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Thermal insulation role and possible exploitation of *Posidonia oceanica* detritus in the Mediterranean area*

Abstract

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The paleoendemic seagrass *Posidonia oceanica* (L.) Delile represents a key species of the most important and productive ecosystem in subtidal habitats of the Mediterranean Sea. This species is the most common seagrass in Sicily where it forms dense and extensive beds, which are characterized by high coverage and primary production values. The beaching of *P. oceanica* detritus (banquette) can be an environmental, economic and social problem, if it comes into conflict with a number of activities (tourism, bathing establishments, etc.). Even though seagrasses play a fundamental ecological role in limiting coastal erosion and promoting the origin of the coastal dunes, the presence of *P. oceanica* detritus along the coasts can negatively decrease the tourism value of beaches. As a result, according to national and regional laws and guidelines, local authorities are required to remove banquette and to accumulate it in landfills. In this survey, the ancient exploitation and current uses of *P. oceanica* detritus are reported according to literature data. Moreover *P. oceanica* detritus were used to replace soil in an experimental installation located at the University of Palermo. Meanwhile, continuous temperature values measurements by using hobo data logger sensors were carried out. The results confirm the thermal insulation role of this material and highlight potential applications in the field of Soil Bioengineering.

Key words: seagrasses, soil bioengineering, circular economy, Sicily.

Introduction

The world population is expanding incessantly, and economic and demographic growth are leading to the exploitation of the environment and the reduction of natural resources, with potentially important impacts on global climate change (Vörösmarty & al. 2000). Therefore, more efficient management of resources is necessary, based on the modification of sustainable objectives of environmental policies and strategies and lower consumption of resources. Actions are needed to promote the transition from a linear economy

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model to a circular one, consisting of a continuous positive development cycle that preserves and improves natural capital, optimizing the use of resources (MacArthur 2013).

P. oceanica (L.) Delile is an endemic seagrass found in the Mediterranean Sea, where it forms extensive meadows in the marine infralittoral zone (Duarte 1991). This species is the most common seagrass in Sicily, covering a surface of about 76,000 ha and growing at a depth of 0-50 m (Calvo & al. 2010). In particular, along the western coasts of Sicily *P. oceanica* meadows form dense and extensive beds, which are characterized by high coverage and primary production values. The seagrass plays a fundamental ecological role in limiting coastal erosion and promoting the establishment of the coastal dune system (Boudouresque & Meinesz 1982; Simeone & De Falco 2012; Boudouresque & al. 2016). As a consequence of phenological process, the beached detritus of *P. oceanica* (banquette) are widely considered a problem by local inhabitants, conflicting with many economic activities such as coastal tourism, bathing, etc. As a result, local authorities are required to remove *banquette* and dispose them in landfills. In fact, Italian legislation considers these plant biomasses as a special kind of solid waste material to be disposed to landfills, thus resulting in an enormous loss of organic materials, nutrients and useful biomolecules (Saidi & al. 2009), with additional problems associated with their transport to landfills.

Circular no. 35792/2009, issued by the Sicilian Regional Administration, proposes a management option that consists in the reuse of biomass in landscape reconstruction, as a compost in agriculture or as environmental restoration work in coastal areas (Legislative Decree 75/2010 reforming and revision of the fertiliser guidelines, pursuant to Article 13 of Law no 88 of 7 July 2009).

In this regard, Soil and Water Bioengineering uses plants as living building material in environmental and landscape development works. Such works with low environmental impact promote biodiversity and, in addition, offer a promising strategy for mitigation and adaptation to climate change (Duarte & al. 2013). Thus, the use of adequate, sustainable, easy to find and low-cost materials is essential for the achievement of these objectives. From the viewpoint of the circular economy, the reuse of *P. oceanica* detritus has a double beneficial effect. It constitutes a solution to the problem of waste disposal and an opportunity for the creation of local and low-cost new products.

Considering the great availability of detritus resulting from the annual cleaning of beaches from the leaves of *P. oceanica* in Sicily, the aim of present work is to test if this detritus could exert a thermal insulation role with potential applications in the field of Soil Bioengineering. For this purpose an experimental installation located at the University of Palermo were set up, where different treatments consisting of mixtures of *P. oceanica* detritus-soil composed were assembled in modular structures.

