste management company of ČISTOĆA, directly manages the composter.

1.3 The geographical location in Fossalto

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 a 2 km rural district named “Sant’Agnese”. Young people with an age less than 20 years amounts to 155 and the average age of the population is 50 years old (source Italian National Institute of Statistics, 2020

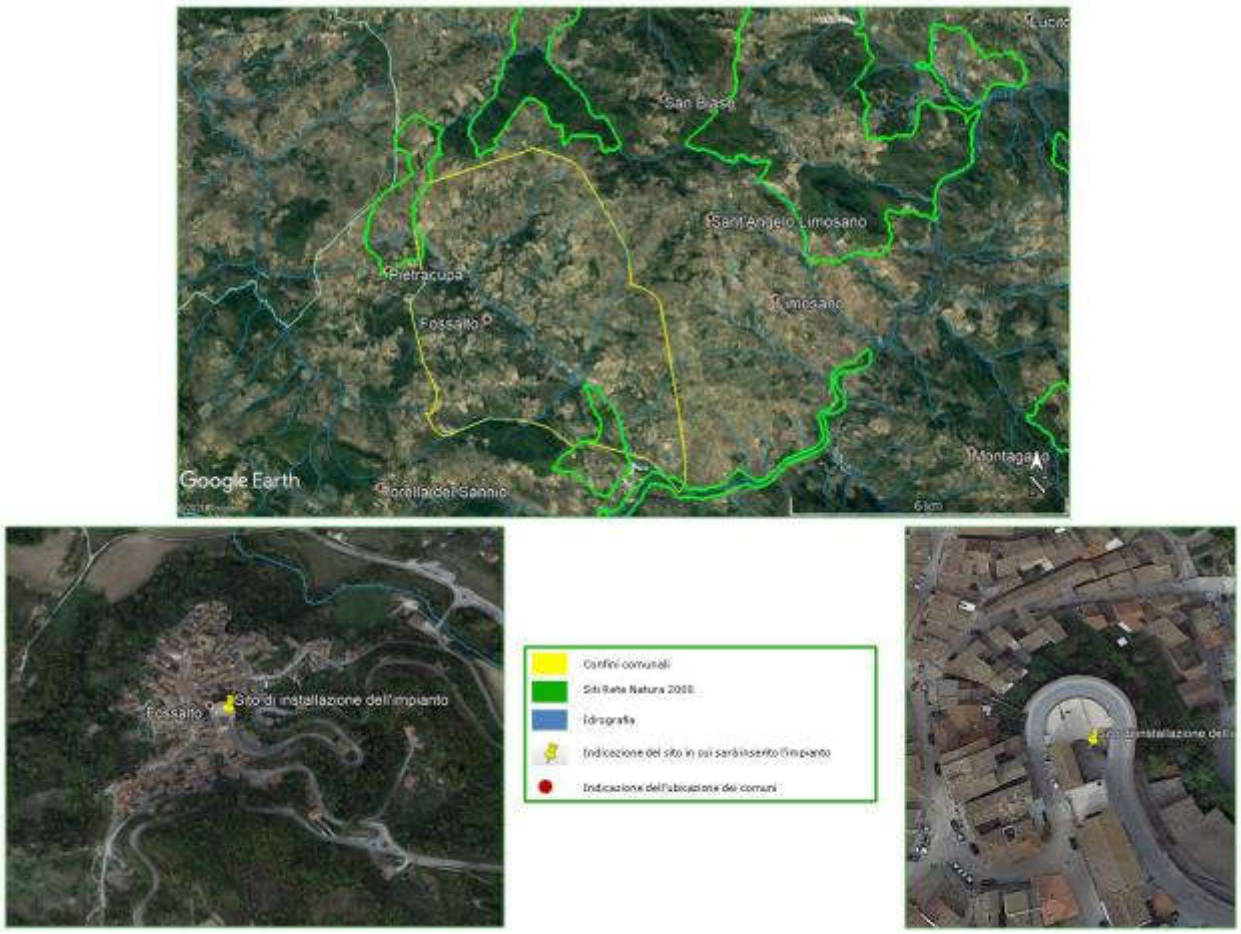

Figure 4. – satellite map of the village of Fossalto with the location of the composter

The electromechanical composter has been installed in a deposit/garage directly managed by the municipal administration.

