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Presentation of the Content

In the first article we present, *Reduction of fluorides present in drinking water in the municipality of Calera de Víctor Rosales Zacatecas, using chitosan gel beads* by GONZÁLEZ-MARTÍNEZ, Enrique Iván, GARCÍA-GONZÁLEZ, Juan Manuel, CONEJO-FLORES, Ricardo and GUZMÁN-PANTOJA, Javier, with adscription in the Universidad Autónoma de Zacatecas and the Instituto Mexicano del Petróleo, as a second article we present *Comparative Study of Fat and Oil Contaminants in the localities of the Grijalva river basin in the years 2019 and 2020 in Surface Waters of Frontera, Centla, Tabasco* by REYES-HERNANDEZ, Guadalupe, SUAREZ-GARCÍA, Sandra Manuela, VAZQUEZ-AGUILAR, Clotilde and ZARATE, Marco Antonio, with adscription in the Instituto Tecnológico Superior de Centla, as the following article we present, *Production of four varieties of Cocoa (Theobroma cacao L), in Úrsulo Galván, Veracruz, Mexico* by GARAY-PERALTA, Ignacio, HERRERA-ALARCÓN, Jesús, DÍAZ-CRIOLLO, Alfredo and ESCUDERO-RAMÍREZ, Leira Carol, with adscription in the Centro de Investigación Atmosférica y Ecológica Sede Banderilla and the Tecnológico Nacional de México Campus Úrsulo Galván, as the last article we present, *Erosion reduction in beach dunes, through the technological implementation for thesand-dead pelagic sargassum mixture treatment* by JIMÉNEZ-ROANO, Guadalupe, CRUZ-GOMEZ, Marco Antonio, MEJÍA-PÉREZ, José Alfredo andFLOREZ-MARTINEZ, Guillermo, with adscription in the Benemérita Universidad Autónoma de Puebla.

Content

Article **Journal-Agrarian and Natural Resource Economics**
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Reduction of fluorides present in drinking water in the municipality of Calera de Víctor Rosales Zacatecas, using chitosan gel beads

Disminución de fluoruros presentes en agua potable del municipio de Calera de Víctor Rosales Zacatecas, usando perlas de gel de quitosano

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Abstract

The quality of water distributed to the population in Zacatecas shows a deficit due to contaminants such as fluorinated compounds that exceed the limits allowed in the volumes of water used as a source of public supply. The objective of this work is to reduce the concentration of fluorides present in the drinking water of the municipality of Calera de Víctor Rosales, Zac., by using PVA cross-linked chitosan gel beads. An initial sample from a public supply was characterized, showing a fluoride concentration of 5.3 ppm, a value higher than the limit set in NOM-127-SSA1-1994. Batch experimentation was carried out at different degrees of sample dissolution with stirring conditions temperature of 450 rpm and 18.5 ºC, respectively, in volumes of 150 mL and 0.3 g of chitosan gel beads. The adjustment of the experimental data to the various models of isotherms and adsorption kinetics was carried out; of these, the Freundlich isotherm and the pseudo-second order kinetic model are the models with the highest correlation to the experimental data. In addition, an average fluoride decrease of 80.08% was achieved in the samples with the established conditions.

Fluorides, Adsorption, Chitosan

Resumen

La calidad del agua distribuida a la población en el estado de Zacatecas muestra un déficit debido a contaminantes como compuestos fluorados que superan los límites permitidos en los volúmenes de agua empleados como fuente de abastecimiento público. El objetivo del presente trabajo es disminuir la concentración de fluoruros presentes en el agua potable del municipio de Calera de Víctor Rosales, Zac., mediante el uso de perlas de gel de quitosano reticuladas con PVA. Se caracterizó una muestra inicial proveniente de pozo de abastecimiento público, arrojando una concentración de fluoruros de 5.3 ppm, valor mayor al límite marcado en la NOM-127-SSA1-1994. Se realizó experimentación por lotes a diferentes grados de disolución de la muestra con condiciones de agitación y temperatura de 450 rpm y 18.5 ºC, respectivamente en volúmenes de 150 mL y 0.3 g de perlas de gel de quitosano. Se realizó el ajuste de los datos experimentales a los diversos modelos de isotermas y cinéticas de adsorción; de estos, resultan la isoterma de Freundlich y el modelo cinético de pseudo-segundo orden como los modelos con mayor correlación a los datos experimentales. Además se logró una disminución de fluoruros promedio del 80.08% en las muestras con las condiciones establecidas.

Fluoruros, Adsorción, Quitosano

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1. Introduction

Water is an indispensable resource for human development. Of the total water present on the planet, only 2.5% is available as fresh water, suitable for consumption. Only small amounts of freshwater from the shallow rivers, lakes and aquifers that are the Earth's main water resources can be easily exploited. However, these resources are not exempt from containing contaminating substances or species of a natural or anthropogenic nature, which implies a latent risk to human health, examples of which are arsenic and fluorine, the latter being found in various minerals, such as topaz, fluorite and fluorapatite, to name a few.

Given the poor solubility of these rocks and minerals, the concentration of F- in natural waters does not usually exceed mg/L on average, and may be much higher in volcanic areas rich in fluorinated rocks and in some mineral waters. In the state of Zacatecas, located in central Mexico, groundwater naturally contains high amounts of arsenic and fluoride. Studies carried out by Martínez et al. (2016), show that approximately 90% of samples taken in public supply intakes exceeded the levels established by the WHO and 43% exceeded the limits allowed by NOM-127-SSA1-1994 in terms of As content and 43% exceeded the limits for fluorides set in the same standard.

The intake of high doses of F- in constant periods can result in the formation of dental and skeletal lesions, as well as negative effects in the endocrine, renal and even neurological fields (Alarcón-Herrera *et al*., 2020).

The study area has as its main hydrological source of supply the Calera aquifer, which is located in the central zone of the State, in an area of low availability of surface water, in which the largest industrial and agricultural activity of the State is located, for what is of the utmost importance is to ensure that the parameters are within the regulatory limits to guarantee an optimal quality of the water that is used to cover the demand of the productive sectors and in the same way to cover the supply in homes.

Its center-south area is made up of the municipalities of Enrique Estrada, Calera and Morelos, with an area of 766,447 km2, which represents 33.97% of the total area of the aquifer. It borders to the north with the municipality of Fresnillo, to the east with Pánuco and Vetagrande, to the south with Zacatecas and to the west with Jerez. In this area, the temperate semi-dry climate predominates with average annual temperatures of 14.6 to 16.6 °C, average rainfall of 425 mm per year and evapotranspiration of 2,263 mm per year (Flores-Rodarte, Cristobal-Acevedo, & Pascual-Ramírez, 2019).

The objective of the present is to reduce the concentration of fluorides present in the drinking water of the municipality of Calera de Víctor Rosales, Zacatecas, through the adsorption process using chitosan gel beads as adsorbent material, as well as to determine the possible adsorption load that may occur per gram of adsorbent. Being a current and constant problem, several conventional methods have been proposed for the removal of fluorides present in water, examples of which are electrocoagulation, reverse osmosis or the use of ion exchange resins to mention a few, however, there are certain drawbacks within its application such as operating costs, sludge generation or resin selectivity.

Examples of the most recent work on fluoride removal within the country are the application of the batch adsorption process using natural Mexican zeolites by (Sampedro Duran, 2018), which were obtained from the states of Oaxaca and Guanajuato and were later modified with Ca^{+}, Mg^{+} and Fe^{+} ions, obtaining removal percentages of 83% when dealing with the iron-modified zeolite from Guanajuato (ZCSF-Fe) after a stirring process at 120 rpm for 72 hours, the maximum adsorption load reported in said work with the zeolite ZCSF-Fe is 0.19mg of F-/g of adsorbent. Despite being a method that contemplates the prior management of a national natural resource, the drawback is the contact time necessary with the medium to be treated to achieve a considerable decrease in the fluorides present.

(Robledo-Peralta, López-Guzmán, Morales-Amaya, & Reynoso-Cuevas, 2021) tested removal methods such as electrocoagulation using aluminum and steel electrodes, in addition to varying the pH in two scenarios: pH=3 and pH=5, for which removal percentages of 41.51% and 55.50%, respectively, were obtained using only aluminum electrodes.

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These results show a considerable improvement by reaching 93.16% removal when using the steel and aluminum electrodes together in an environment conditioned at a pH of 3. The improvement is due to the fact that there is a greater release of Al^{+3} within the solution to be treated, so there is a greater number of coagulating species within the medium. It should be noted that, although the scene is more favorable in terms of the percentage of fluoride decrease, it also implies a greater generation of sludge, which is considered an inconvenience due to the impact they can have on the environment and also on the cost of operation of the process due to its treatment or disposal.