State of art of multiple-uses of *P. oceanica* detritus

The uses of beached *P. oceanica* detritus date back to prehistoric history. In fact, the occurrence of vegetable biomass was detected in the Lazaret's Cave (Nice), where dissected *P. oceanica* detritus were used to build beds (De Lumeley & al. 1969). The ancient Egyptians made seaball to make shoes (Tackolom & Drar 1954). Along the coasts of North Africa, in Spain and Balearic Islands (Terrados & Borum 2004), the beached leaves of *P.*

oceanica were used for the construction of roofs and bricks for the construction of walls and shafts (Trotter 1915). A rich macrofauna (gastropods, crustaceans, annelids and insects) inhabits the banquettes (Deidun & al. 2009). Whatever the role of the *P. oceanica* debris in the diet of the harboured fauna, banquettes are very important as a physical structure that provides detritivorous and predatory species with refuge from environmentally stressful conditions (Colombini & al. 2009) and top predators such as sea birds (Bartoli & Prévot 1978; Bartoli & Holmes 1997). *P. oceanica*, because of the high content of cellulose, may be suitable for the production of paper (McRoy & Helfferich 1980). The detritus of *P. oceanica* have found a greater field of application in agriculture as organic substance to increase the fertility of soil (Cocozza & al. 2009; Parente & al. 2009; Montesano & al. 2014; Mininni & al. 2015; Pirrera & al. 2017; Calvo 2018). The thermo-absorbent properties of *P. oceanica* leaves, combined with their low density and high porosity (Milchakova 2014), allowed its use as thermal insulator in Greece (Sordina 1951).

Some uses in traditional medicine were confirmed as well as antibacterial and antifungal activity of leaves extracts. Gokce and Haznedaroglu (2008) have conducted a study on diabetic rats, which showed how the oral intake of the extracts of *P. oceanica*, reduces blood glucose and induces blood vessel protection.

Researches on the possible use of *P. oceanica* in cosmetics were introduced by the Company Egadi Natural Cosmetics which defined a protocol of green collection on *P. oceanica* beached and has obtained an extract with excellent antioxidant properties for a new line of treatment cream.

Finally, several projects have provided for the use of *P. oceanica* detritus. In the whole Mediterranean area there are different experiences of composting, thanks to the high presence of beached detritus of *P. oceanica* along the coasts. In Tunisia, for example, the compost was used as substrate for the cultivation of vegetables and, in particular, tomato (Verloot & al. 1983). In Italy, experimental activities of composting and the use of the compost were carried out by several authors (Cocozza & al. 2011; Mininni & al. 2015; Montesano & al. 2014). *P. oceanica* detritus were also recently used in a Soil Bioengineering project to the Municipality of Custonaci (province of Trapani, Sicily) (Pirrera & al. 2017).

Materials and Methods

The construction of modular structures was made with organic waste materials, namely detritus of *P. oceanica* and vine pruning (vine shoots). In this regards, vine shoots were assembled in the form of fascines to constitute the basic element used to create a fascinate module, a linear Soil and Water Bioengineering work with anti-erosive, consolidation and stabilization functions, while the detritus of *P. oceanica* were used as a growing medium, to permit it, after planting with native species, an evolution toward a more natural substrate. Finally continuous temperature values measurements using hobo data logger sensors were carried out within different mixtures.

A small prototype of fascinate has been set up in experimental fields at the University of Palermo. (38°06'27.73 "N; 13°20'59.48" E). The work 20 m long, is structured in 12

fascines. The fascines were subsequently filled with 30 liters of substrate composed of several mixtures of detritus of *P. oceanica*-soil according to the scheme:

- no. 3 fascine filled with 100% of *P. oceanica* detritus;
- no. 3 fascine filled with 80% soil - 20% of *P. oceanica* detritus;
- no. 3 fascine filled with 100% soil;
- no. 3 fascine as control.

Temperature values inside the fascines was measured from July to November 2017 by using hobo data logger sensors. The data were recorded continuously every 30 minutes only in a) the external environment, b) inside the *P. oceanica* detritus (5 cm depth) contained in fascines and c) in the soil (5 cm depth) next to the installation. On the whole, 18.603 temperature values were acquired.

Results

During summer, temperature values ranging between 36.6°C in *P. oceanica* detritus and 55.1°C in the external environment. Instead, in autumn the minimum temperature values measured were 5.6°C in the external environment and 9.7°C in the detritus of *P. oceanica*. Moreover, maximum and minimum temperature values registered in the soil were 43.2 °C and 11.9°C (Fig. 1).