A picture of the composter inside the garage is reported in Figure 5.

Figure 5. The electromechanical composter installed inside the municipal garage of Fossalto

The electromechanical is provided with the following added characteristics:

- Exhausted air from the composter after being treated by a biofilter can be released into a public sewer through a siphon in order to avoid any undesired odour;
- The filled package of biofilter has been reinforced with active carbon and peat;
- Gaseous emissions and temperature.are monitored by a system of electronic sensors set up for this aim

Liquid effluent to be released in sewer is less than 10 L/month

1.3.1 The management of the composter

In Fossalto the electromechanical composter is directly managed by the technical office for the environmental protection department of the municipal administration. A trained employee is responsible for the biowaste separate collection and the management of the composter (daily loadings, organic output withdrawals, stockpile preparation for the curing phase, data recording). This person is trained by Dizio Inoxa company. Therefore, the small scale composting scheme adopted in Fossalto is the local or municipal composting according to the definition of Art. 183 of D. Lgs.152/2006 (legislative decree of Italian National law) and is authorized according to point 7.bis of art. 214 of the same decree. The municipality communicated the starting of this activity to the environmental protection agency of Molise Region which issued a favorable opinion on 23rd of June 2021.

2 Technical specifications for the Electromechanical Composter

2.1 The compost

The compost (from latin *compositus* "*composto*", "*variegato*") is the result of bio oxidation and humification of a mixture of organic matter (yiard prunings, leaves, kitchen waste) by the action of macro and micro organisms under particular conditions: oxygen content and equilibrium among chemical elements of matter involved in the transformation.

Composting or biostabilisation is a biological aerobic process under human control which leads to the production of humic substances (the compost) from organic residues by means of fungi and bacteria. In order to lower the moisture content in the organic mass and to maintain a correct carbon to nitrogen ratio a wooden fraction is added to kitchen waste (tipically 10% wt.) assuming the role of bulking agent.

The bulking agent usually consists of prunings or wooden pellets (this product is the same as that one used as fuel in a domestic heater).

The compost can be used as soil improver for agronomic uses, floriculture or garden maintenance.

As soil improver, the compost enhance the soil structure diminishing the need of water and the availability of nutrients (phosphorous and nitrogen compounds). The compost contributes to carbon sequestration in soil and therefore it helps to contrast climate change.

Composting takes place in two stages:

- A bio-oxidation consisting in the activation of hydrolysis of organic substances and consequently in a temperature increase. If it is carried out by a reactor under controlled conditions, this phase lasts from two to four weeks.
- A curing stage carried out by aerated stockpiling where the less degradable fraction is being

concentrated and subsequently humified. This phase lasts 2-3 months and at the end of which temperature approximates ambient conditions.

Considering a mass balance, the compost equals 30% wt. the input organic fraction at the beginning of the process. The remaining mass consists of CO_2 and H_2O in gaseous form released in atmosphere.

2.2 Small scale composting

Small scale composting is regulated in Italy by the National Law 28 December 2015, n 221 through the artt. 37 and 38.

2.2.1 Local/proximity/collective composting

According to art. 37

"*.. aerobic composting facilities which treat biodegradable waste whether from agri- and floriculture or kitchen, canteen, fruit and vegetable market, garden or parks, having an input capacity lower than 80 t* y^{-1} *and are exclusively conceived for treatment of waste collected in the territory of the municipality where this waste is generated and in the territories of neighbouring municipalities which signed a special partnership agreement for the common service management, asking the Regional Environment Protection Agency for its opinion, after writing a ruler procedure which envisage the appointment of a facility manager, can be realised and put into operation and notification of activity beginning...*"

In the local composting the use of the produced compost by the deliverers is not required. Therefore, the compost can be given to other users but it must comply with the law foreseen for the fertilisers (L. 75/2010).

