

INTERACTIONS BETWEEN PLANTS AND ARBUSCULAR MYCORRHIZAL FUNGI TO MITIGATE DUNE EROSION INDUCED BY STORM WAVES

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INTRODUCTION

Coastal dunes are one of the most important ecosystems to protect the coast versus seaward hazards (Temmerman et al., 2013). In these environments, vegetation plays a key role and is directly related to the degree of protection that dunes can offer. Recently, it has been demonstrated that plants act as a bio-shield during storm impact and mitigate erosion induced by waves (Silva et al., 2016). However, this protection is species-specific, so some species protect more than others and confer higher resistance to the dunes (Charbonneau et al., 2017; Maximiliano-Cordova et al., 2019). Additionally, an increase in plant functional richness covering the dune is not always beneficial, and dunes covered by key species could be a better solution (Maximiliano-Cordova et al. 2019).

These findings are highly relevant to empirically support the role of coastal dunes and their vegetation as natural barriers. However, since coastal protection offered by vegetation is a non-linear process, and apparently depends on many biotic and abiotic factors, new research has to be conducted to better understand how to mitigate erosion by using plants.

One important variable are biological interactions. For example, plants interact with other organisms, such as fungi in the roots, and this can in turn determine their biological traits and features (Clements et al. 1929). Consequently, interactions could play an important role in coastal protection. The mutualistic interactions between plants and arbuscular mycorrhizal fungi (AMF) are common in coastal dunes (Koske et al., 2004). It has been widely documented that AMF promotes the establishment and growth of plants because they enhance plant nutrient uptake and increase the tolerance to salt stress and drought (Koske et al., 2004). Additionally, AMF promotes soil aggregation through the secretion of water-stable adhesive compounds and physical entanglement of soil particles through the hyphae, which bind fine grains into larger assemblages (Feagin et al., 2015). The result is that non-cohesive material changes and increases its weight thus, erosion resistance increases.

In the literature, it has been hypothesized that Plant-AMF interactions could improve directly or indirectly the level of protection that plants offer against erosion. However, despite its apparent relevance, there is no empirical evidence to validate it. So the aim of this study is to explore and evaluate if Plant-AMF interaction mitigates embryo dune erosion induced by wave attack during storm impact.

An experiment will be carried out in a wave flume where artificial dunes in a 1:1 scale covered by plants will be exposed to storm waves. In the experimental set-up, we will use *Ipomoea pes-caprae* (L.) Roth as the focal species, which is highly abundant in the tropics and relevant to mitigate dune erosion (Silva et al. 2016). Plants will be propagated vegetatively in boxes with sand from Playa Paraíso, a beach located in La Mancha, Veracruz. We will have two treatments (i) dunes covered by plants interacting with AMF and (ii) dunes covered by plants without AMF. For plants with AMF, spores will be inoculated into the sand and roots. On the other hand, the treatment without AMF will use sterilized sand and propagules, before the planting process. To evaluate the effect of AMF in plants, every month we will record plant attributes such as stem diameter, number of leaves and length and width of leaves.

Artificial dunes and beach profile will be constructed taking as reference the work by Silva et al. (2016). Plants will be extracted carefully from the boxes and planted in the exposed face of the dunes. They will be exposed for 40 minutes of wave attack from two storm intensities. For every trial, the volume of the dune will be calculated before and after the storm and the difference will be considered as net erosion. Six replicates per treatment will be used and finally, a linear model will be performed to explore the results statically.

AVAILABLE BACKGROUND INFORMATION & DATA

- Ecosystem threats
- Coastal dunes and their biodiversity are highly vulnerable and threatened by anthropogenic factors and because of climate change. Both phenomena have induced coastal squeeze (Doody, 2004) and consequently, dune biodiversity will decrease. Especially plants are highly sensitive because they cannot

migrate landward or expand their distribution because of the presence of human infrastructure (Martínez et al., 2014).