Similarly, these authors tested the use of bioadsorbents obtained from the peel of apple (*Citrus senesis*) and orange (*Malus domestica*), but impregnating them with zirconium oxychloride ($ZrOCl_2 \cdot 8H2O$); for pH of 3, removal percentages were obtained in a range of 69-85% after 60 minutes of contact under stirring conditions at 320 rpm and 93-95% after 1440 minutes under the same stirring conditions and pH.

(Wang *et al*., 2017) carried out modifications with lanthanum to bone debris in order to improve the adsorption capacity of fluorides in a batch process at 200 rpm, which lasted 24 hours, thus obtaining removals of more than 91% under pH conditions, 2.5-10, and decreasing to 81.9% when reaching a pH of 11.5, which may be due to a higher affinity of hydroxide ions towards adsorption sites compared to fluoride ions.

In the use of chitosan as a fluoride adsorbent molecule, (Pamila Tecuatzin, 2019) developed hydrogels synthesized with gamma radiation and grafted with dimethylacrylamide with the purpose of reducing the presence of fluorinated compounds and arsenic in the groundwater of Chihuahua, achieving better results for arsenic and reporting a decrease percentage of F- of 14% under its operating conditions.

The work carried out in comparison to those previously described uses a bioadsorbent in the same way however, the advantage of this lies in issues such as the use of waste from the fishing sector to obtain chitosan from chitin present in the exoskeletons of crustaceans.

In addition to offer better results when cross-linking the gel beads with polyvinyl alcohol (PVA) since a better mechanical resistance to impacts by the magnetic bullet is obtained within the batch process and removal percentages are higher than those shown by the study already carried out with chitosan in the form of a modified hydrogel in shorter periods of time.

2. Chitosan as bioadsorbent

Chitosan is a compound derived from chitin which comes from the exoskeleton of industrially processed crustaceans; as a natural polymer, it has great potential in different applications ranging from the area of health to agriculture, they have a wide advantage in the market for benefits provided by this polymer such as: its biodegradability, its non-toxicity and its biocompatibility (Romero, Sánchez, & Benavente, 2018).

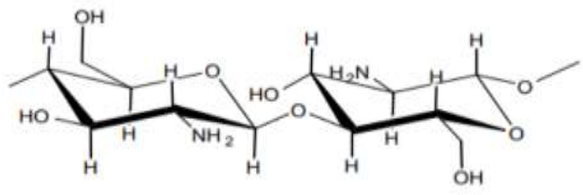

Figure 1 Chitosan structure. *(Vera, 2020)*

Various techniques have been used to physically modify chitosan and thereby condition the shape of the polymer, such as powder, nanoparticles and gels, the latter asbeads, membranes, sponges, honeycombs, etc. The mixture of chitosan with PVA has been reported as a good option to improve the mechanical and chemical properties of the material. PVA is a non-toxic, water-soluble, biocompatible and biodegradable synthetic polymer that offers good tensile strength and flexibility. Some of its applications have been in the field of biomedicine and biochemistry. On the other hand, it has also been used to remove lead in aqueous solution. However, the chitosan/PVA mixture has rarely been studied (Flores Alamo, 2016).

3. Adsorption

Adsorption is a method of mass transfer by which a substance is concentrated at the interface where the interfacial composition is different from the corresponding compositions within the phases.

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The process can be batch, semi-continuous and continuous. At molecular level, adsorption is primarily due to attractive interfaces between a surface and the adsorbing group. All adsorption processes rely on equilibrium and mass transfer rates. Depending on the type of intermolecular attractive forces, the adsorption could be physical or chemical (Baby Abrarunnisa, Devanna, & Chari, 2019).

There are two aspects that must be considered in the adsorption process: the effect of adsorption on the interfacial energy of the system in equilibrium and the speed of the adsorption process.

In the analysis of adsorption processes, equilibrium data are usually expressed as adsorption isotherms.

In recent years, linear regression analysis has been one of the most applied tools to define the most suitable adsorption model since it analyzes the adsorption system and verifies the consistency of theoretical assumptions of the adsorption isotherm model (Ayawei, Ebelegi , & Wankasi, 2017).

The type II isotherm is the Freundlich isotherm, in which it is assumed that the surface of the adsorbent is energetically heterogeneous, made up of groups of adsorption sites with characteristic energies.

It is also considered that there are no lateral interactions between the adsorbed molecules and that only one monolayer is adsorbed. It is used to describe the adsorption of aqueous solutions, although this type of isotherm cannot define the linear interval at very low concentrations or the effect of saturation at very high concentrations, which is why intermediate concentrations are used (Ureña Gómez, 2017). The mathematical expression is as follows:

$$q = K * C_{eq}^{\frac{1}{n}} \quad (1)$$

where K is the adsorption capacity constant, where the higher the value of K, the higher the adsorbent load that can be achieved; and is the adsorption intensity constant, which factor is related to the energetic heterogeneity of the adsorbent surface and isotherm and if n = 1, the graph becomes linear; isotherms with n>1 are considered unfavorable.

The linearized equation is expressed normatively in its logarithmic form:

$$Log\ q = Log\ K + \frac{1}{n}\ Log\ C_{eq} \quad (2)$$

One of the most important factors for the design of an adsorption system is to predict the rate at which adsorption will occur, the residence time of the adsorbate and the dimensions of the reactor, which will depend on the kinetics of the adsorption system.

Adsorption kinetics is expressed as the rate of solute removal that controls the residence time of the solute at the solid-solution interface. In adsorption studies, it is important to identify the involved mechanisms, which may include external diffusion, internal diffusion and chemical reactions. For this, there are kinetic models that are based on the reaction surface as the kinetic step that controls the rate of adsorption. These models include the pseudo-first-order kinetics, pseudo-second-order kinetics, and the intraparticulate diffusion equation.

The pseudo-second order kinetic model was proposed by Ho and McKay in 1999. In this model, the adsorbate is assumed to be adsorbed on two active sites. Since then, better fits of the experimental data to this model have been reported with respect to its predecessors (Carbonel Ramos, 2018).

The equation of this kinetic model is the following:

$$\frac{dq}{dt} = k_2(q_e - q_t)^2 \quad (3)$$

By integrating the expression from t=0 to t=t and rearranging the expression to make the graphic form, the following equation is obtained:

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^2} + \frac{t}{q_e} \quad (4)$$

where k_2 is the adsorption rate constant for pseudo-second order (g/mg*min), q_t and q_e remain the amount of adsorbate at time t and at equilibrium, respectively.

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4. Methodology to be developed

Based on the CONAGUA, SEMARNAT and Official Mexican Standards, NOM-014-SSA1-1993 and NOM-230-SSA1-2002, the water was sampled at different points in the city of Calera, Zac.; the samples were mixed to homogenize them, combining a volume of 20 L. For the physicochemical analysis, the Official Mexican Standard NOM-127-SSA1-1994 was used as reference. The following properties were determined: Hardness (a HANNA-Instruments HI3812 equipment was used); pH and conductivity (a HANNA-Instruments HI98130 equipment was used); chlorides (a HANNA-Instruments HI3815 equipment was used) and fluorides (a HANNA-Instruments HI739 equipment was used). For arsenic sorption tests on chitosan gel beads, a series of experiments were performed in batches. For the batch regime 150-mL samples were used, the concentration of fluorides in the sampled water was varied by adding deionized water, 0.3 g of chitosan gel beads were placed in each flask, stirred at 450 rpm on a stirring grid at a temperature of 18.5 °C ± 0.5 for 135 min to determine the adsorption model and the kinetic model.

5. Results

Table 1 shows the results obtained for the physicochemical characterization of the original sample collected in the supply well, as well as the standard deviation between the obtained data.

Parameter	Obtained value
Fluoride (ppm)	5.3±0.0
Hardness (ppm $CaCO_3$)	46 ±1.73
pH	8.19±0.37
Free chlorine (ppm)	0.5±0.0
Chlorine (ppm)	20±0.0
Temperature (°C)	18.46±0.30
Conductivity (mS)	0.47±0.025

Table 1 Characterizacion of drinking water from Calera, Zacatecas, from a supply well

Table 2 presents the results obtained from the sorption of arsenic in the cross-linked chitosan gel beads.

