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Erosion reduction in beach dunes, through the technological implementation for the sand-dead pelagic sargassum mixture treatment

Reducción de erosión en dunas de playa, mediante la implementación tecnológica para el tratamiento de la mezcla arena - sargazo muerto pelágico

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Abstract

The invasive presence of pelagic sargassum on the coasts has increased disproportionately in the last decade, causing great damage to the ecosystems of coastal and marine flora, and fauna, as well as the tourism sector, due to the fact that the sargassum when it enters into decomposition generates fetid odors, detachments of Ammonium concentrations and Hydrogen Sulfide H2S that together with hypoxic conditions were the mass death cause of species, therefore it is necessary to clean affected areas. The aim of this research was to analyze how to reduce erosion in beach dunes, through the technological implementation for the treatment of the mixture sand - dead pelagic sargassum. The methodology had a mixed approach to propose the application of centrifugation and precipitation technologies to significantly reduce beach dunes erosion. However, the machines that do not have this process present a sand-sargassum mixture as residue that, when removed, erodes the dunes. The results obtained were the proposal for the implementation of a new complementary process to those carried out by beach cleaning machines to reduce erosion, in addition to compacting the sargassum for its transfer optimization.

Pelagic sargassum, Beach dune erosion, Beach cleaning

Resumen

La presencia invasiva de sargazo pelágico en las costas ha incrementado de forma desmedida en la última década, provocando grandes afectaciones a los ecosistemas de flora, fauna costera y marina, así como al sector turístico, debido a que el sargazo al entrar en descomposición genera olores fétidos, desprendimientos de concentraciones de Amonio y Sulfuro de Hidrógeno H2S que en conjunto con condiciones hipóxicas fueron la causa de muerte masiva especies, por ello es necesario la limpieza de zonas afectadas. El objetivo de esta investigación fue analizar cómo reducir la erosión en dunas de playa, mediante la implementación tecnológica para el tratamiento de la mezcla arena - sargazo muerto de mar. La metodología tubo un enfoque mixto para proponer la aplicación de tecnologías de centrifugado y precipitación para disminuir la erosión de las dunas de playa significativamente. Sin embargo, las maquinas que no cuentan con este proceso presentan como residuo una mezcla de arena- sargazo que al retirarlo erosionan las dunas. Los resultados obtenidos fueron la propuesta de implementación de un nuevo proceso complementario a los que realizan las máquinas de limpieza de playa para disminuir la erosión, ademas de compactar el sargazo para su optimización de su traslado.

Sargazo pelágico, Erosión de dunas de playa, Limpieza de playas

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Introduction

The Sargassum Sea is a region of the Atlantic Ocean delimited by four currents that form an oceanic gyre and present land boundaries, NGS 2011, and Ocean Service NOAA.gov 2017. This is located near Bermuda, between 20° and 35° north and 40° and 70° west, and is 1,100 kilometers wide by 3,200 kilometers long, this western fringe of the sea. The Sargassum Sea is bounded by a system of clockwise ocean currents, to the west by the Gulf Stream, to the north by the North Atlantic Current, to the east by the Canary Current, and to the south by the Atlantic Equatorial Current. North NGS 2019 and Greenpeace 2014.

A technical report determined that the specific limits of the Sargassum Sea were between "22° and 38° N, 76° and 43° W and centered at 30° N and 60° W" with a total of 4,163,499 square kilometers. The report considered variables such as ocean currents, algae's presence, and the ocean floor (Wilson, 2010).

All the currents deposit the marine plants and debris that they carry to this sea; however, the ocean water in the Sargassum Sea is distinguished by its deep blue color and exceptional clarity, with underwater visibility up to 61 m FEE., 1958 and Heller, 2000. The first known written account of the Sargassum Sea dates from Christopher Columbus in 1492 SPA. 2011. This may have been known to sailors previously, because in a poem by the author Avienius, at the end of the 4th century, he describes a part of the Atlantic covered with algae and without wind, citing a now lost account of the 5th century BC, the Carthaginian Himilco the Navigator Akyeampong, 2012.