2.2.2 Autocomposting

Art. 38 regulates the autocomposting. This practice consists of compost production from one's own organic residues. As this article does not use the term "waste" but "residue", this practice is not considered as a waste treatment option. There are no limits to the quantities of transformed organic residues, provided that they are consistent with the production capacity of the owner. In this case the produced compost must be used by the user himself and cannot be handed over to external subjects. No authorisation is required but a simple communication to the municipality. This practice is allowed to single users like: any touristic infrastructure (hotel, touristic village, camping,…) canteen, schools, institutes, markets. The produced

compost might not be considered like a soil improver according to the prescriptions of the law for the fertilisers (L. 75/2010). Autocomposting for agri- or floriculture must receive a fee reduction foreseen for the waste management by the municipality.

2.2.3 Community composting

The community composting (art. 38) is jointly performed by more than one domestic and not domestic users which want to treat their organic fraction waste in order to use the produced compost in their own green area*. Not every user but one must necessarily use the produced compost*

A partnership agreement must be established. A simplified authorisation consisting in a mere communication to the municipality is delivered. A conductor of the composter must be appointed by the partnership of users. These composters can show a capacity up to 130 t y^{-1}. The produced compost should not comply with the characteristics of a soil improver according to the L. 75/2010 and therefore must not be given to users outsider to the partnership.

The main features for the three typologies of small scale composting are summarised in the table 1.

Table 1. – Main features of various typologies of small scale composting in Italy

User	**Facility location**	**compost utilization**	**Definition**	**Limits**	**Examples**
Single	close to the user	For the user	Autocomposting	no restrictions but compatible with the capacity of the user	Household, school, company, hotel with a green area
Plural	close to the same or neighbouring municipality	whoever, no restrictions	Local composting	<80 t/y + EPA opinion Compliance with Law on fertilisers and soil improvers	Municipal facility or various users linked with a partnership agreement
Plural	close to (at least) one of the users	for at least one of the users	Community composting	<130t/y	Apartement block with a partership agreement

User	Facility location	compost utilization	Definition	Limits	Examples
Plural input > 130 t/y < 200 t/y	Close to the municipality	whoever, no restrictions	Small scale composting	EPA opinion Compliance with Law on fertilisers and soil improvers	Facility
Plural input > 200 t/y	Close to the municipality	whoever, no restrictions	Large scale or industrial composting	Regular authorisation Compliance with Law on fertilisers and soil improvers	Facility

2.3 Electromechanical composters

Electromechanical composters are devices of 1 to 50 m^3 of internal capacity, designed to process 10 to 180 t/y of biowaste. They are structured into the following parts:

- feed hopper for the blend of food waste and bulking agent, optionally provided with a shredder. The shredder has the advantage to enhance the specific surface of the material which is supposed to be degraded and increase the speed of the process. On the other hand it has the drawback of possible jams during operations due to hard fragments incidentally inserted.

- bio – oxidation reactor where organic matter through microbial activity, under aerobic conditions starts an intensive process involving the degradation of readily fermentable organic substances like carbohydrates, amino acids, proteins, and lipids. The degradation involves high microbial activities and generates heat, carbon dioxide, and water in addition to a partially transformed and stable organic residue. Lastly, bio oxidation must assure a temperature of 55°C at least for 4 consecutive days which serves sanitation purposes. For this reason, electromechanical composters must be provided with an internal temperature control system of the organic matter.

- a forced aeration system realised by a fan which continuously extracts exhausted air inside the reaction chamber letting the composter work in slight air depression;

- a biofilter for odour control;

- a wood chipper to grind the pruning which serves like bulky agent;

In case of lack of a shredder, prunings can be usefully recovered after the curing stage (which will be further described) by means of a sieve operating by a rotating drum system (sieve openings: 10 x 10 mm). Commercial price is between 500 and 1000 €.

Two classifications are foreseen for the electromechanical composters, each of which can be classified in turn into two main categories, based on the number of reaction chambers and the turning system:

- two-chambers systems which are made up of two adjacent chambers separated by an internal movable wall: uploading occurs in the first chamber where a bio-oxidation lasting about 20 days occurs; subsequently, the composting matter is transferred to the second chamber and left to be cured for additional 20 – 40 days.

- single chamber systems which are made up of a single drum where composting matter undergoes bio-oxidation, pushed along the axial direction and withdrawn after an overall period of 40 – 60 days. When the bioreactor lacks any moving mechanical part, this solution is highly recommended in case the kitchen waste is loaded inside compostable plastic bags. In fact it was proven that compostable bags easily degrade and do not bring about any jam of the mechanical moving mechanisms inside the reactor.