Knowing the concentration level of fluorides present at different times, the adsorption capacity of the beads can be calculated using the following expression:

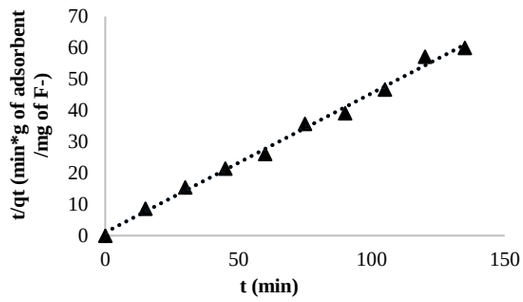
$$q = \frac{C_o - C_t}{m} * V \quad (5)$$

where q is the adsorption capacity, C_o is the initial concentration of fluorides in the untreated water (mg F-/L), C_t is the concentration of fluorides at a time "t" of stirring of the treated water (mg F-/ L), m is the mass of the adsorbent (g chitosan beads) and V is the control volume (L).

Time (min)	Fluoride (ppm)	q_t (mg F^-/ g)
0	5.30	0
15	1.80	1.75
30	1.40	1.95
45	1.10	2.1
60	0.70	2.3
75	1.10	2.1
90	0.70	2.3
105	0.80	2.25
120	1.10	2.1
135	0.80	2.25

Table 2 Results of the fluoride sorption process on chitosan gel beads

The batch process was considered stable after 135 minutes, since in subsequent measurements, the fluoride concentration values ranged between 1.10 and 0.8 ppm, so it was considered that the maximum adsorption capacity of the beads had been reached. It should be noted that the pH of the treated sample was in a range of 8.4-8.7 during the adsorption-desorption process and it was not necessary to acidify the sample. The sorption data of the process and its fitting to the pseudo-second order kinetic model are shown in Graphic 1.



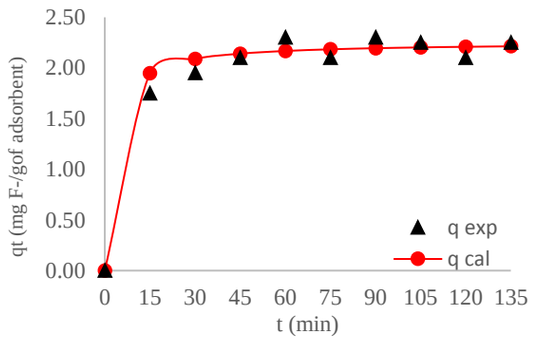
Graphic 1 Fitting of sorption data based on a pseudo-second order kinetic model

Compared to other kinetic models, this fitting shows a Pearson correlation coefficient (R^2) of 0.9943. With the equation in the graph, it was possible to calculate the values of k_2, q_e and h, the latter being the initial adsorption rate (mg/g*min) and whose equivalence is:

$$h = k_2 q_e^2 \quad (6)$$

The values obtained for these parameters were: qe= 2.25 mg F^- /g of adsorbent, k_2=0.19 g/mg*min and h=0.96 mg F^- /g of adsorbent*min.

Graphic 2 shows the relation of the values obtained experimentally with respect to those calculated based on the theory of the pseudo-second order kinetic model, for which an average error percentage of 4.69% was obtained according to the adjustment of the data.



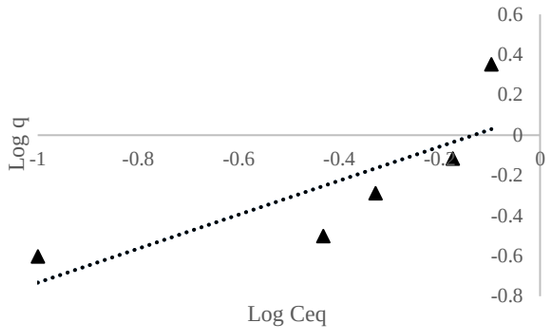
Graphic 2 Comparison of experimental data (q_{exp}) vs psuedo-second order model(q_{cal})

For the modeling of the adsorption process, dilutions of the sample to be treated were made, for which 0.3 grams of chitosan pearls were used in each system; in the same way, a time of 135 minutes was taken as necessary to achieve equilibrium. The results obtained are shown in Table 3.

Sample (ml) + deionized water (ml)	C_o (ppm)	C_{eq} (ppm)	q (mg F^-/ g)
150 +0	5.3	0.8	2.25
120+30	2.2	0.67	0.76
90+ 60	1.5	0.47	0.51
60+90	1	0.37	0.31
30+120	0.6	0.1	0.25

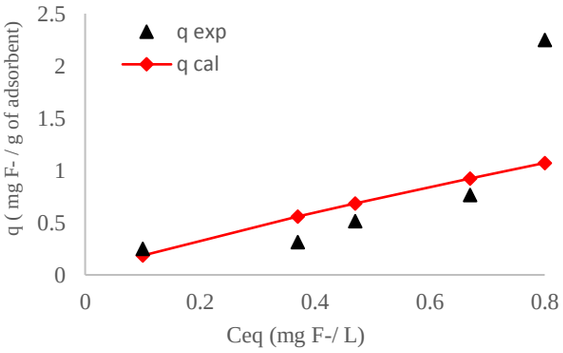
Table 3 Results obtained by varing the dissolution range of the sample

With the obtained values, the adjustment was made to the various models of adsorption isotherms, resulting in the Freundlich model, which presents a Pearson coefficient of 0.6395, the values obtained for K and n are 1.29 mg F^-/g of adsorbent and 1.18, respectively.



Graphic 3 Adjustement of the data with respect to the Freundlich adsorption model

With the obtained parameters, it was possible to calculate the theoretical adsorption capacity for each system. Graphic 4 presents the comparison between the experimental adsorption load values in relation to the theoretical load predicted by the Freundlich model. When adjusting the experimental data with respect to the theoretical data, there was an error of 45%.



Graphic 4 Comparison of experimental data (q_{exp}) vs the Freundlich adsorption model (q_{cal})

6. Conclusions

The established process conditions yielded favorable results in the reduction of fluorinated compounds through adsorption, with average efficiencies of 80%; this result opens the way to a new stage of experimentation in which the adsorption process through chitosan will be carried out continuously, with the implementation of the continuous process it is expected to minimize the contact times necessary to achieve the adsorption of fluorides at the levels obtained at the batch stage or even to improve the removal efficiency achieved so far.

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The pseudo-second order kinetic model fitted very adequately to the adsorption process that occurred in the chitosan beads, in addition to the fact that the maximum adsorption capacities obtained by this model and experimentally do not present a significant variation. On the other hand, it can be said that when coupling the data to the Freundlich model, being in an alkaline medium of pH 8-9, the adsorption sites may have been occupied by OH^- ions instead of F^- ions, so the adsorption capacity of F^- in most of the dilutions was lower than expected according to the theory.

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Comparative Study of Fat and Oil Contaminants in the localities of the Grijalva river basin in the years 2019 and 2020 in Surface Waters of Frontera, Centla, Tabasco

Estudio comparativo de los Contaminantes grasas y aceites de las localidades de la cuenca del rio Grijalva de los años 2019 y 2020 en agua superficial de Frontera, Centla, Tabasco

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Abstract

At a global level, rivers serve as receptors for large amounts of waste generated by human activities such as agriculture, industrial activity and domestic activities, on the other hand, they are an important source of water supply for both agricultural, industrial and domestic. Therefore, in recent years, receptors have been affected by pollutants, in the case of Contamination by fats and oils is a problem caused by activities such as: the existence of outboard motor repair shops, boat landings, discharges of water from houses-rooms, gas stations, public markets, yards, among others. The effects of these pollutants affect the public health of the population living outside the Grijalva basin, with the respiratory and skin conditions when in direct contact with these chemicals, even causing various types of cancer. For all of the above, the development of this research project was motivated, which will allow knowing the levels of contamination of fats and oils in the years 2019 and 2020 in the study area, being Arroyo Polo 1st and 3rd sections of Frontera, Centla, Tabasco, based on the comparison of the maximum permissible limits (LMP) of the NOM-001-SEMARNAT-1996. To evaluate the behavior and projection of the data, the Minitab version 18 software was used, where the analyzed data of the years 2019 and 2020 were taken to be able to indicate if there is a significant increase in later years. A trend towards an increase in contaminating fats and oils was observed. In the first sampling, the average concentrations of fats and oil were 5.23 mg/L. In the second sampling, the concentration of fats and oils was the lowest of 5.02 mg/L and the highest concentration was 6.23 mg/L. of the third and fifth sampling point, it is observed in both cases that there is a tendency towards an increase in contaminants. At the fourth sampling point, It is observed that there is a tendency towards the decrease of this contaminant. In both samples, the concentrations of fats and oils are below what is established by NOM-001-SEMARNAT-1996, since said norm establishes the maximum permissible limit of 25 mg/L per month.