Lowest average temperature values were recorded in *P. oceanica* detritus inside fascines, both in the summer period (25.7±3.6) and throughout the measurement period (21.8±5.2) (Table 1).

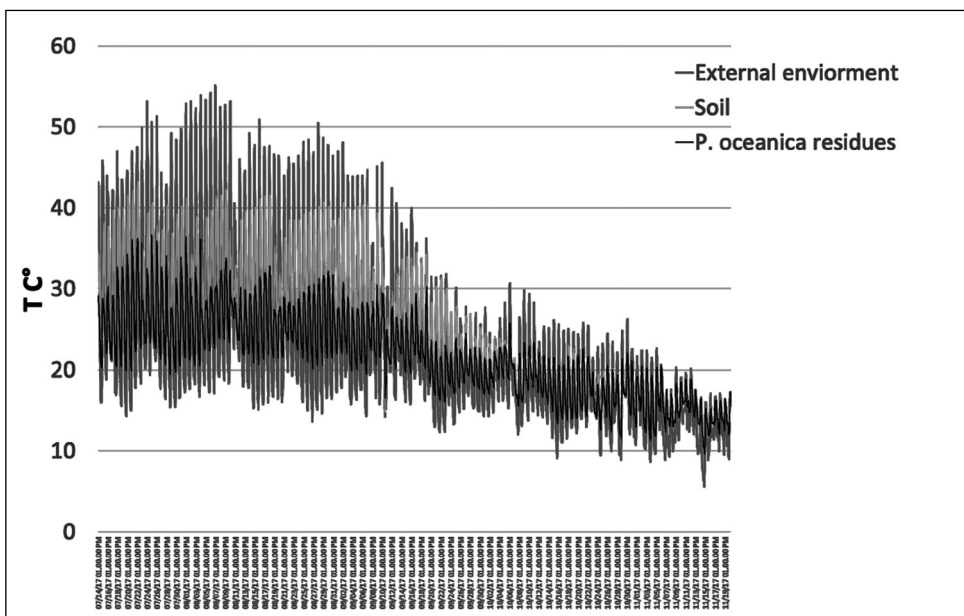


Fig. 1. Temperature values recorded from July to September 2017 during the experiment.

Table 1. Average temperature values (\pm SD) recorded in the experimental installation.

Dates	External temperature (mean \pm SD)	P. oceanica detritus (mean \pm SD)	Soil (mean \pm SD)
14-31 July 2017	29.6 \pm 10.2	26.4 \pm 4.2	31.2 \pm 5.1
01-31 August 2017	29.1 \pm 10.9	26.4 \pm 3.2	30.7 \pm 5.0
01-30 September 2017	23.1 \pm 7.2	25.5 \pm 3.1	25.5 \pm 5.0
01-31 October 2017	17.8 \pm 4.2	18.3 \pm 2.6	19.0 \pm 2.0
01-20 November 2017	13.7 \pm 3.2	15.2 \pm 2.2	15.8 \pm 1.6
14 July - 21 September 2017 (Summer)	28.0 \pm 10.0	25.7 \pm 3.6	29.8 \pm 5.2
22 September – 20 November 2017 (Autumn)	16.8 \pm 4.6	17.5 \pm 3.0	18.5 \pm 3.0
14 July - 20 November 2017	22.7 \pm 9.7	21.8 \pm 5.2	24.5 \pm 7.1

Discussion and Conclusions

In the framework of an efficient use of resources and a good waste management, this study underlines the high insulating capacity and the value of *P. oceanica* detritus as a replacement for the plant substrate. In fact, using *P. oceanica* detritus a significant attenuation of maximum and minimum daily temperature values was observed at level of root system, comparing with soil and external environment (Figure 1). Hence, this study suggests that beached of *P. oceanica* detritus, in addition to finding application as thermal insulation in buildings (Sordina 1951; Milchakova 2014), can also be used to promote the rooting and growth of plants that find application for their biotechnical characteristics in the field of Soil Bioengineering (Tuttolomondo & al. 2017).

Moreover, the use of *P. oceanica* detritus, widely detectable in Sicily and in the Mediterranean basin, represents a valuable example of low cost, sustainable use, energy efficiency and complete respect of the environment. In this context it is also necessary to consider the opportunity to raise public awareness of the importance of seagrass and the beached detritus for the preservation of coastal ecosystems.

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