The Sargassum Sea is home to algae of the genus Sargassum, which float a masse on the surface. Sargassum is not a threat to shipping, Shaw *et al*., 2014. The diversity of microbial life through metagenomic samples from the Sargassum Sea taken during the year 2000, as part of the Global Ocean Sampling survey, the identified result that the area has a wide variety of prokaryotic life. Ryther, 1956. In addition to the fact that the sargassum currents accumulate a high concentration of garbage and non-biodegradable plastic waste. Brian *et al*., 2017,

The Sargassum Sea plays a very important role as a refuge in the phenomenon of hatching of species; Loggerhead sea turtles, fish (sargassum, toad), eels (catadromous, European, American), American conger, among others, and as they grow they travel in ocean currents to different positions on the globe, taking advantage of marine sargassum as a habitat that generates protection against predators until they reach maturity and then migrate back to the Sargassum Sea to breed and the life cycle begins again Dickey *et al*., 2011.

For these reasons, several nations and non- governmental organizations have come together to protect the Sargassum Sea. Crocker *et al*., 1898. These organizations include the Sargassum Sea Commission Jolley, 2005, established on March 11, 2014, by the governments of the Azores (Portugal), Bermuda (UK), Monaco, UK, and USA.

Proliferation of the Transatlantic Pelagic Sargassum Belt and its impact

The impact of climate change on sea currents has been more favorable for the proliferation of algae, Lapointe *et al*., 2021. Macroalgae blooms of the genera Ulva and Sargassum pelagic (Sargassum fluitans and Sargassum Natans) generate immense amounts of floating tidal green and gold algae, which are carried by currents and winds inundating coastlines and affecting a multitude of species. Floating rows of algae seasonally affect the Caribbean forming a "transatlantic sargassum belt" stretching from the Gulf of Mexico to West Africa Putman and. the abundance of sargassum on beaches today has increased 200-fold when compared to 2015 Maurer *et al*., 2019

Sargassum stranded on beaches by natural wave carry, wind energy, and redistribution through cleaning can alter subterranean thermal sand environments for nesting and incubation of sea turtle eggs with changes in embryonic survival, Johns *et al*., 2020. Previous studies of turtle reproductive environments that consider variables attached to the reality of reproduction and with effects on sargassum coverage determined that a large amount of macroalgae represents a blockage for females that try to access the sandy nesting substrate Maurer *et al*., 2015; Ricardo and Martín, 2015, as well as for the hatchlings that seek the sea after leaving the Gavio and Santos-Martínez nests, 2018.

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In addition, the incubation temperature between 29°C and 29.5°C, suffered an increase of 0, 21°C in autumn Maurer et al., 2021a, Maurer et al., 2021b, and a decrease of 0.17°C in summer, over which the percentage of female offspring increased from 17% at 85%, and Andrew S. *et al*., 2022.

In 2018, the Mexican Caribbean coast received a massive influx of pelagic Sargassum SPP. that accumulated and decomposed on the beaches turning the water brown in color. The mortality of fauna associated with massive stranding and decomposition of pelagic sargassum due to a combined effect of high concentrations of ammonium and hydrogen sulfide H2S, together with hypoxic conditions, was the cause of massive death of organisms belonging to 78 species such as demersal neritic fish, crustaceans, mollusks, echinoderms, and polychaetes.

Various proposals for solutions aimed at cleaning Sargassum SPP have been implemented, among which manual cleaning (workers with industrial safety equipment and with manual tools), and mechanical cleaning (use of motorized pumps, sargassum boats, tractors with automatic collection systems) stand out. and the implementation of barriers to divert pelagic sargassum to locations on the beach, and adjacent coral reef lagoons where collection and transport are easier. This last measure could affect the reef fauna if the algae are allowed to die and sink, potentially harming reefs in the region Rodríguez-Martínez *et al*., 2019.