Fats and oils, Physicochemical parameters, Water pollution

Resumen

A nivel global, los ríos sirven como receptores de grandes cantidades de residuos generados por las actividades humanas como la agricultura, la actividad industrial y las actividades domésticas, por otro lado, son una importante fuente de suministro de agua tanto para usos agrícolas, industrial y domésticas. Por lo anterior, en los últimos años, los receptores se han visto afectados por contaminantes, en el caso de la contaminación por grasas y aceites, es un problema originado por las actividades como: la existencia de talleres de reparación de motores fuera de borda, desembarcaderos de lanchas, descargas de aguas provenientes de casas-habitaciones, gasolineras, mercados públicos, cárcamos entre otras. Los efectos de estos contaminantes afectan en la salud pública de la población que se encuentran al margen de la cuenca Grijalva, con las afecciones en las vías respiratorias y de la piel, cuando se efectúa el contacto directo con estos químicos, llegando incluso a ser causantes de diversos tipos de cáncer. Por todo lo anterior, se motivó al desarrollo de este proyecto de investigación que permitirá conocer los niveles de contaminación de grasas y aceites en los años 2019 y 2020 en el área de estudio siendo arroyo polo 1era y 3era sección de Frontera, Centla, Tabasco, basándonos en la comparación de los límites máximos permisibles (LMP) de la NOM-001-SEMARNAT-1996. Para evaluar el comportamiento y proyección de los datos se usó el software Minitab versión 18, en donde se tomaron los datos analizados de los años 2019 y 2020 para poder señalar si existe un incremento significativo en años posteriores. Se observó una tendencia hacia el incremento de los contaminantes grasas y aceites. En el primer muestreo en promedio las concentraciones de grasas y aceite fueron de 5.23 mg/L. En el segundo muestreo la concentración de grasas y aceites fue la más baja de 5.02 mg/L y la concentración más alta fue de 6.23 mg/L. del tercer y quinto punto de muestreo, se observa en ambos casos que existe una tendencia hacia del incremento de los contaminantes. En el cuarto punto de muestreo, se observa que existe una tendencia hacia la disminución de este contaminante. En ambos muestreos las concentraciones de grasas y aceite se encuentran por debajo de lo que establece la NOM-001-SEMARNAT-1996 ya que dicha norma establece el límite máximo permisible es de 25 mg/L mensuales.

Grasas y aceites, Parámetros fisicoquímicos, contaminación del agua

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Introduction

Rivers are a clear example of surface water, defined as the natural current of water flowing through a riverbed, from an elevated place to a lower one, the great majority of which drain into the sea (Zarate, Luján and Laque, 2022) or into a lake, although some disappear because their waters seep into the ground or evaporate into the atmosphere. Throughout the world, rivers serve as receptors for large quantities of waste generated by agriculture, industrial activities, and domestic uses. They are an important source of water supply for both agricultural and domestic uses; in recent years, they have been affected by pollution.

The amount of water flowing through a river varies in time and space. These variations define the hydrological regime of the river. Temporal variations occur during or after storms as well as runoff that produces an increase in flow. In extreme cases, flooding can occur when the water input is greater than the river's capacity to evacuate it, overflowing and covering the nearby flat areas or floodplain. Derived from the phenomena that can occur other events such as: spills and filtration of diverse materials such as residual oils and greases derived from sources such as mechanic workshops and houses that are dumped anywhere without taking into account the precautions for their handling, represent two of the main pollutants that deteriorate the environment. According to experts, if the aforementioned waste and any other type of waste is not properly treated, it could cause serious problems to our environment. In particular, fats and oils contain a series of hydrocarbons that are not biologically biodegradable and destroy plant humus and soil fertility.

Oil in particular also contains toxic substances such as lead, cadmium and chlorine compounds, which pollute water, sediments and soils. Its action is also reinforced by the action of some additives that are added to it and that favor its penetration into the soil, thus contaminating groundwater. If poured into the water either directly or through the sewage system, used oil has a great capacity for environmental deterioration since it produces an impermeable film that prevents adequate oxygenation and can suffocate the living beings that inhabit it; a single liter of used oil contaminates a million liters of water.

One of the main problems faced by the population is environmental pollution, the result of poor waste disposal that has affected the quality of life of aquatic organisms.

A river is a system comprising both main flow and tributaries, which carry a significant load of dissolved and particulate matter in the unidirectional channel from both natural and anthropogenic sources (Shrestha and Kazama, 2007). The quality of these water bodies at any point reflects several important influences, such as watershed lithology, atmospheric inputs, climatic conditions, and anthropogenic inputs (Bricker and Jones, 1995).

The present study was carried out in the municipality of Frontera, Centla, Tabasco, where the main economic activities are engine maintenance in automotive mechanic workshops, motorcycle workshops, outboard motor workshops, car washing and greasing, establishments that process food using vegetable oils, as well as in homes. The aforementioned activities do not have adequate management in the generation of waste fats and oils and are discharged directly into the pipes or the tributary of the Grijalva River, causing the contamination of surface water by fats and oils. For all these reasons, this work was developed with the purpose of generating an environmental diagnosis, based on fats and oils contaminants, under the normative criteria of NOM-001-SEMARNAT-1996 for public urban use of rivers.

Problem Statement

A recent study has determined that water pollution is increasing by leaps and bounds, which is why more than a billion people do not have access to the minimum amount of clean water that every human being requires to meet their basic needs; likewise, more than 2 billion people lack basic services related to sewage effluents, therefore, every day more water bodies such as rivers, aquifers and seas are polluted. Rivers around the world serve as receptors for large quantities of waste generated by agriculture, industrial activities and domestic uses (Goudie, 2000). In Mexico, more than 70% of water bodies present some degree of contamination, which causes serious problems of availability and access to this vital liquid (CONAGUA, 2011).

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The high levels of contaminants, fats and oils, are a problem associated with the health of people exposed to the respiratory tract and skin, when in direct contact with these chemicals. Considering the study area in the Grijalva river basin, this research project was developed to allow a study prior to the diagnosis of the contamination levels of fats and oils for two years 2019 and 2020. It is worth mentioning that the area where the project was developed is where the main fishing and agricultural activities exist. By doing this type of study, we can solve the following problems:

- Prevent infectious diseases, whether cutaneous or internal.
- Prevent contamination by raising awareness among the inhabitants of the area.
- To make important decisions for the well-being of the inhabitants.
- Identify through the results issued by the coastal laboratory of Ciudad del Carmen, Campeche, the amount of contamination of fats and oils in the Grijalva river.

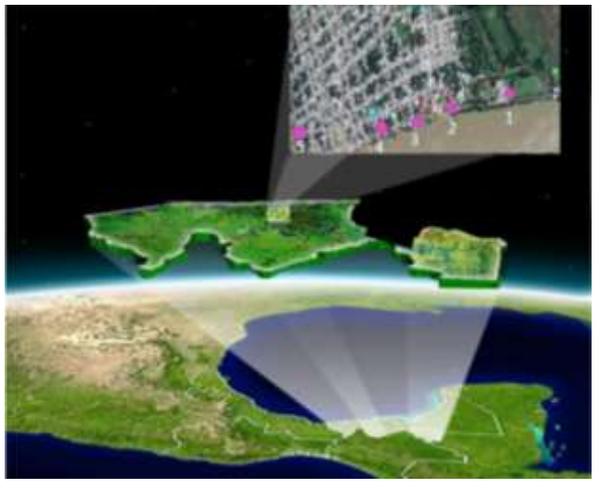
Objectives

- Identify the levels or concentrations of fats and oils that exist in the five sampling points and evaluate if there is an increase between each sampling year 2019 and 2020.
- To evaluate the behavior of the levels of fats and oils contaminants in subsequent years.

Methodology

a) Description of the sampling site

The municipality of Centla is located in the Mexican Republic in the state of Tabasco. The municipal seat is the city and port of Frontera. It covers an area of 3,093 square kilometers, which corresponds to 10.8% of the state's total; this places the municipality in fourth place in territorial extension. It is bordered to the north by the Gulf of Mexico, to the south by the municipalities of Macuspana and Centro, to the east by the state of Campeche and the municipality of Jonuta, and to the west by the municipalities of Centro, Nacajuca, Jalpa de Méndez and Paraíso.



