Volume 8, Issue 14 — January — June — 2022

ECORFAN

Journal- Republic of Nicaragua

ISSN-On line: 2414-8830

ECORFAN®

ECORFAN Journal-Republic of Nicaragua, Volume 8, Issue 14, June 2022, is a journal edited semestral by ECORFAN. First Avenue Southwest, San Sebastian area, León, Republic of Nicaragua. P. C. 21000. WEB: www.ecorfan.org/republicofnicaragua/, journal@ecorfan.org. Editor in Chief: ZAPATA-MONTES, Nery Javier, PhD. ISSN Online: 2414-8830. Responsible for the latest update of this number ECORFAN Computer Unit. ESCAMILLA-BOUCHÁN, Imelda, LUNA-SOTO, Vladimir, First Avenue Southwest, San Sebastian area, León, Republic of Nicaragua. P.C. 21000, last updated June 30, 2022.

ECORFAN Journal Republic of Nicaragua

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Instructions for Scientific, Technological and Innovation Publication

Knowledge Area

The works must be unpublished and refer to topics of agriculture-forest, pathology-sustainable, forest, management, horticulture, engineering and integrated water useand other topics related to Biotechnology and Agricultural Sciences.

Presentation of Content

Volume eight, issue fourteen, as the first article we present, *Production structure and commercialization of green vegetables in the valley of Tecamachalco, Puebla, Mexico*, by XIMITL-ISLAS, Iván, RODRÍGUEZ-DE LA VEGA, Marisol, CABILDO-OREA, Alejandra and MACHORRO-DÍAZ, Rafael, with adscripction in the Universidad Tecnológica de Tecamachalco, as a second article we present, *Evaluation of the UV index in the campus UAZ siglo XXI for the year 2019*, by FRÍAS-HERNÁNDEZ, Juan Daniel, GONZÁLEZ-CABRERA, Adriana Elizabeth, VILLEGAS-MARTÍNEZ, Rodrigo Cervando and GARCÍA-GONZÁLEZ, Juan Manuel, with adscripction in the Universidad Autónoma de Zacatecas and Universidad Nacional Autónoma de México, as third article we present, *A comparative study between a system of commercial mixed oxide ceramic membranes and a system of mixed oxide ceramic membranes impregnated with porcine gelatin for the removal of emergent pollutants*, by ESTRADA-PÉREZ, Jeniffer Giovanna, PÉREZ-MORENO, Víctor, RAMOS-LÓPEZ, Miguel Ángel and RODRÍGUEZ-MORALES, José Alberto, with adscripction in the Universidad Autónoma de Querétaro, as fourth article we present, *Cenote Chen ha, and water quality indicators*, by VIZCAINO-RODRIGUEZ, Luz Adriana, RAVELERO-VAZQUEZ, Victor, LUJAN-GODINEZ, Ramiro and CANUL-GARRIDO, Divino Miguel, with adscripction in Universidad Politécnica de la Zona Metropolitana de Guadalajara and Universidad Tecnológica del Poniente.

Content

Article **ECORFAN Journal-Republic of Nicaragua**
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Production structure and commercialization of green vegetables in the valley of Tecamachalco, Puebla, Mexico

La estructura de producción y comercialización de hortalizas, en el valle de Tecamachalco Puebla, México

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DOI: 10.35429/EJRN.2022.14.8.1.10 Received January 10, 2022; Accepted June 30, 2022

Abstract

In the current project we have the opportunity to show a study, at a regional level, in the state of Puebla, in the central highlands of Mexico, located in the Balsas Basin; belonging to the Rural Development District of Tecamachalco, Puebla. The object of the study were the vegetable producers, who were interviewed through a questionnaire addressed to 89 producers, to carry out the diagnosis of the production and commercialization of vegetables in the local, regional, state, national, and international market. Within the framework of the TMEC, current legislation requires producers to obtain different certifications to comply with each of the standards that exist in regulations, in national and international markets. Within the value chains, the main marketing channels are Huixcolotla and Iztapalapa's Supply Centers, supermarkets, markets, street markets, and exportations, which prevails in a regional and local market. The field study was carried out in 2021 in the municipalities of Tecamachalco and Palmar de Bravo; the technique was the interview, and the instrument was a questionnaire.