Research methodology

This research had a mixed approach, applying both quantitative and qualitative technologies, using systematic processes, as well as records and estimated data. The objective of this research was to analyze how to reduce erosion in beach dunes, through the technological implementation for the treatment of the sand mixture - dead pelagic sargassum. For this, the application of the quantitative method was relevant in the identification of previous studies that identify the control variables involved in beach cleaning, as well as records of results obtained by different Companies, Government Agencies, Institutes, and Monitoring Centers in time. of the impact of sargassum on the coasts.

The application of the qualitative method allowed the possibility of obtaining results from the estimation of variables that played an important role in decision-making for the implementation of actions to clean beaches with the invasive presence of sargassum. The operational data resulting from this investigation determined that the beach cleanup brought with it adjacent problems such as uncertainty in how to implement the cleanup, and erosion of the dunes on the beaches, among others. Finally, by the mixed method, an analysis of the impact of sand erosion on dunes was carried out, analyzing variables such as the structure of the sargassum, humidity, adhesion, and the estimation of the erosion that occurred due to the waste of the sand-dead sargassum mixture. pelagic. From the results obtained, a discussion of the results generated on the technological proposal that meets the parameters of sustainable development to prevent erosion in beach dunes was carried out.

Beach cleanup

According to a study carried out by Jhoan Sebastián García and Kevin Jean Pool Penagos, it was found a lower degree of inclination is necessary to reduce erosion, this conclusion was reached through a study to reduce erosion on slopes, however, works coastal. There are variations due to the particularities of each case. Penagos 2022, Arevalo-Quintero, 2022. Water erosion is considered the most important because it involves losses due to the action of water. Jáuregui Estupiñán explains that urbanization projects generally cause erosion processes, wearing away large areas of a non-renewable resource, the soil.Beaches require continuous cleaning processes that transform them into ecological, attractive, healthy, safe environments, free of garbage and dangerous sharp objects that can endanger the health of the species that inhabit them and their visitors.

Beach cleaning methods that comply with sustainable development techniques should be considered, for which cleaning stages can be carried out according to the amount of contaminants and their origin. Cleaning can be done manually, using automated electromechanical technologies and indirect zone isolation techniques.

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Beach cleaning machines remove and turn over huge amounts of sand, exposing moisture to the surface, oxygenating the sand and the sun's rays fulfilling their natural function of eliminating bacteria, fungi, and viruses, transforming the sandy mass into spongy, attractive and clean for the species. marine and tourism.

The disinfection of the beach is carried out prior to the removal and turning that generates oxygenation. This process is carried out in a controlled manner, releasing a natural disinfectant through spray nozzles during various sieving stages of the cleaning process, which does not affect the life of vertebrates, fish and only eliminates bacteria, fungi, and viruses.

The elimination of large amounts of waste on beaches that accumulate due to the action of uncontrolled dumping or dragging to land by the tides, industrial and fishing activities, is achieved through the process of removal, turning, sifting, disinfection by spraying (liquid based on neutral quaternary ammonium compounds, odorless, tasteless, non-toxic, does not alter the pH of the water and does not irritate the nose, eyes or mucous membranes, does not contain chlorine or copper), aerated and exposed to ultraviolet rays.

Removing accumulated waste on the beach every day or at least three times a week is recommended. In the case of sargassum and algae, it must be removed before they begin their decomposition process, which will be identified by a change in color, bad odors and the proliferation of insects Unicorn 2022.

Specialized beach cleaning machinery

The beach cleaning machines guarantee optimal cleaning of the sand and offer the peace of mind of leaving the beach free of sharp or dangerous objects that could endanger the health of visitors. The current models are the result of more than 35 years of experience. These carry out the process of sifting the sand, returning it to the beach, and separating it from the algae or sargassum easily and comfortably. The front compress adapts to all types of algae and allows working at a constant speed, in addition to offering automatic unloading through a large capacity rear hopper and can reach 2.5 m in height, working depth from 0 to 0.3 m, machine width 2.5 m, hopper capacity 2 m3, tare weight 3 120 Kg, noise from 70 to 80 dB.

