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Short Communication

Converting beach-cast seagrass wrack into biochar: A climate-friendly solution to a coastal problem

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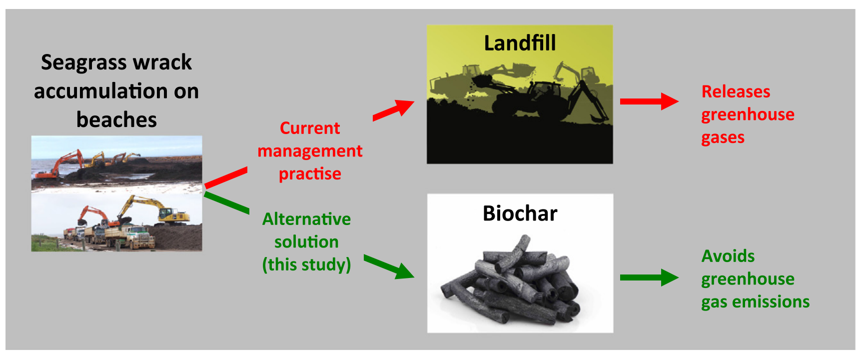
HIGHLIGHTS

- Accumulation of seagrass wrack on beaches has become a global disposal challenge.
- We explore the feasibility of converting seagrass wrack into biochar via pyrolysis.
- Biocharring offsets CO_2 emissions and creates a commercially-valuable byproduct.
- Wrack carbon was converted into biochar with an efficiency of 48–57%.

GRAPHICAL ABSTRACT



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ABSTRACT

Excessive accumulation of plant 'wrack' on beaches as a result of coastal development and beach modification (e.g. groin installation) is a global problem. This study investigated the potential for converting beach-cast seagrass wrack into biochar as a 'climate-friendly' disposal option for resource managers. Wrack samples from 11 seagrass species around Australia were initially screened for their biochar potential using pyrolysis techniques, and then two species – *Posidonia australis* and *Zostera muelleri* – underwent detailed analyses. Both species had high levels of refractory materials and high conversion efficiency (48–57%) of plant carbon into biochar carbon, which is comparable to high-quality terrestrial biochar products. *P. australis* wrack gave higher biochar yields than *Z. muelleri* consistent with its higher initial carbon content. According to ^{13}C NMR, wrack predominantly comprised carbohydrates, protein, and lignin. Aryl carbon typical of pyrogenic materials dominated the spectrum of the thermally-altered organic materials. Overall, this study provides the first data on the feasibility of generating biochar from seagrass wrack, showing that biocharring offers a promising climate-friendly alternative to disposal of beach wrack in landfill by avoiding a portion of the greenhouse gas emissions that would otherwise occur if wrack was left to decompose.

1. Introduction

The accumulation of plant wrack (e.g., seagrass and macroalgae) on beaches - by surf, tides, and wind - is a natural phenomenon that occurs

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all around the world. Wrack production occurs when old seagrass leaves become detached during annual or interannual senescence and are transported in surface waters, with a significant proportion being cast upon beaches before eventually breaking down (Machas et al., 2006; Mateo, 2010). For example on the Kenyan coast, Ochieng and Erftemeijer (1999) estimated an annual accumulation of 6.8 million kg dry weight (DW) along a 9.5 km stretch of coast. The amount of leaf material shed during senescence cycles varies among seagrass species and locations, but can be as high as 100% of annual leaf production (Cebrian and Duarte, 2001; Mateo et al., 2006). Much of this leaf detritus can be exported from its point of origin in seagrass meadows (~90% reported by Cebrian and Duarte (2001)), eventually accumulating on-shore.

Wrack has important ecological value. It provides food and habitat to species that inhabit shorelines (e.g., birds and invertebrates) and provides protection to coastal dunes (Kirkman and Kendrick, 1997; Dugan et al., 2003; Orr et al., 2005; Nordstrom et al., 2011). However, excessive accumulation of seagrass wrack on beaches has become common in recent times due to coastal development, largely as a result of the installation of groynes (Fig. 1A) that cause abnormal retention of plant material on beaches. Above 'normal' levels of beach wrack can negatively impact tourism (Kirkman and Kendrick, 1997), reduce habitat amenity for beach infauna (McGwynne et al., 1988), and wrack piles might be significant sources of greenhouse gas emissions (Coupland et al., 2007; Oldham et al., 2010; Lavery et al., 2013). Local councils and coastal resource managers frequently opt to remove excessive accumulations of wrack, which can come at great expense. For example, Port Geographe on the Western Australian coast reports having spent $28.15 million during 2008–09 to remediate shorelines that had become 'wrack hotspots' following shoreline reconfiguration (Oldham et al., 2010; Fig. 1B). A significant proportion of this cost is associated with the disposal of collected wrack, whether via landfill or municipal biomass waste facilities.