Symbology
Sampling points:

1. House-home (arrollo polo 2da.seccion).
2. Fifth Naval Zone Battalion (arrollo polo 1st Section, Benito Juárez García Street).
3. Farmer's Market (Madero Street between Abasolo and Reforma).
4. Morelos Market (Francisco Madero, Colonia Centro).
5. Gasolinera Cosugo (Esteban Samberino #413, Colonia Centro).

Figure 1 Micro-location of sampling points

b) Criteria for determining sampling sites

The following criteria were used to determine the sampling points, thus defining the five sampling points for the two years of work.

1. Existence of outboard motor repair shops.
2. Boat landing sites
3. Discharges of water from residential homes
4. Gas stations (supply of fuel to boats).

c) Design and implementation of the sampling plan

Once the sampling points were defined, water samples were taken as established in NMX-AA-005-SCFI-2013, "From the surface of the water body, collect a volume of approximately 1 L of sample in a wide-mouth glass bottle with a plastic lid or Teflon back cover". The samples were simply taken and labeled as established in the aforementioned standard.

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First sample	Second samle
October 1, 2019	October 1, 2020

Table 1 Sampling Dates

d) Water sample processing

The following is a diagram of the processing of the samples in the laboratory.

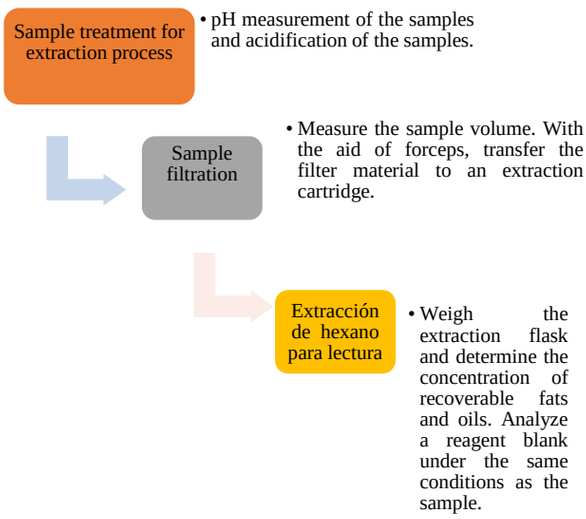


Figure 3 Sample procedure under the criteria of the NMX-AA-005-SCFI-2013

e) Data analysis and interpretation

To evaluate the behavior and projection of the data, the minitab software version 18 was used, the existence of data analyzed during the years 2019 and 2020 were taken to be able to indicate if there is a significant increase in subsequent years.

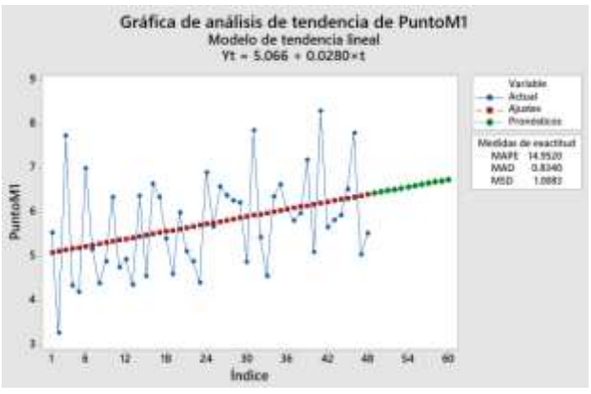
Results

The following are the results of the sampling carried out in October 2019 and October 2020 (Table 1), where the behavior of the concentrations of fats and oils can be observed, analyzed under the NMX-AA-005-SCFI-2013 standard, and compared with the maximum permissible limits (MPL) of NOM-001-SEMARNAT-1996.

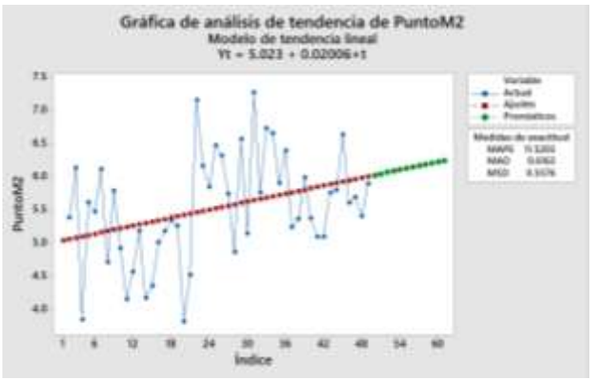
Site	Sample 2020	Sample 2019	Difference	LMP NOM-001-SEMARNAT-1996
1	≤6.23	≤5.25	0.98	25
2	≤6.12	≤5.37	0.75	25
3	≤5.51	≤5.16	0.35	25
4	≤5.02	≤5.21	-0.19	25
5	≤5.94	≤5.19	0.75	25

Table 2 Measurements of fats and oils concentrations of the sampling periods October 2020 vs. October 2019 of the samples supported by the methodology

In Table 2, it is observed that in the first sampling the monthly average of fats and oils is 5.24 mg/L of 2019, in the second sampling the monthly average of fats and oils is 5.76 mg/L of 2020. In both samplings, the concentrations of fats and oils are below what is established by NOM-001- SEMARNAT-1996, since this standard establishes a maximum permissible limit of 25 mg/L per month.



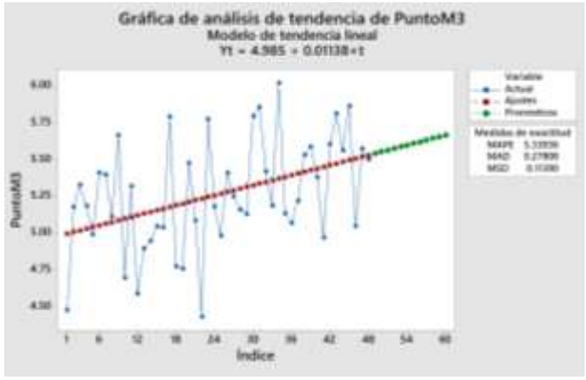
Graph 1 Trend of the first sampling point and behavior simulation



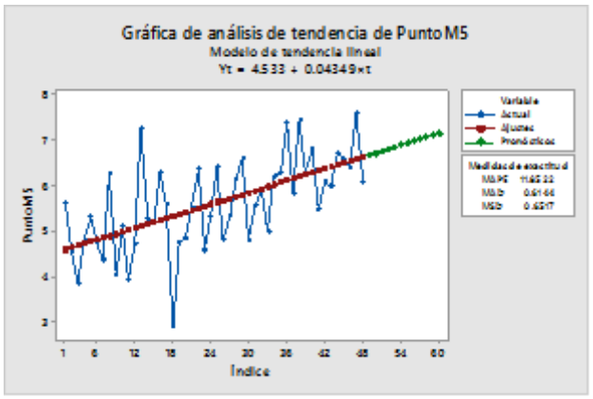
Graph 2 Trend of the second sampling point and behavior simulation

In the following graphs 1 and 2, a projection was made with data from the years 2019 and 2020 obtaining a projection for the years 2018 and 2021, of the first and second sampling points, it is observed that there is a trend towards the increase of fats and oil pollutants, it is worth mentioning that the first sampling point is located at a boat dock in Colonia Arroyo Polo 2nd section, The location of the second sampling point is located at the dock of the fifth naval zone facilities where loading and unloading activities are identified, as well as maintenance of the Secretary of the Navy vessels, and could indicate a significant increase in pollutants for the data obtained.

In both samplings 2019 and 2020, in sampling points 1 and 2, an increase of the pollutant grease and oil is observed according to the trends in graphs 1 and 2, considering that these values are due to the sampling season since they were sampled in October (rainy season) and as mentioned by Caho-Rogriguez and López-Barrera (2917), who register in their work the lowest concentrations of fats and oils in the rainy season, due to the higher rainfall, showing that an increase in the water level allows diluting their concentration more easily and facilitates the microbial activity for their degradation.