They have a very robust chassis and with the option to be made of galvanized materials or stainless steel. The control of the machine is very intuitive and easy, it can be operated by anyone capable of driving a tractor. The hydraulic system allows independent control of the speed of rotation of the pick-up and the speed and direction of rotation of the mesh screen. The machine must be coupled to a 4x4 tractor with pneumatic wheels whose required traction power is between 80 and 100 C.V., Unicorn 2022.

Recommendations for purchasing a beach cleaning machine

A market analysis between existing brands is essential to determine which is the appropriate machine for beach cleaning. This analysis must include a list of the client's requirements according to the business or government sector. The technical characteristics of the beach cleaning machines offer characteristics of the machine, but not of the coupling tractor, for this reason, you should consider the cost of the beach cleaning machine plus coupling attachments and coupling machines.

The technical characteristics of the beach cleaning machine are restricted on the sales web pages, for this reason, the manufacturer offers some videos and field demonstrations as part of its promotions, however, you must consider that the ideal beach cleaning machine does not exist. and your expectations of cleaning efficiency could be well above what commercial brands of beach cleaning machines offer. The client must consider that in the purchase of a beach cleaning system there may be several cash or credit options and the different financing plans will increase the final cost of the machine.

The total cost of equipment or machinery is contemplated in several items such as the initial investment of the cost of the machine, payment of acquisition, and import taxes of the required machines, and in the case of making it tax deductible, you should consult with a financial representative. Payment of special permits before government agencies for the operation of machinery.

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Payment of comprehensive coverage insurance policies in case of loss or total theft with replacement machinery coverage until the insurance company issues the expert opinion and generates the remuneration of the commercial value, payment of extended policy of comprehensive coverage of maintenance and consumables of components that cover hidden defects by the manufacturer. Scheduled maintenance costs under machine warranties to qualify for the brand and extended warranty policy. Payment of wearing parts that are not covered by the guarantee because they are consumables required during the operation. Expenses for consumables such as fuel, cleaning fluids, and transfers if required, remember that it is low-speed heavy machinery and requires special transportation for transportation on federal highways and expressways. Operator salaries, benefits, services, and insurance policies.

An exhaustive analysis of amortization of the cost of the machinery at lost value plus direct and indirect costs will be essential so that you can determine the hourly machine cost to identify its profitability based on the operating efficiency of the machine according to the design of the maker.

Limitations of beach cleaning machines

Beach disinfection machines offer an optimal cleaning of the dune from foreign objects of different kinds, however small they may be, and disinfection of this Unicorn 2022. However, the reality is that the ideal machine does not exist, and to achieve Optimum cleanliness should be considered ideal conditions in operation, which are directly related to the manufacturer's test conditions where the machines were calibrated and tested under controlled conditions, which set certain parameters for sample control of machine operation for optimization. of parameters in the laboratory.

It must be considered that the beach cleaning machine may present variations when changing the test conditions to real conditions, where the volume of sargassum increases, it is distributed in a non-uniform way, it has different percentages of humidity, there is a mixture of live sargassum with characteristic properties of natural fiber in optimal conditions of the species and dead sargassum where its physicochemical characteristics and mechanical properties change.

The granulometry of the sand is not controlled, the slope from the dune to the beach and the topographic slope of the area present irregularities, the chemical composition of the sand is based on sediments of different indoles and adherence to the structure of sargassum, etc. All these laboratory test parameters in an idealized way are the basis for the technical specifications of machinery with a great technological development that support years of technological development and experience in its designs.