- Even though we do not have a specific study area because the experiment could apply for most of the sandy coast with vegetation, especially in the tropics, we will use data from the NOAA for the Gulf of Mexico to get an average of maritime climate during storms. We will use data from usual conditions and for extreme. The two conditions will be scaled to simulate the two storm intensities in the wave flume.

A BRIEF STATE OF THE ART

Armoring the coasts with hard infrastructure to protect human settlements has been a widespread practice (van Rijn, 2011). However, this solution could transfer erosion problems to adjacent areas and induce negative effects on coastal dynamics (Nordstrom 2003).

Because coastal vulnerability is a relevant problem, there is a great interest in understanding how

to better protect the coast and human property. However, coastal protection is not an easy problem to solve and requires the integration of information from many viewpoints. Worldwide, scientists have been gathering information to fill the gaps on how abiotic and biotic elements interact and help protect the coast.

From a geomorphological and an engineering approach, we know that beach morphology plays a key role during storm impact (e.g. Saye et al. 2005). Many studies have explored the erosive role of waves during storm impact (e.g. van Rijn, 2009) and other studies have explored the impact of an increment in storm frequency (e.g. Leatherman et al. 2000).

More recently, the biological elements have been integrated into numerical models and programs to protect the coast. Especially, plants have been highlighted because of their relevance in wave attenuation. In coastal dunes, plants play a key role in dune development and stability (Hesp, 2002). During storm surges, plants mitigate wave energy and erosion. Belowground initially mitigates wave overwash, wave-overtopping and displace the wave up rush (e.g. Kobayashi et al. 2013). Additionally, the roots confer sand stability and promote dune resistance.

This information could be integrated into new research to test how biotic and abiotic elements are highly relevant for coastal protection. Only through hard evidence, natural barriers can be eventually considered into coastal management programs.

SUMMARY

Plants from coastal dunes are key elements to mitigate erosion induced by waves and to protect the coast from seaward hazards. Recent research has demonstrated that protection is not only dependent upon the presence of plants. It also depends on additional variables related to biotic and abiotic factors, such as biological interactions. Especially, in coastal dunes, plants have a mutualistic interaction with Arbuscular Mycorrhizal Fungi (AMF). This interaction contributes to enhancing plant nutrient uptake and increasing plant tolerance to salt stress and drought. Additionally, it promotes sand aggregation because of the secretion of adhesive compounds and physical entanglement of soil particles. Consequently, resistance to sand erosion is higher. Although Plant-AMF interaction seems to be an important factor, there is no empirical information to validate it. So, the aim of this study is to evaluate if Plant-AMF interaction is important to mitigate embryo dune erosion induced by wave attack during storm impact. In a wave-flume, we will carry out an experiment where plants of the species *Ipomoea pes-caprae* interacting with AMF and plants without AMF will be exposed to wave from two storm intensities (normal and extreme conditions) during 40 minutes. Pre and post-storm volume will be measured and the difference will be considered as net erosion. Results will be interpreted statically through a linear model.