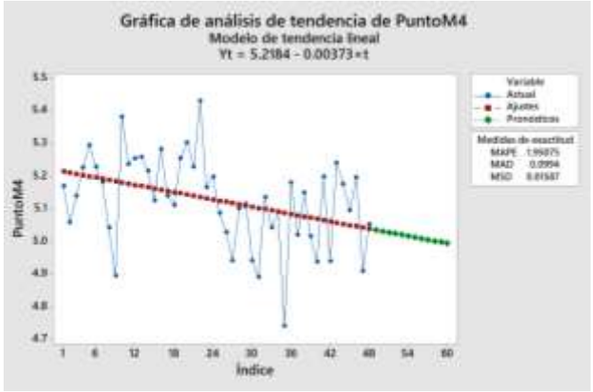
Graph 3 Trend graph of the third sampling point and behavioral simulation



Graph 4 Trend graph of the fifth sampling point and performance simulation

In graphs 3 and 4, a projection was made with data from the years 2019 and 2020, obtaining data in the projection of 2018 and 2021, from the third and fifth sampling points, where it is observed in both cases there is a trend of increase in pollutants, it is important to mention that this third sampling point is located in the facilities of a market called farmer in the municipal capital of Frontera, Centla, Tabasco, The fifth sampling point is located at the dock of the Cosugo gas station, where the main activity is the loading of fuel to the boats and the risk is that the outboard motors may have oil leaks into the body of water, this factor can be an influence in the generation of increased concentrations of fats and oils in the area.

As mentioned in the previous paragraph, the concentrations of fats and oils are largely due to the generating sources of domestic wastewater discharges, mechanical workshops and activities such as cleaning boat engines, the presence of fats and oils allow measuring the degree of contamination of the surface waters under study, since it is an indicator of the solubility of other substances that may be in the environment Caho-Rodríguez and López-Barrera (2017).



Graph 5 Trend graph of the fourth sampling point and behavior simulation

In graph 5, a projection was made with data from the years 2019 and 2020 obtaining data in the projection of 2018 and 2021, of the fourth sampling point, it is observed that there is a trend towards the decrease of pollutants, it is worth mentioning that point four is located in the main market Morelos (Mercado Grande) of the municipality of Frontera, the activity of the sampling area has a great activity in the preparation of food using edible oil in the fondas, It is also important to mention that this market has an oil waste collection program for the aforementioned businesses, as well as other waste, considering that this collection activity has an influence on the reduction of contaminants.

Conclusion

It is important to mention that the five sampling points selected did not exceed the MPLs corresponding to the NOM-001-SEMARNAT-1996 standard, since the reference value is 25 mg/L. With the support of the Minitab program, a simulation was performed for the years 2018 and 2021, using data from the years 2019 and 2020, where it is observed that four sampling points tend to increase the concentration levels of fats and oils influencing future industrial and domestic activities that are not considered in the study period 2019 and 2020, for the fourth point it is observed that there is a downward trend, This is due to the fact that there is currently a collection program for used oils by an external company that provides the final treatment to avoid contamination in the receiving water bodies, which allows us to observe in general that there is an adequate environmental education among the market's tenants to avoid pouring used oil into the water body.

Previous studies in Tabasco's rivers, in which trends in the parameter fats and oils were made, date from 1978-1984 (Rodríguez, Ramos, Romero and Hernández, 1997) in which they applied the Aquatic Quality Index (ICA), where they mention that the parameter fats and oils is one of the main environmental variables that affect the detriment of water quality in Tabasco. On the other hand, Ramos-Herrera, Broca-Martínez, Laines-Canepa & Carrera-Velueta, (2012), conducted trend studies of physicochemical parameters in the rivers of Tabasco, using data from 1978 to 2011, finding that in general the parameter fats and oils has a tendency to decrease.

Recommendations

– In order to obtain other results, it is recommended to carry out sampling in other study periods in different zones that include other communities in the Grijalva river basin, in order to determine if the MPLs for fats and oils are exceeded.

– Identify other sampling points to be able to have with greater precision, diverse activities carried out by the population in general, as well as businesses that generate fats and oils, in such a way that the results obtained would be known if there could be environmental impacts in the future.

– Establish by various means an adequate risk communication to the population in case of high limits in the parameters of fats and oils in the study basin.

– That there is a laboratory of some agency or educational institution that has all the equipment, reagents and tools, as well as the human resources are trained in the mentioned instances and can perform the sampling and analysis in a timely and efficient manner.

– The environmental protection coordination of the Centla town hall should have an updated list of outboard motor maintenance establishments, as well as any business that generates grease and oil as part of its activities, in order to locate sources of contamination in receiving water bodies.

Continue with the edible oil collection program in the Morelos Public Market in the municipality of Centla by an external company to keep the results of the presence of fats, oils, and grease at a low level.

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Production of four varieties of Cocoa (*Theobroma cacao L*), in Úrsulo Galván, Veracruz, Mexico

Producción de cuatro variedades de Cacao (*Theobroma cacao L*), en Úrsulo Galván, Veracruz, México

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Abstract

Currently, research in the introduction of crops in an area, region, or zone, is essential to determine the potential that the species being introduced may have. Therefore, the importance of introducing four species of cocoa (*Theobroma cacao L*), in the region of Úrsulo Galván, under a completely randomized experimental design. Specially in those places where monocultures predominate, since the option provided as an alternative must meet several characteristics, among which the main ones are: adaptation, growth, development, production and commercialization. To determine which of the species are those that adapt to the climatic conditions, as well as edaphic conditions of the area. If we add to the above economic improvements in terms of the income received per hectare, it will be much more attractive for producers. However, proposals should also be sought that contribute to reforestation, carbon dioxide capture and that benefits the local species. All the above with the intention of implementing sustainable polycultures and improving the characteristics of the region where they are established, as well as diversifying crops.

Research, Sustainability, Polycultures

Resumen

En la actualidad, la investigación en la introducción de cultivos en un área, región o zona, es fundamental para determinar el potencial que pueda tener la especie que se pretende introducir. Por ello, la importancia de introducir cuatro especies de cacao (Theobroma cacao L), en la región de Úrsulo Galván, bajo un diseño experimental completamente al azar. Especialmente en aquellos lugares donde predominan los monocultivos, ya que la opción que se brinde como alternativa debe cumplir con varias características, entre las cuales las principales son: adaptación, crecimiento, desarrollo, producción y comercialización. Determinar cuáles de las especies son las que se adaptan a las condiciones climáticas, así como edáficas de la zona. Si a lo anterior le sumamos mejoras económicas en cuanto a los ingresos percibidos por hectárea, será mucho más atractivo para los productores. Sin embargo, también se deben buscar propuestas que contribuyan a la reforestación, a la captura de dióxido de carbono y que beneficien a las especies locales. Todo lo anterior con la intención de implementar policultivos sustentables y mejorar las características de la región donde se establezcan, así como diversificar los cultivos.

Investigación, Sostenibilidad, Policultivos

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Introduction

The production of cacao (*Theobroma cacao L*), in many parts of the world is classified mainly by its aroma and flavor qualities, this has a great impact on social characteristics, as well as on economy, which influence the productive aspect (León-Villamar, *et al.* 2016).

Nowadays cocoa faces competition at national and even international levels (Unda & Carrillo, 2017). In addition to its yields, organoleptic properties are sought, as well as high nutritional requirements (Puentes-Páramo, *et al.* 2016).

Additionally, we could say that according to De La Cruz-Landero, *et al.* (2015), it is recommended to redesign or apply planting methods which in a shorter term increase the profitability of cocoa cultivation through higher population densities, as well as train producers, technicians, or managers of the orchards, to carry out a plan or program that includes genetic certified material and increasingly resistant to pests such as *Crinipellis perniciosa* and *Monilia roreri* (Hernandez- Gómez *et al*. 2015).

However, it is also very important to investigate, test or experiment, the behavior of different materials according to climatic and soil conditions determined in an area, zone or region, in order to be sustainable and incorporate the three sectors that make up this concept: society, environment and economy, as well as increase production (Cerda *et al*. 2014); with the intention of incorporating strategies such as the 2030 agenda, to contribute with solutions to the political proposals and achieve the objectives set.

Mexico is a producer of cocoa worldwide, because only in the year 1999-2000, it contributed with 1.2% of the world production and contributes with 80% of its production, the main producing area is Chontalpa, (Córdova-Ávalos, 2001). This region contributes 97.24% of the state area to the aforementioned crop (INEGI, 1999). In addition, it constitutes 16.38% of the state area and contributes 17.4% of the state's agricultural production (SAGARPA, 2000).

It is for all the above and many more things the importance it takes to implement this type of research in regions other than where it expresses its genetic potential, but that nevertheless, can also be alternatives to produce this crop, mainly if we analyze that it is a crop with a great economic potential, but that also preserves the principles of sustainability that are so needed in these times where climate change is in order of the day and severely affects the weather conditions of different places, also affecting the fauna, because it does not have areas or forests to have an ecological niche.
Finally, we could say that this type of work contributes to generating knowledge and a reference to the null or little information that exists in these topics.