In the frame of the above mentioned categories electromechanical composters are classified on the basis of the turning system. They may be 1) provided with mechanical parts in motion such as an axial shaft connected with blades around it or 2) a simple cylindrical chamber, possibly with diaphragms, which rotates around its horizontal axis.

Curing can take place whether in an open air-area where the partial stabilized organic matter outputting the electromechanical composter is arranged in a stockpile under a roof cover and periodically turned or aerated. This phase lasts about two to three months. Alternatively, by adopting a two chamber composter one can dedicate the second chamber to the curing phase applying periodical turnings, aeration and controlling temperature and moisture within the organic mass. This second solution can shorten the times but is slightly more expensive.

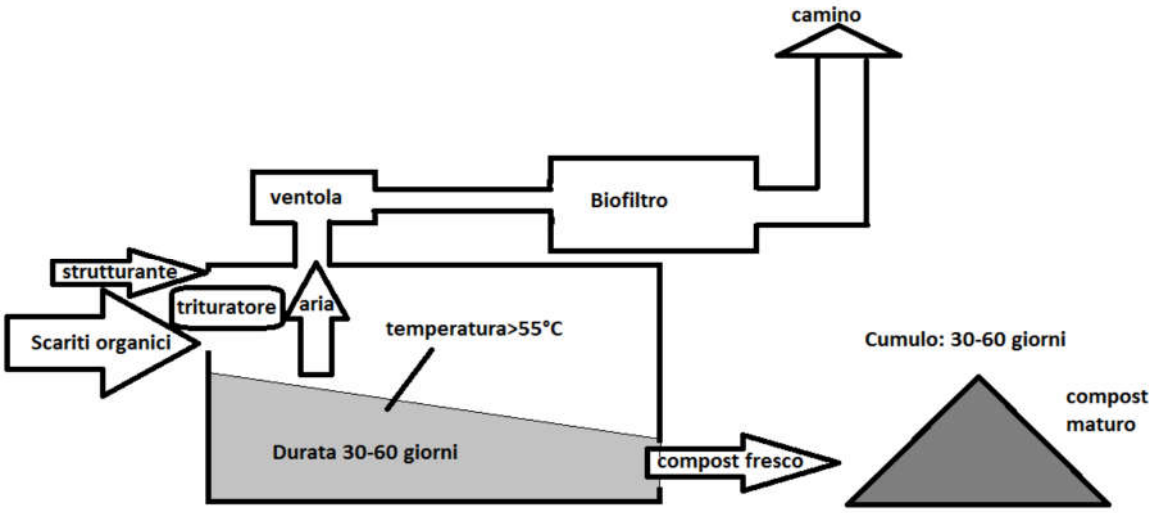

Figure 1: sketch of an electromechanical composter and its operations

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The compost can be utilised as soil improver for a specific quantity equal to 25 t/y/ha.

3 Recommendations of technical specifications concerning the public procurement of an electromechanical composter

3.1 Estimation of the input capacity

The input capacity is made up of two items: the yearly kitchen waste and the bulky agent amounts. The first item is drawn from the municipal waste production, the percentage of organic waste in waste composition and the number of inhabitants. For Italy this datum is 120 kg/in/y, for Croatia, 115 kg/in/y. If one considers a basin of "α" inhabitants, the yearly organic waste production would be α x (115 or 120) t/y. Fluctuations due to touristic activities can sensitively enhance this number. Pruning production estimation

The bulky agent is necessary to manage properly a small scale composting activity and amounts to 10% of the organic waste input. This bulky agent may consist either of wooden pellets, which is a commercial commodity and as it is, should be bought, or natural prunings from garden maintenance. The conservative production estimation related to an hectar is 15 t/ha extracted from the following table. In other words an area of around half an hectar is necessary to obtain the production of prunings.