Diagnosis, Market, Green vegetables, Exportation, Regions, Certification

Resumen

En el presente trabajo tenemos la oportunidad de mostrar un estudio, a nivel regional, en estado de Puebla, en el altiplano central de México ubicado en la cuenca del Balsas; perteneciente al Distrito de Desarrollo Rural de Tecamachalco, Puebla. El objeto de estudio fueron los productores de hortalizas, mismos que fueron entrevistados por medio de un cuestionario dirigido a 89 productores, para realizar el diagnóstico de la producción y comercialización de hortalizas en el mercado local, regional, estatal, nacional e internacional. En el marco del TMEC, la legislación actual demanda a los productores obtener diferentes certificaciones para cumplir con cada una de las normas que existen en las regulaciones en mercados nacionales e internacionales. Dentro de las cadenas de valor, los principales canales de comercialización son: central de abasto de Huixcolotla, central de abasto de Iztapalapa, supermercados, mercados, tianguis y exportación; lo que predomina, es un mercado regional y local. El estudio de campo se realizó en el año 2021 en los municipios de Tecamachalco y Palmar de Bravo; la técnica fue la entrevista y el instrumento un cuestionario.

Diagnóstico, Mercado, Hortalizas, Exportación, Regional, Certificación

Citation: XIMITL-ISLAS, Iván, RODRÍGUEZ-DE LA VEGA, Marisol, CABILDO-OREA, Alejandra and MACHORRO-DÍAZ, Rafael. Production structure and commercialization of green vegetables in the valley of Tecamachalco, Puebla, Mexico. ECORFAN Journal-Republic of Nicaragua. 2022. 8-14:1-10.

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Introduction

Packing and exporting companies, this sector has a high level of economic capital and infrastructure. They are in the most important municipalities of the region (Acatzingo, Huixcolotla and Los Reyes) and in the vicinity of the Central de Abasto de Huixcolotla. According to the list managed by the Council of Horticulturists of Puebla outdoors, there are more than 40 packing companies in the region, and they export to the countries that make up the North American Free Trade Agreement (NAFTA, now called TMEC). They are linked to production through farmers who have a regional leadership to establish sale-purchase commitments. To gain a foothold in the regional market, some companies rent warehouses in the municipalities with the highest vegetable production. They demand excellent quality vegetables, offering the best prices, according to small producers.

The social actors that make up the horticultural system of the Tecamachalco valley are structured in a differentiated manner, with diverse economic power, from which small producers establish relationships of negotiation and subordination with input suppliers when acquiring agrochemicals and seeds, because at the same time they offer them technical assistance.

A regional study was conducted on the production and marketing of vegetables in the regional, national and international market and the impact on the regional economy between the municipalities of Tecamachalco, Quecholac, Acatzingo, Tepeaca and Huixcolotla with vegetable producers and marketers, as well as the determination of distribution channels in the Irrigation District of Tecamachalco, Puebla.

Determine the influence of the Central de Abastos de Huixcolotla and regional vegetable production. Identify the crops that predominate in the regional, national and international vegetable markets, carry out an investigation of the main packing companies in the study region.

The Tecamachalco valley aquifer is in the central portion of the state of Puebla, with a surface area of 3,600 square kilometers (km²). It is bordered by the Soltepec mountain range to the northeast; La Malinche volcano to the north; the Zapotitlan mountain range to the south and southwest; and the Tenzo mountain range to the west. Municipalities In this zone there are 29 municipalities totally or partially contained: Acatzingo, Amozoc, Cañada Morelos, Cuapiaxtla de Madero, Cuautinchán, Chapulco, Esperanza, General Felipe Angeles, Huitziltepec, Mixtla, Molcaxac, Nicolás Bravo, Palmar de Bravo, Quecholac, Los Reyes de Juárez, San Salvador Huixolatla, Santiago Miahuatlán, Santo Tomas Hueyotlipan Tecali de Herrera, Tecamachalco, Tepanco de López, Tepatlaxco de Hidalgo, Tepeaca, Tepeyehualco de Cuautémoc, Tlacotepec de Benito Juárez, Tlanepantla, Tochtepec, Xochitlán Todos Santos and Yehualtepec. (CONAGUA, 2020). According to the Federal Water Rights Law 2015, the aquifer is classified as availability zone 1.