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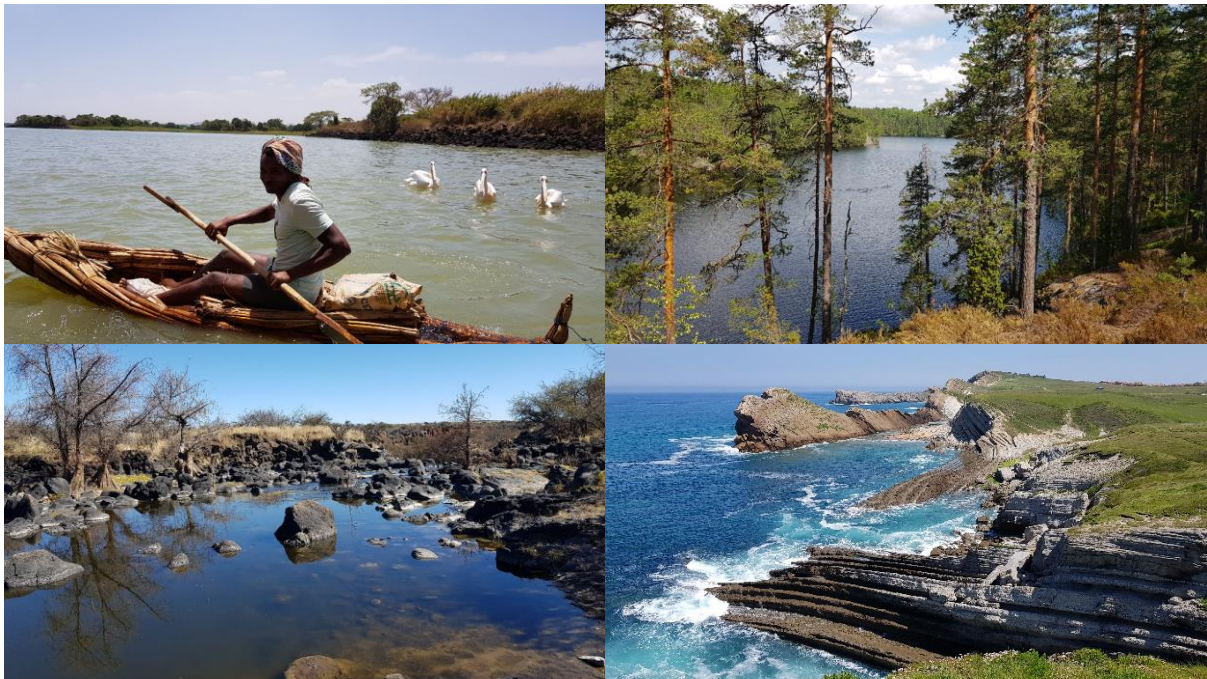
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EXCEED - SWINDON Conference 2019

THE FUTURE OF WATER RESOURCES

October 13th - 16th, Mérida, Mexico



Programme and Book of Abstracts

PROGRAMME

Sunday, 13 th		Arrival	
19:00	-	21:00	Welcome cocktail

Monday, 14 th		Conference Day 1	
08:30	-	09:00	Registration
09:00	-	09:30	Opening Ceremony <ul style="list-style-type: none"> • Norbert Dichtl • Andreas Haarstrick • Rodolfo Silva • Local authority
09:30	-	10:00	Keynote speech <ul style="list-style-type: none"> • Norbert Dichtl
10:00	-	10:10	Break
Session 1: The impact/performance/role of SDGs Chairman: Valeria Chávez			
10:10	-	10:30	Exploring some ocean energy possibilities in Latin America (Jassiel Hernández)
10:30	-	10:50	Water energy nexus in the MENA region (Abbas Al-Omari)
10:50	-	11:10	Ocean energy and marine biodiversity affectations: a life cycle assessment review (Dora Ruiz-Méndez)
11:10	-	11:40	Coffee Break
Session 2: Water-Energy-Nexus (I) Chairman: Dwi Andreas Santosa			
11:40	-	12:00	Wastewater/waste to energy in MENA region: A review for opportunities (Zeinab Abou Elnaga)
12:00	-	12:20	Water-energy nexus in a wastewater treatment plant: Energy efficiency and recovery (Wang Hongtao)
12:20	-	12:40	From wastewater treatment plants to a resources recovery facility (Marcelo Nolasco)
12:40	-	13:00	Seasonal assessment of the energetic potential associated with salinity gradient: Champoton River, Mexico (Gregorio Posada Vanegas)
13:00	-	14:30	Lunch
Session 3: Water, ecosystem and socio-economic integrating aspects (I) Chairman: Germán Rivillas			
14:30	-	14:50	Decolourization and mineralization of acid green 25 dye through single and catalytic ozonation (Liliana Amaral Féris)