However, when the machine is subjected to fieldwork in real conditions, the test parameters tested in the laboratory do not agree with the technical data sheets due to the variation of parameters and it is understandable that varying the input conditions in an uncontrolled manner, the output will be unpredictable. On the other hand, this does not mean that the machinery has a bad engineering design, but all the machines undergo optimization based on the improvement of the design, involving the house of quality with greater rigor that makes it perfectible. A machine to present expected parameters in tests with repeatability expected by the customer, the manufacturer establishes input parameters or adheres to standards for compliance.

In the case of beach cleaning machinery of different brands and capacities, it has been possible to identify that after the cleaning recommended by the manufacturer, the machine presents residues of a mixture of crushed sargassum with the presence of a large amount of sand, even though it has passed through the screening process, because the wet sand adheres to the structure of the sargassum, generating an erosive phenomenon of the beach dunes. This phenomenon of tribological wear due to erosion must be treated with an additional machine that, once the cleaning has been generated with the beach cleaning machine, the residues of the dead pelagic sargassum-sand mixture are treated to prevent the erosion of the dune on the beaches by separation by centrifugation and decantation with the addition of water through a pump for dirty liquids or with the presence of soft solids. This process will separate the sand from the sargassum, and the sand will be reincorporated into the dune, while the sargassum can be compacted in a hydraulic compacting machine to reduce transportation costs to the certified collection site for dead sargassum for decomposition.

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Continuous monitoring through technological systems of sargassum tidal waves

The development of a detection and monitoring system for sargassum stranding in advance is of great importance. Previous knowledge of the occurrence, magnitude, and movement of sargassum will help places with the possibility of impact to prepare and respond appropriately to sargassum events for the proposal of strategies for attention to collection and tourism guidance, among other activities.

In recent years, systems based on satellite images have been developed. However, in these, the sargassum beds are barely visible, due to their size. So, the images alone are not enough to determine the real risk, making it difficult to predict the arrival of sargassum on the beaches, which is why the help of coastguards, fishermen, and aircraft is required. Of sargassum and it is estimated that the sargassum island is made up of 10 million tons Hinds *et al*. 2016., so there will be no human effort that can clean it entirely.

In the event of massive strandings in coastal areas, the sargassum must be removed as soon as possible after its arrival. to prevent large accumulations of algae along the tide line which break down and serve to trap more weeds in the water and form dark brown plumes near the shoreline. Prioritize which beaches will be cleaned and which will be left untouched Hinds *et al*., 2016.

The algae must be cleaned quickly before they decompose, that is, within 48 hours according to previous studies Hinds et al., 2016., before the concentrations of Ammonium and Hydrogen Sulfide H2S are released puts the health of workers at risk.

Portable Hydrogen Sulfide meters will ensure H2S levels stay within healthy limits. The minimum detectable concentration is 0.05 and when reaching values of 5 ppm, workers must be equipped with masks. When levels exceed 10 ppm, the affected area should be evacuated, due to eye irritation, headaches, nausea, or difficulty breathing, a concentration of 50 ppm or less is indicated as not recommended access for sensitive people, and a concentration of 100 ppm or more: Effects can be life-threatening and include shock, convulsions, inability to breathe, coma, and even death.

According to the US Occupational Safety and Health Administration, rotten egg odor first becomes noticeable at a concentration of 1.5 ppm and a concentration of 3-5 ppm special mask is required to withstand odors and above 30 ppm, "the smell is described as sweet or revolting".

A strategic plan sequenced for the proper storage and removal of sargassum, garbage, etc. must be generated. that are found on the beaches with different techniques, both manual and automated, because the requirements will depend on the conditions of the area to be cleaned due to its use and factors of the presence of species in their natural habitat that will influence the cleaning strategy and method in harmonious and ecological coexistence with the environment Maurer *et al*., 2021a. But it is very important to establish that the sargassum begins its decomposition when it is stagnant or out of the water and that the maximum time for its cleaning will be 48 hours before it begins to release Hydrogen Sulfide H2S. Hinds et al. 2016.