Table 2. – Prunings and grass cutting data from various experiences in Italy (source: ENEA interviews)

Source	Estimation (t/ha)
Rome airport administration (Italy)	30
Natural Park of Gran Sasso (Italy)	30-40
Varese province administration	13-20
Sicily region administration	22

3.2 Estimation data for the pilot experience

The electromechanical composter which is supposed to be installed to carry out the pilot experience has a capacity up to 8.3 t/y (27.5 kg/d), 0.75 t of which consisting of prunings and 7.5 t/y consisting of kitchen waste. A compost production of 2.5 t/y is expected. This composter can serve 70 inhabitants per year. The volume of the composter is 1 m^3. The needed space is: 2 – 2.5 m length, 1.5 m width. Therefore the equipment should be installed inside a 50 m2 Hall provided with the following equipments and services:

- Three phase power;
- Mono phase power for service equipment like the rotating drum sieve and the wood chipper
- Water network

- Compressed air

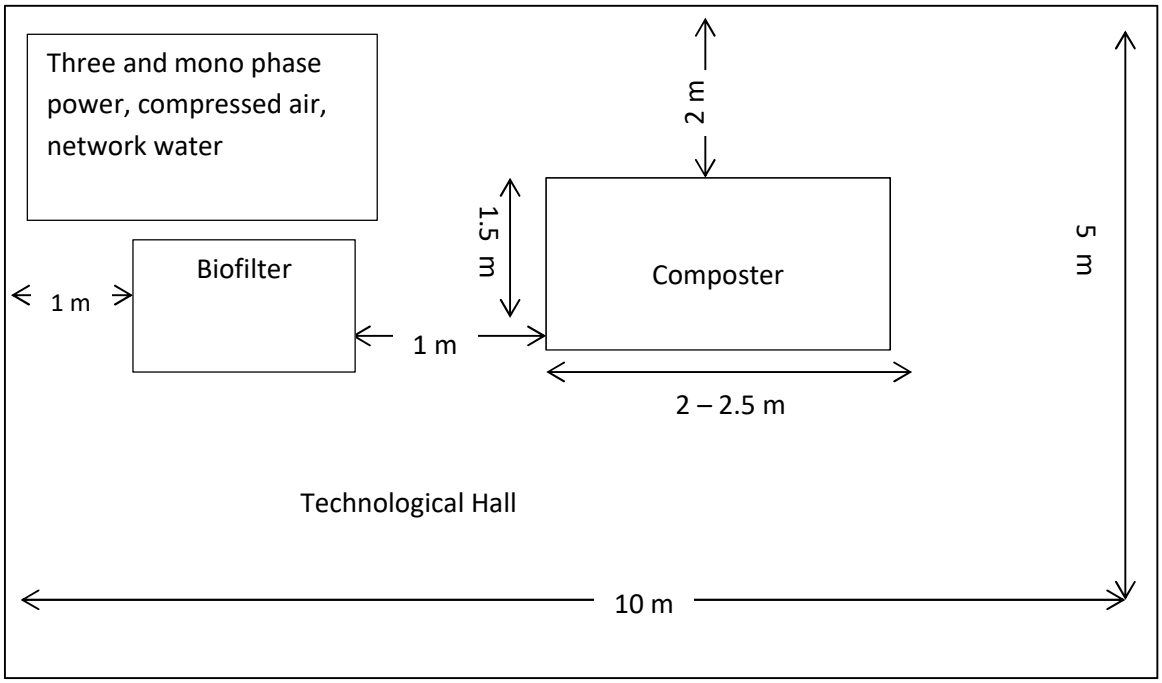

Figure 2. Layout sketch of a technological hall for the electromechanical composter

The compost quantity which is produced each month amounts to 200 kg. If we assume a compost specific gravity of 0.4 t/mc, a stockpile occupies a volume of 0.5 m^3.

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Let's take a conical shaper for a single stockpile. Se si immaginano i cumuli di forma conica allora:

Then, the cone volume = п/3 r^2 h

where r is the basis radius and h is the height.

Because of geometrical considerations, the height is equal to the tangent of the basis angle multiplied by the radius.

Let's take an angle of 30° (natural hillside slope angle for wetlands) , one gets h=r X tan(30)= r X 0.577

Then, if we have 0.5 m^3= п/3 r^3 0,577

As a consequence, radius r= 1 m and the diameter is 2 m.

Stockpile or cone height= h= 1 X tan(30) = 0,5 m

This is the space necessary for the stockpile which is formed during the curing stage.