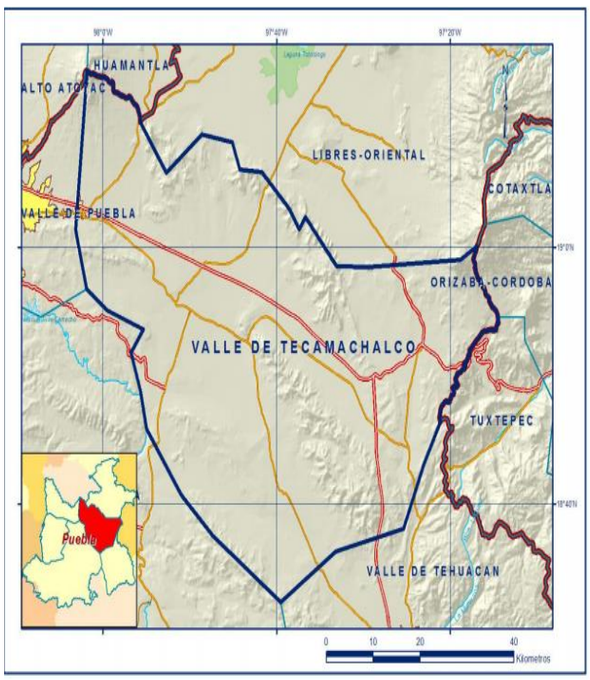

Figure 1
Source: CONAGUA, 2020
https://sigagis.conagua.gob.mx/gas1/Edos_Acuiferos_18/puebla/DR_2101.pdf

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Literature review

The diagnosis has been one of the most used tools for market studies, they have diversified, in terms of markets, products, a study in 2015, in Costa Rica, points out that an alternative can be organic crops, because they have a high added value, Camacho indicates:

The organic vegetable market in the GAM is composed of small and medium producers who offer their products through organic fairs, farmer's fairs, supermarkets, intermediaries, hotels and restaurants, as well as home deliveries. As producers gain seniority, they increase the area dedicated to production, the number of species produced and make the decision to become certified. Producers with less time of dedication have smaller areas and produce a smaller number of species than those with more seniority. And in some cases they have recently embarked on the road to certification (Camacho, *et al*., p. 2015).

Certifications in organic and conventional products are necessary to market in formal markets, supermarket chains, restaurants, and even export is substantial quality control.

According to Soto, *et al*., pp: 1036-1037 (2014): Currently in different entities of Mexico there are networks of tianguistas of organic products, which perform a very important work by marketing, informing, imparting courses, experiences and knowledge to their colleagues, this for consumers is of utmost importance as it modifies attitudes of consumption and creates a great initiative and confidence to continue with a process of consumption of these foods.

The area of organic products is becoming more mature day by day, it is an emerging market that needs to have regulations, which makes this scenario of complicated adoption as it does not have uniformity in different areas such as cultivation, production, processing and the different processes involved in the value chain of each of the products marketed, the current legislation requires producers to obtain different certifications to meet each of the standards that exist in the different regulations either in national and international markets". (Soto, *et al*., p. 1035, 2014)

The opportunities for producers are diverse, the problem in the markets is that the certification process implies an investment that is not considered, this is why training and laboratory tests, as well as field certification, sometimes are not very expensive or there is little knowledge about it, the advantage is that through certifications producers can obtain better benefits.

As main positioning strategies in supermarkets, the consolidation via quality at an affordable price for middle class consumers, regardless of the marketing volume, is pointed out. All this clearly shows the confluence towards the adoption of a cost strategy, consisting in the reduction of production costs and obtaining large marketing volumes that ultimately allows them to obtain greater competitiveness through market prices (Soleno, 2013).

According to Soleno, in a study in Buenos Aires, Argentina, the study of marketing strategies is fundamental in the analysis of costs when determining the value chains among supermarkets, unlike in the present study the value chains are oriented to the central supply centers. Traceability is fundamental in vegetable marketing processes, as indicated by Gil, *et al*., 2010, in a study in Spain:

Traceability, the tracking of the product from the origin (field) to the consumer's table (market) has guided the marketing process in recent years. To this end, they scrupulously program the planning of plantations, the selection of varieties, the preparation of the land, the control of transplanting, harvesting, control at the entrance to the warehouse, packaging and handling, the quality of the finished product, cooling, shipping and delivery after sale. Strict control standards from the field to the supermarket require that each lot or batch be recorded (the plot where it was harvested, the day, the time, the owner, etc.). Even the smallest package carries its identification card (in some companies all by electronic means and bar code or numbering as in most of the sample of companies visited), and it is maintained until the shipment and fractionation of cargo arriving at the supermarket or point of sale (Gil, *et al*., p. 200, 2010).

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The comparative advantages are shown in the geographical location and markets of emerging economies, although Mexico is a country with multiple opportunities, but not all producers can develop the same level of competition, according to Borbón:

Traditionally, Mexico has been the main supplier of fresh vegetable imports to the United States. Today, this dynamic and competitive trade, has given room for other countries to also have a presence in the U.S. fresh vegetable markets. Such is the case of: Canada, Honduras, Dominican Republic, Spain and Holland, which stand as some examples of the competition faced by Mexican exports, to such a degree that they concur with homogeneous product in terms of: health, quality and safety, eventually influencing a reduction in the market share that our country served. (Borbón, *et al*., p. 43, 2018).