Avoid the use of cleaning equipment and machinery in the presence of bathers on beaches because heavy machinery on wet sand can be unpredictable in its control and handling. For this reason, it is recommended to make a strategic daily cleaning plan with scheduled cleanings during the early hours of the morning and after 6:00 in the afternoon, where tourist activity must be restricted on beaches and take advantage of the hotel infrastructure to speed up cleaning work. and avoid accidents.

The implementation of infrared cameras on heavy machinery, directed toward the work area, is recommended to identify living species in the beach area or between the agglomerations of sargassum layers. Therefore, in the operation of heavy machinery, an operator and a person specialized in the identification of species through thermal images are required.

Limitations for the acquisition of specialized machinery for sargassum cleaning

The governments and the hotel sector of the affected areas have redoubled their efforts to deal with this phenomenon that fills the beaches with sargassum, however, most low-budget hotels and hostels do not have the means to clean their beaches daily.

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And no matter how much effort and commitment they put into hiring cleaning staff manually, they are outmatched in the battle against sargassum. In a process of competition between the hotel sector, slogans are made if you are thinking of visiting a coastal area, avoid sargassum during your visit, make sure you stay in a hotel that has technology and staff that constantly monitors the constantly changing situation, and has the means to address the issue for your enjoyment.

The problem of clean areas of sargassum is not only the responsibility of the hotel sector, but it is also of all those involved coordinated by Governments, Dependencies, Institutions, and Monitoring Centers with the management and allocation of local, state, national, and international economic funds united in fighting to the sargassum invasion.

Machinery and equipment for the reduction of erosion in beach dunes, through the technological implementation for the treatment of the sand mixture - dead pelagic sargassum

The use of beach cleaning and disinfection machinery is made up of a tractor and a cleaning machine, but the addition of machinery in the cleaning process is essential to prevent sand erosion from beach dunes. The waste after cleaning has large concentrations of sand adhered to the structure of the sargassum, so when it is discarded, the dune erosion process takes place. To generate an alternative solution that contributes to the solution of this problem, the incorporation of a mixer is proposed that, by incorporating the dead pelagic sand-sargassum mixture and a washing process with water, spins the sargassum and precipitates the sand at the bottom. of the container. The sargassum adheres to the walls of the container and it will be easy to remove it with a manual tool, while the sand will settle to the bottom of the container together with the water, so it can be poured directly onto the beach for distribution. The dead pelagic sargassum may be compacted using a hydraulic compactor to reduce its transfer volume and density concerning the mixture, optimizing transportation costs to the sargassum collection center for decomposition, see figure 1.

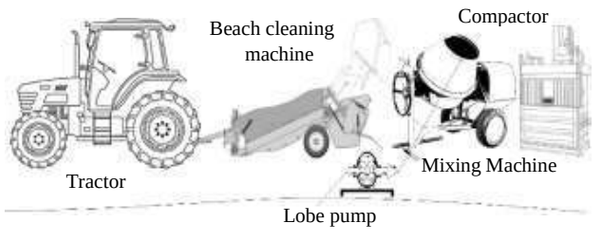

Figure 1 Beach cleaning system to prevent erosion of sand dunes

The proposed pump is a lobe pump: with two shafts that mesh with each other, but do not touch due to the use of synchronization gears. This enables the smooth pumping of liquids containing soft or brittle solids or shear-sensitive viscous liquids. They are used in sanitary applications in the food, beverage, pharmaceutical, and biotech industries. This required pump is of low flow because it will only be used to rinse the sargassum during the centrifugation process, making a process of sustainable development. The built-in equipment has proven designs for years, is easy to find anywhere, requires minimal maintenance, and, above all, is cheap compared to the replacement of sand and the ecological damage caused by the erosion process.

Conclusions

An analysis of the residuals of the cleaning methods allowed to propose additional cleaning processes to reduce the erosion in beach dunes. The implementation of existing machinery and equipment made it possible to effectively resolve the treatment of the sand-dead sargassum mixture, adhering to sustainable development parameters, and considering the variables that affected the line machinery screening process.

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