The curing stage is usually carried out by settling the stockpile under a roofed area having the dimensions and services like reported in figure 2.

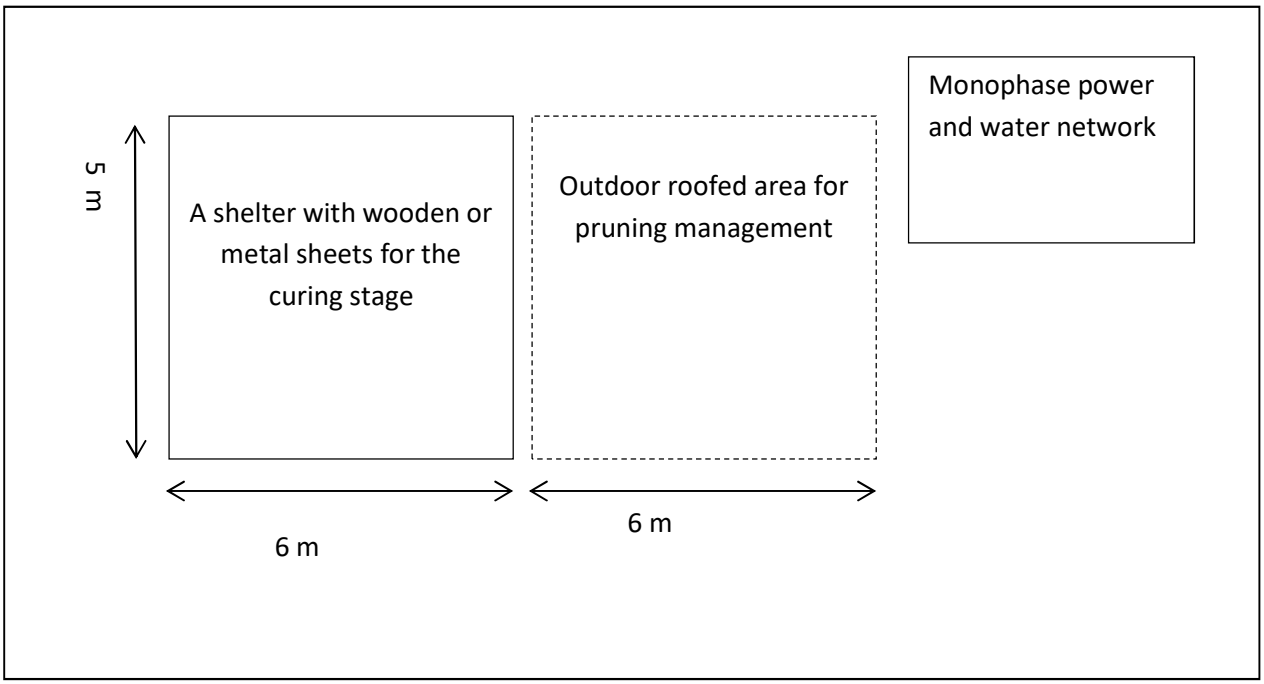

Figure 3. – Area for the curing stage of composting

Alternatively if one does not have such a space, one can settle the material outputting from the composter into a properly holed 2 m^3 container. It is important that sufficient aeration is ensured.

A storage area for pruning is also needed. During a year ca. 750 kg pruning is consumed which corresponds to 10% wt. of the overall organic waste input. The space volume is 1 m^3. It is recommended that pruning is saved inside breathable bags.

Pruning management (collection, grinding and recovery by sieving) can be conducted in the outdoor area adjacent the curing stage. It is recommended to purchase acoustic bollard to avoid the intrusion of small rodents.

This area should be provided with monophase power to perform the pruning grinding and recovery by sieving . Morevoer water networks ensures the needed periodical wathering of stockpiles The periodic turining of the curing compost is carried out manually by shovels.