Materials and Methods

Location

The area of influence that comprises this project is the entire municipality of Úrsulo Galván, where it is important to mention that basically this area, zone, or region, is dedicated to agriculture.

The experimental research was carried out at the facilities of the Tecnológico Nacional de México (TecNM) Campus Úrsulo Galván, which is located in the same municipality of Úrsulo Galván, Veracruz, Mexico, at the coordinates 19° 24 48.91" north latitude and 96° 21 09.10" west longitude of the Greenwich meridian, at a height of 9 meters above sea level.

Method design

The experiment was a completely randomized design, with 4 treatments and 10 repetitions, using a total of 40 cacao plants of the four varieties to be evaluated.

The varieties or experimental materials are:

INIFAP 4 = Treatment 1
INIFAP 8= Treatment 2
INIFAP 9= Treatment 3
Almendra Blanca = Treatment 4

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E N S 0	T4R4	T4R10	T4R1	T3R6
	T2R10	T1R9	T2R2	T4R3
	T1R10	T3R5	T4R5	T3R3
	T3R4	T1R4	T1R7	T3R2
	T2R3	T1R5	T1R1	T3R9
	T3R1	T3R10	T2R9	T2R5
	T2R1	T2R8	T2R4	T4R6
	T1R2	T1R3	T4R9	T2R6
	T2R7	T4R7	T4R2	T3R7
	T3R8	T1R6	T1R8	T4R8

Table 1 Distribution of treatments in the field
Source: Own

Vegetative material used

In this experimental research, 4 varieties of this crop were used, which were developed by the National Institute of Forestry, Agricultural and Livestock Research (INIFAP), of Huimangillo Tabasco, they are varieties with high yields and resistant to diseases such as moniliasis and black spot, which allow a production between 700 to 1,100 kilograms per hectare under field conditions (SAGARPA, 2018). And that they were provided by the company Nestlé for its establishment.

Variables to be evaluated

– **Cob weight**

To determine this variable, all the cobs harvested in the experimental unit were weighed and an average per experimental unit was obtained, after having weighed them in a granataria balance (CEESA brand, with a maximum capacity of 2,610 g). This variable is carried out after the cut.

– **Equatorial diameter of the cob**

With an electronic vernier (Truper brand of 150 mm). Each of the harvested cobs was measured. This variable is carried after the cut.

– **Polar diameter of the cob**

With an electronic vernier (Truper brand of 150 mm). Each of the harvested cobs was measured. This variable is carried out after the cut.

– **Weight of seed with pulp**

The cocoa cob must be cut, and the seed must be removed, as well as the pulp, then weighed on a granataria scale (CEESA brand, with a maximum capacity of 2,610 g). This variable is carried out after cut.

– **Weight of seed without pulp**

To collect this variable, the seed is dried and then weighed in a granataria balance (CEESA brand, with a maximum capacity of 2,610 g). This variable is carried out after the cut.

– **Equatorial diameter of seeds**

With a vernier (Truper brand of 150 mm) after drying the seeds outdoors, the diameter of 10 seeds per cob will be determined. This variable is carried out after the cut.

– **Polar diameter of each seed**

After performing the same drying process as in the variable equatorial diameter of each seed, this variable is determined with an electronic vernier (Truper brand of 150 mm), repeating the same previous procedure. This variable is carried out after the cut.

– **Weight of the dry seeds**

Once the seeds are dry, the seeds of each treatment are weighed on an analytical scale (OHAUS brand). This variable is carried out after the cut.

Results

For the variable number of cobs, we find in the ANOVA, α0.05 that there is no statistical difference when performing the test of comparison of means by the Tukey method. However, within the treatments we find a numerical difference.

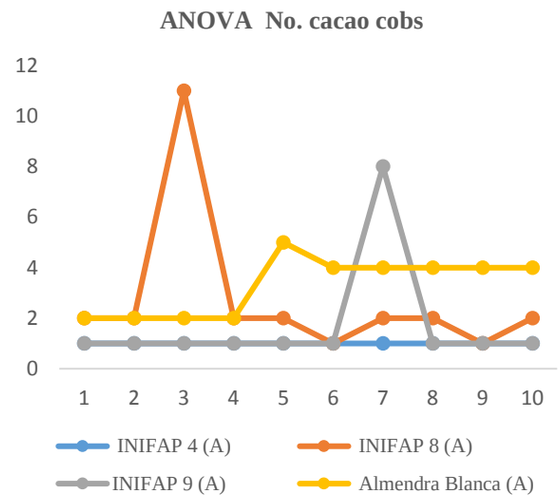

Figure 1 Analysis of variance of the number of cobs plant[1]
Equal literals indicate that there is no statistical difference
Source: Own

While, for the variable polar diameter of cob, when performing the ANOVA, α0.05, we find that there is a statistical difference when performing the mean comparison test by Tukey's method. Treatment 1 (INIFAP 4) is statistically superior compared to the rest.

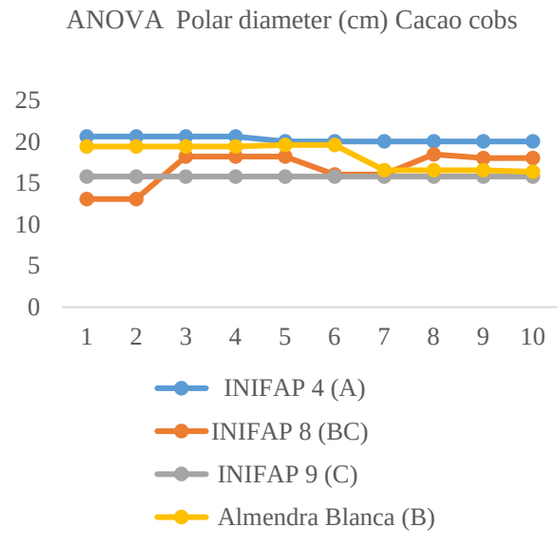

Figure 2 Analysis of variance of the polar diameter of cobs plant^{-1}
Different literals indicate that there is statistical difference
Source: Own

As far as the variable equatorial diameter of cobs is concerned, we find in the ANOVA, α0.05 that there is no statistical difference when performing the mean comparison test by Tukey's method. However, within the treatments we find that there is a numerical difference.

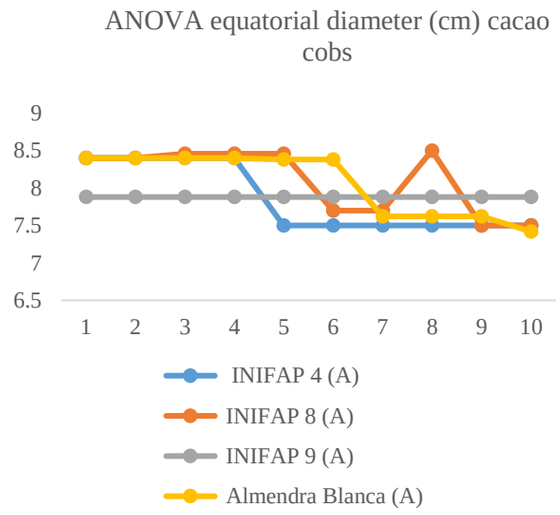

Figure 3 Analysis of variance of the equatorial diameter of cobs plant^{-}
Equal literals indicate that there is no statistical difference
Source: Own

As for the variable total weight of the fruit of cobs, we find in the ANOVA, α0.05 that there is no statistical difference when performing the test of comparison of means by the Tukey method. However, within the treatments we find that there is a numerical difference.

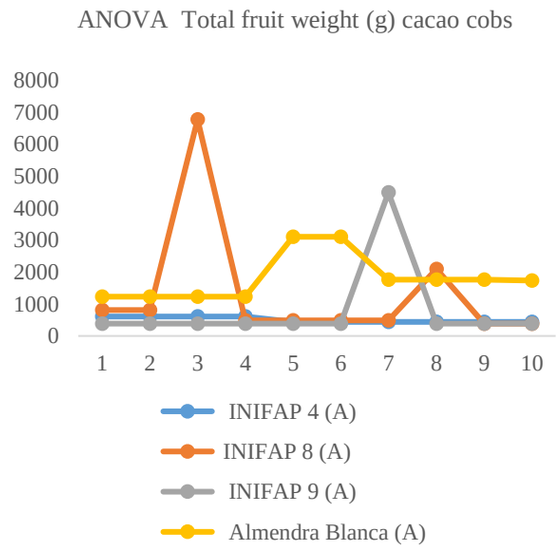

Figure 4 Analysis of variance of the total fruit weight of cobs plant $^{-1}$
Equal literals indicate that there is no statistical difference
Source: own

For the variable weight of the pulp with seed of the fruit of cobs, we find in the ANOVA, α0.05 that there is no statistical difference when performing the test of comparison of means by the Tukey method.