This study explores the potential of converting wrack into biochar for the purpose of providing an 'environmentally-friendly' disposal option for resource managers. Biocharring refers to the thermochemical conversion of biomass in an oxygen-limited environment to create a solid material with high carbon content (Sohi et al., 2010). The technique of biocharring is a 2000-year-old practice that was originally used to improve soil fertility, and more recently, biochar has gained recognition as a tool to enhance the sequestration of atmospheric carbon and thereby help mitigate climate change (Sohi et al., 2010; Das et al., 2015). Studies into biochar have increased exponentially, with more than 10,000 refereed journal articles on biochar in the past 5 years according ISI's Web of Science. Previous studies have explored biochar potential of algae (e.g. seaweeds; Bird et al., 2011), but not seagrasses.

In the context of wrack accumulation, this study proposes that conversion of wrack into biochar will help offset CO_2 emissions that would otherwise occur if wrack was left to decompose. The aims of this study were to: 1) provide initial screening of a number of seagrass species for their biochar potential; 2) based on the initial screening, compare the conversion efficiency of wrack into biochar for the most promising and common species; 3) assess whether the state of the plant (fresh or partially decomposed; Fig. 1C) makes a significant difference to biochar yield, and 4) analyse the chemical composition of wrack and wrack biochar.

2. Materials and methods

As part of a preliminary screening, the 'biochar potential' of different seagrass species from around Australia, using the pyrolysis methods described below, was assessed to identify those with high contents of refractory materials. The fresh seagrass leaf samples collected represented eleven species from 4 families: Cymodoceaceae (*Amphibolis antarctica* (Labillardière) Sonder & Ascherson ex Ascherson, *Halodule*

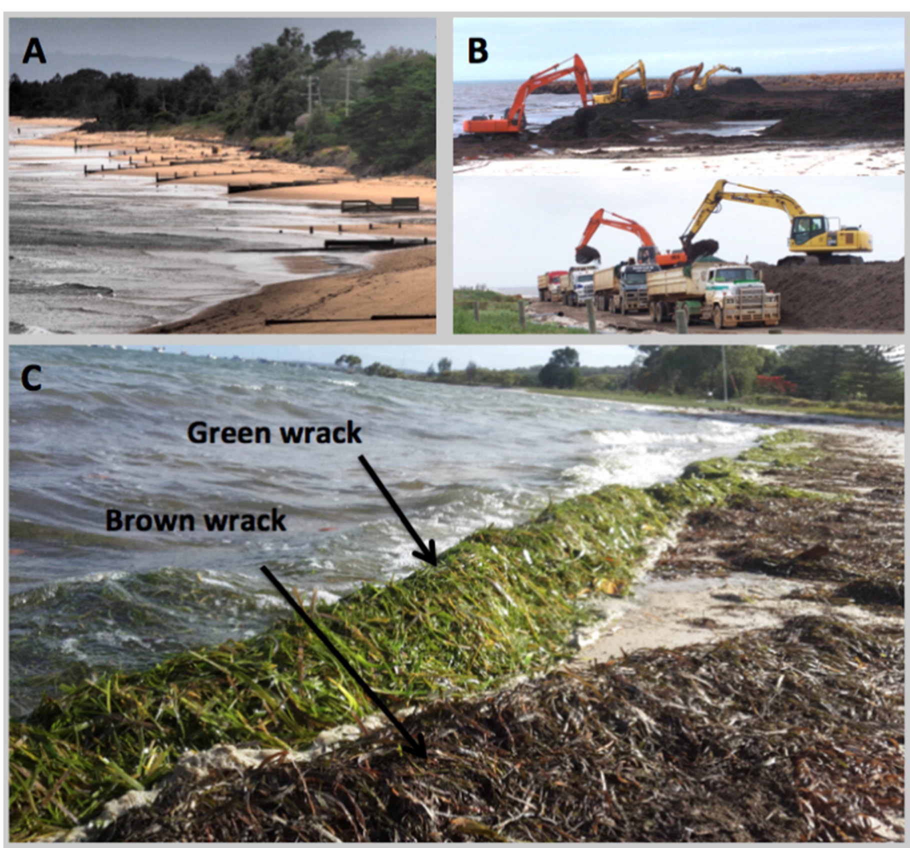

Fig. 1. Photo collage showing (A) installation of groins on beaches often increases wrack build up on beaches (photo credit: Peter Macreadie); (B) seagrass wrack being removed from Port Geographe (Western Australia; photo credit: Busselton-Dunsborough Mail); and (C) green (fresh) and brown (decayed) wrack (photo credit: Peter Macreadie).