Methodology

The information collected was classified into primary and secondary, the first concerns obtaining information through questionnaires, interview forms, research guides, ordinary observation, the second refers to information extracted from documentary sources, censuses, vital statistics, through statistical tables, the secondary information serves as a basis for the analysis of the problem, in the collection of information, producers and leaders of organizations in the region were interviewed who provided first-hand information on the different aspects of the study. The field work was carried out using a random sample of producers with which we can make inferences from the results obtained in the survey applied to the target population.

Technique and instrument used

The technique whether survey, structured interview, or observation has its own limitations in the research. The survey was the technique used to explore certain aspects of the population; it was also necessary to use observation and key informant interviews. About the experience in economic studies, the selected technique was the survey, this technique consists of the collection of a part of the population called sample, data, opinions, through questions formulated on various indicators, the information obtained is processed in a quantitative analysis, to identify and understand the magnitude of the problem, the instrument used was the questionnaire.

The questionnaire was addressed to representatives of organizations and producers, where the questions asked were aimed at finding out the specific aspects of the variables, the exploration of which can be with one or more questions, and sometimes a single question was used to investigate one or more variables.

1) Gathering information from secondary sources.

The first phase consisted in the compilation of bibliographic information related to the research problem in books, newspapers, theses and magazines, in the libraries of the B.U.A.P., El Colegio de Postgraduados and newspaper and periodical libraries. Subsequently, secondary or statistical information was collected in I.N.E.GI. (Censuses, Yearbooks and municipal notebooks) in the city of Puebla, as well as the consultation via Internet of the official pages of I.N.E.G.I., SADER, for this stage the method of bibliographic synthesis was used, using the instrument denominated bibliographic work card, with the information obtained a data base will be made to interpret the situation of the coffee production at national, state and municipal level.

2) The second phase involved trips to the study municipalities in order to have contact with key informants: municipal authorities, representatives of farmer organizations, intermediaries and producers. The purpose of this activity was to identify the regional marketing channels, as well as to identify the main points of sale, in central supply centers inside and outside the State of Puebla, and to find out where these organizations sell the product at wholesale and retail.

3) The third phase consisted of the elaboration of questionnaires to be applied in the organizations in the municipalities of study, the interviews were carried out in the second half of July and the first half of August, applied in the municipality of Tecamachalco. The interview technique was used, using a field notebook and questionnaire guide.

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4) Coding and processing of the information the next phase was the emptying of the information obtained in the questionnaires in tabular sheets, to create a data base by key, subsequently the analysis of the data was made in the program Statstical Pachage for the Social Sciences (S.P.S.S.).

Sample design

Information was sought on the coffee growers in this region and the list of problems was obtained through the coffee census, this census includes information that will allow us to determine the necessary sample size, the first thing that was done was to identify a variable that gives us information related to the topic of research and was dedicated to using the number of farms as a necessary variable to determine the sample size in the first stage was to identify the number of farms total farms that were located in the two municipalities studied, In the calculation of the average and variance, as well as other important measures of each of the municipalities contemplated in the study.

The size of the sample of producers

Upon analyzing the information, it was determined that the appropriate sampling scheme for these data was a random stratified sampling, and due to the differences in the population sizes of each stratum, it was decided to allocate the data proportionally to each of the municipalities.

The equation for estimating the sample size in a random stratified sampling with proportional distribution is explained as follows:

Equation 01. Mathematical expression for calculating the sample size in a stratified random sampling with proportional distribution

$$n = \frac{N\sum_{i=1}^{k} N_i s_i^2}{N^2 V + \sum_{i=1}^{k} N_i s_i^2}$$

dα/2 Accuracy
Z Reliability
N Population size
Ni Population size of stratum i
S²i Variance of stratum i

Relationship between precision and reliability for the sample size calculation in equation 1.

$$V = \frac{d^2}{Z^2\, \alpha/2}$$

Equation 2. Assignment of sample size to each of the strata.

$$n_i = \frac{Ni}{N} n$$

It was decided to use a precision of 15% of the general mean and a reliability of 90%, so with information obtained on the size of the strata and their variances we have the following information:

Substituting the data previously shown in equation i, we obtain the following data, the size of the sample in each of the municipalities, with a precision of 15% of the general mean and a reliability of 95%, the size of the strata is established as follows:

Municipality	Sample size
Palmar de Bravo	n1 = 50
Tecamachalco	n2 = 39
Total	n = 89
N= 1890	

Table 1 Sample size of the municipalities studied

The sample design was stratified sampling.