14:50	-	15:10	Adsorption of naphtholate-as dye in wastewater of batik industry using green synthesized zn layered hydroxyl salts (Sri Juari Santosa)
15:10	-	15:30	Adsorption of hexavalent chromium in coal beneficiation tailing in fixed bed column (Liliana Amaral Féris)
15:30	-	15:50	Kinetics of the adsorption of anionic and cationic dyes in aqueous solution by low-cost activated carbons prepared from sea cake and cotton cake (Ibrahim Tchakala)
15:50	-	16:10	Distribution of microplastics in water and sediment in a Biosphere Reserve (Cecilia Enriquez)
16:10	-	16:30	Evaluation of microplastics contamination in the margins of the Patos Lagoon in south of Brazil (Eduardo Saldanha Vogelmann)
16:30	-	17:00	Coffee Break
Session 4: Water, ecosystem and socio-economic integrating aspects (II) Chairman: Rodolfo Silva			
17:00	-	17:20	Hydrodynamic modelling of the Huave Lagoon System, Oaxaca (María Fernanda González Amador)
17:20	-	17:40	Impact effects of hard infrastructure in Salamanca Natural Park (Juan Carlos Caez-Perez)
17:40	-	18:00	The decision-making in face to coastal squeeze, analysis between social and economic impacts: Case study of Campeche, Mexico (Debora L. Ramírez-Vargas)
18:00	-	18:30	Keynote speech • Elvis Carissimi
20:00			Dinner

Tuesday, 15th		Conference Day 2	
Session 5: Water, ecosystem and socio-economic integrating aspects (III) Chairman: Arwa Naser Damen Hamaideh			
09:00	-	09:20	Dispersion of submarine groundwater discharges in reef lagoons and associated environmental effects (Arlett Rosado Torres)
09:20	-	09:40	Salt intrusions into a freshwater spring in a tropical coastal lagoon, Yucatán, Mexico (Xaní Malagón)
09:40	-	10:00	Variability of the saline gradient in a hypersaline coastal lagoon (Brenda Natalia Fitch Geymonat)
10:00	-	10:20	Sedimentation and water quality status of lake Tana, the headwaters of the Blue Nile, Ethiopia (Seifu A Tilahun)
10:20	-	10:40	An innovative approach to mitigate risks on the existing iron tailings dams in Brazil (Jose Araruna)

10:40	-	11:00	Urban sustainable water management and water efficiency improvement for buildings – a case study for Istanbul (Ahmet Baban)
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11:00	-	11:30	Coffee Break
Session 6: Water-Energy-Nexus (II) Chairman: Eduardo Saldanha Vogelmann			
11:30	-	11:50	Reverse electrodialysis for energy and water: coupled systems based in salinity gradients (Mateo Roldan-Carvajal)
11:50	-	12:10	Development of graphene oxide membranes for its use in reverse electrodialysis systems (Eddie López Honorato)
12:10	-	12:30	Development of graphene oxide based materials for water treatment (Ana Cecilia Reynosa Martinez)
12:30	-	12:50	Laboratory experiences on marine energy conversion devices for supplying electricity demand of remote coastal communities (Jassiel Hernández)
12:50	-	13:10	Plate type obstacles used for coastal protection and power generation (Luis Eduardo Pérez Paez)
13:10	-	14:40	Lunch
Session 7: Water, ecosystem and socio-economic integrating aspects (IV) Chairman: Thi Thanh Van Ngo			
14:40	-	15:00	Evaluating combinatorial water treatment by locally available materials (Chrispin Kowenje)
15:00	-	15:20	Desalination by capacitive deionization as a tool to provide drinkable water to small communities in the Brazilian semiarid (Luis Augusto Martins Ruotolo)
15:20	-	15:40	Fluoride ions removal from groundwater by alumina adsorption (Elvis Carissimi)
15:40	-	16:00	Bio-refineries: A new concept towards green energy production from agroindustrial wastewater (Víctor Alcaraz)
16:00	-	16:20	The importance of water and nutrients management in paddy fields as an effort to increase crop yields and producing an electrical energy through microbial fuel cells (Dwi Andreas Santosa)
16:20	-	16:50	Coffee Break
16:50	-	17:20	Keynote speech • Klaus Fricke
16:50	-	18:00	Panel discussion Moderators: Edmilson Santos de Lima and Norbert Dichtl
20:00			Gala dinner