Here below, the main technical specifications to be taken into account are summarised:

- Residence time in the electromechanical composter: 30 days;
- Electrical consumptions lower than 5 kWh per day;
- Required electrical power lower than 10 kW;
- Composter material which is supposed to be in contact with the organic waste: stainless steel;
- Three phase electric power 380 volt, 50 hertz.
- Minimal granted aeration by means of electrical fan: 50 Nm3/h
- Touch screen control operations: setup of operating parameters such as number of turnings per day, fan speed. Monitoring of temperatures generated by the organic mass in three spots of the composter: near the input, in the middle (in relation of the central axis of the drum chamber) and near the output. Possibility to vary the temperature measurement frequency (one every hour at least). Possibility to insert the daily quantity of organic waste and bulky agent loaded into the reactor and the daily quantity of withdrawn material. All these data should be recordable and downloadable
- Automatic heating system to enter in operation if temperature goes down a fixed threshold temperature;
- Biofilter filled with barks
- The exhaust air duct of the composter should be connected with the biofilter and the output of the biofilter should be connected outside of the hall

3.3 Costs

ENEA formulated an empirical mathematical expression to estimate investment costs of electromechanical composters, depending on the annual input capacity. This formula was drawn by comparing various public procurements published in 2015 by Italian municipalities interested to purchase a composter:

Cost estimation (€) = 741 x [yearly input capacity] + 21.000 €

If we apply the expression to the present case, we obtain a result near to 30.000 €.

In this amount the VAT voice is included.

3.4 Other recommended service equipment

Here below a list of other equipment and instrumentation which are highly recommended is reported:

- a sieve provided with a rotating drum system and electrically powered. This device is useful to recover used prunings from the cured compost
- an electrical scale, ranging 1 – 100 kg in order to weigh input and output quantities frome the composter
- a wooden chipper in order to grind pruning to be used as bulky agent;
- a T-thermocouple to measure temperature in the composter and in the stockpile;
- a thermo balance or an elecally powered oven (up to 200°C) to measure and monitor the moisture content of the organic mass during the process.

4 Pilot action of plastics valorisation from beach litter

4.1 Geographical locations in Croatia

The pilot action regarding plastic marine litter takes place in two locations: 1) the main bay at the sand-gravel beach of the Ist Island and 2) a small beach in Martinska, which is located across the bay opposite of the town Šibenik.

The bay of Ist is placed at the south cove which is more exposed to a floating litter. The samples are collected manually at one square meter in the middle of the beach before touristic season on the month of May. In Martinska there are only a few houses amongst them is the Research Station of the Ruđer Bošković Institute. The sparsely inhabited area attracts mainly visitors who spend some hours up to a day in Martinska to swim or fish. In July and August music festivals are held around 500m from the sampling site. In the direct surrounding of the beach (200m) there is no infrastructure apart from a gravel road. Off that road leads a small hardly noticeable trail to the sampling location. The beach itself is located in a small (~50m diameter) bay on the western side of Šibenik bay, which at the same time is the estuary of the Krka River. With only around 6 m length and a maximum of 3 m width it is a particularly small beach. It faces a North-Western direction and the prevailing grain size is pebblys flux.

All the activity was carried out by Ruder Boskovich Institute.

4.2 Geographical location in Italy

The geographical location selected for this pilot action is the Adriatic coast in Molise Region and in the Municipality of Campomarino. Its territory covers a surface of 76 km2 and has a population of 8,000 inhabitants who increases up to 35000 on summer.

Beach debris was manually collected in the area at the coast of the campsite “Village Corrado” as represented in Figure 6.

Figure 6 . – Geographical location where the pilot action of plastics from beach litter took place. Municipality of Campomarino

The area in the beach of sampling is 30 m long and 7 meter wide. A sieve of 20 mm is utilised to remove all fragments under the size of the sieve. The over-sieve-fraction is taken apart and saved into large bags for further measurements in the laboratory. Most plastic collected fragments are nets used for mussel cultivation on offshore platforms. Following their use, these nets are wasted in the sea and the tide drags them to the beaches. As these nets are made up of PP plastics. Samples have been valorized through the treatments of extrusion and pyrolysis as it will described in Deliverable 5.2.1. Hereinafter pictures of the sampling activity are reported.

	
Marine litter on the beachside of Campomarino before Camping Corrado	Marine litter sampling operations
	
Delimited area for marine litter sampling operations	Marine litter sampling operations

Plastics collected from marine litter

Detail of a mussels net

Figure 7. – pilot action of waste plastics collection on the coast in the municipality of Campomarino