However, within the treatments we find that there is a numerical difference.

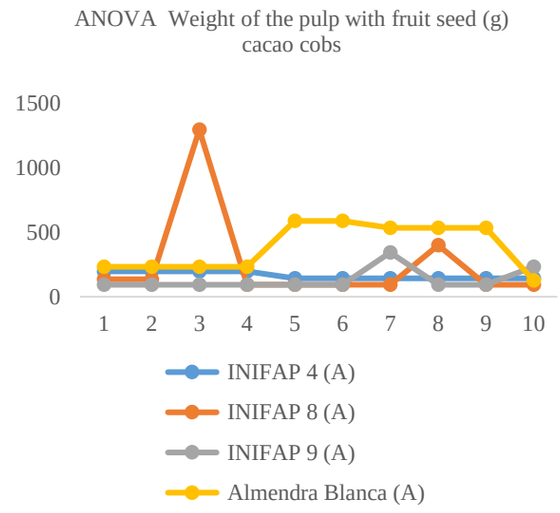

Figure 5 Analysis of variance of the weight of the pulp with fruit seed of cobs plant $^{-1}$
Equal literals indicate that there is no statistical difference
Source: Own

Regarding the variable weight of the dried seed of the fruit of cobs, we found in the ANOVA, α0.05 that there is a statistical difference when performing the test of comparison of means by the Tukey method. Being the treatment 4 (Almendra Blanca), the one that comes out statistically superior to the rest.

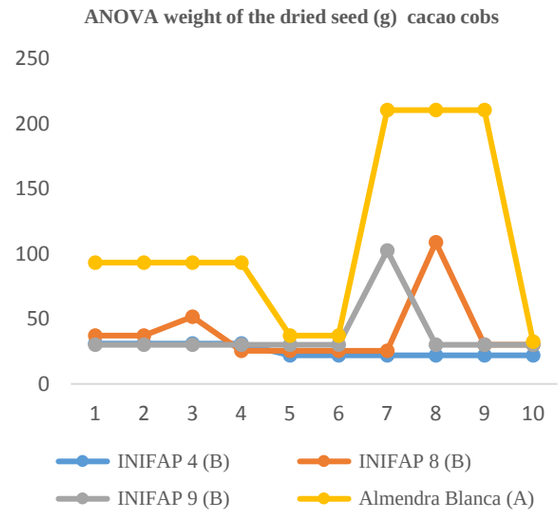

Figure 6 Analysis of variance of the weight of the dried seed of cobs plant^{-1}.
Different literals indicate that there is statistical difference
Source: Own

For the variable equatorial diameter of dried seed of the fruit of cobs, we found in the ANOVA, α0.05 that there is statistical difference when performing the test of comparison of means by the Tukey method. Being the treatment 4 (Almendra Blanca), the one that comes out statistically superior to the rest.

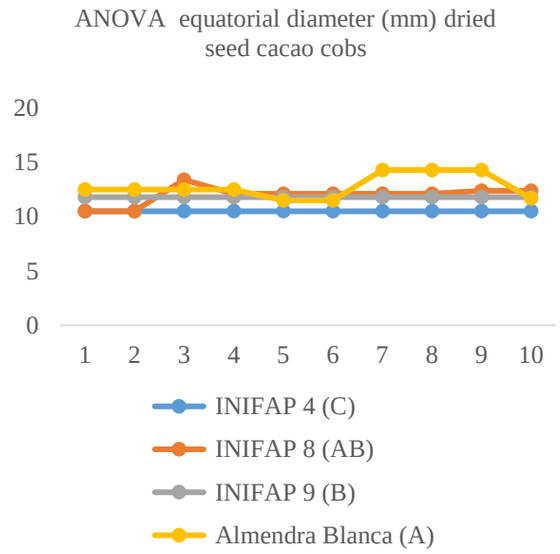

Figure 7 Analysis of variance of the equatorial diameter of the dried seed of cobs plant^{-1}
Different literals indicate that there is statistical difference
Source: Own

Finally, for the variable polar diameter of dried seed of the fruit of cobs, we found in the ANOVA, α0.05 that there is statistical difference when performing the test of comparison of means by the Tukey method. Being the treatment 3 (INIFAP 9), the one that comes out statistically superior to the rest.

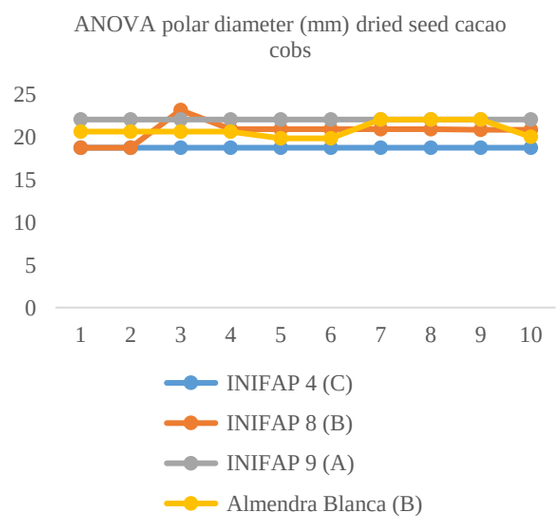

Figure 8 Analysis of variance of the polar diameter of the dried seed of cobs plant^{-1}.
Different literals indicate that there is statistical difference
Source: Own

Conclusions

Based on the results obtained we could say at first that at least for the variables: number of cobs, equatorial diameter of the fruit, total weight of the fruit, weight of the seed with pulp and polar diameter of the dried seed there is no statistical difference, this is quite logical because the treatments had the same management.

However, we found that for the variable polar diameter of the cob, treatment 1 (INIFAP 4) is the one that stands out from the rest, possibly this is due to a characteristic of the aforementioned variety, so if you want to achieve these measures we recommend that treatment.

While for the variable weight of the dry seed, treatment 4 (Almendra Blanca) is the one that comes out higher statistically, this is probably due to a characteristic of the material used, so the use of this material is recommended for the aforementioned variable.

For the variable polar diameter of the dry seed, we find that treatment 3 (INIFAP 9) is statistically superior to the rest of the treatments, possibly a characteristic of the material used, so if this characteristic is sought, the aforementioned material should be used.

Finally, despite finding statistical differences in some treatments and not in others, it is recommended to continue evaluating the treatments so that with more cuts, the results of the present research can be corroborated and there will be more reliability in the data, however in general terms we could say that any of the materials tested adapt to the soil and climatic conditions of the Úrsulo Galván region.

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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.

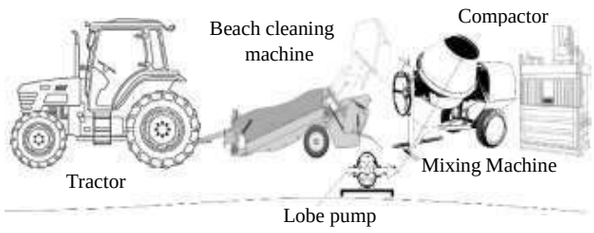

Figure 1 Beach cleaning system to prevent erosion of sand dunes

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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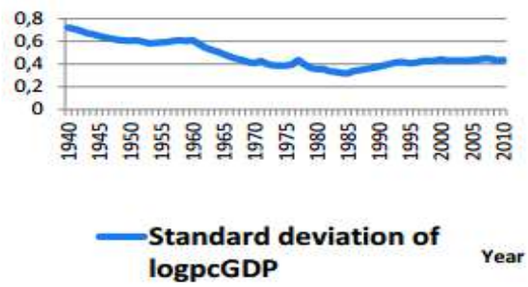

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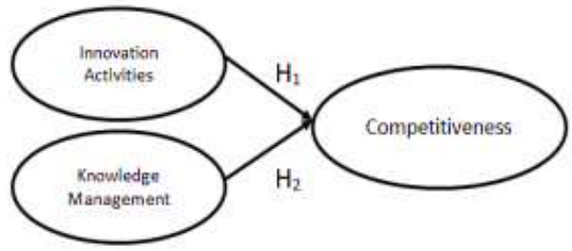

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