Results

The research was carried out in the field, with vegetable producers, who use greenhouses and most of them are in open sky, in the municipalities of Tecamachalco and Palmar de Bravo, where the region has irrigation system, and innovative methods and techniques in intensive production, also the strategic location of the supply centers of Huixcolotla, Puebla and Mexico City, the markets are predominantly local, due to the connectivity between federal roads and highways, between the capital of the Mexican Republic and the southeast. The highway network is one of the strategies in the marketing process.

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Figure 2

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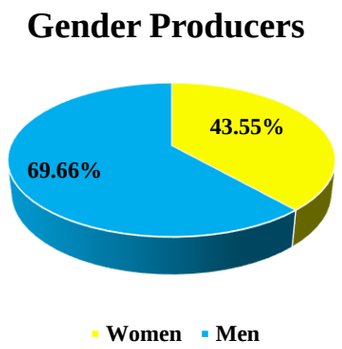
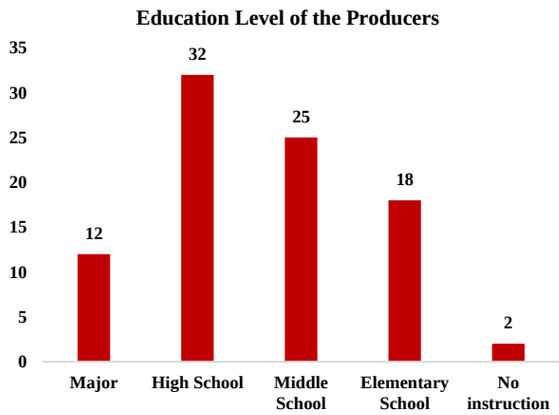
Figure 3

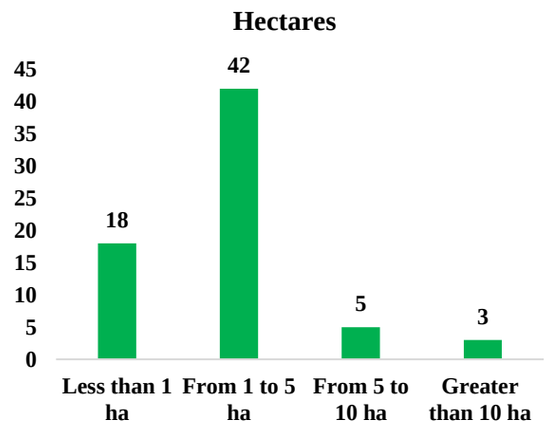


Graphic 1
Source: Own elaboration, obtained in the field, 2021

Of the sample of 89 producers, 69.66% are men and 30.44% are women. In terms of education, 32 have a high school diploma, 25 have a high school diploma, 18 have a primary school diploma, 12 have a bachelor's degree and 2 have no education.



Graphic 2
Source: Own elaboration, obtained in the field, 2021



Graphic 3
Source: Own elaboration, obtained in the field, 2021

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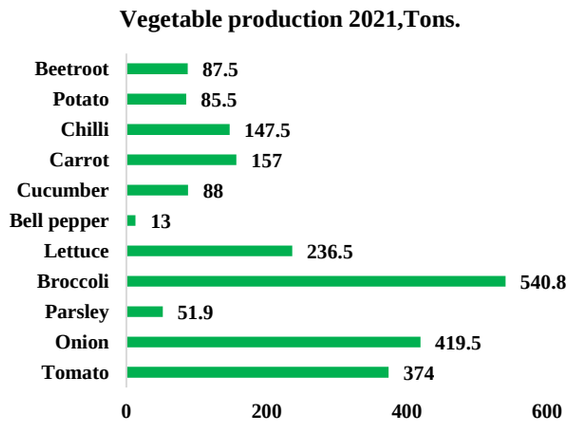
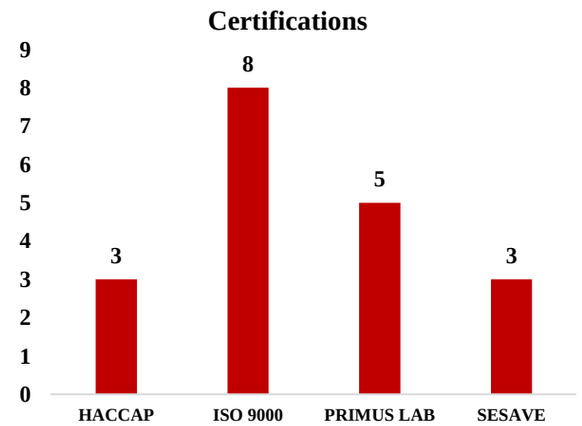


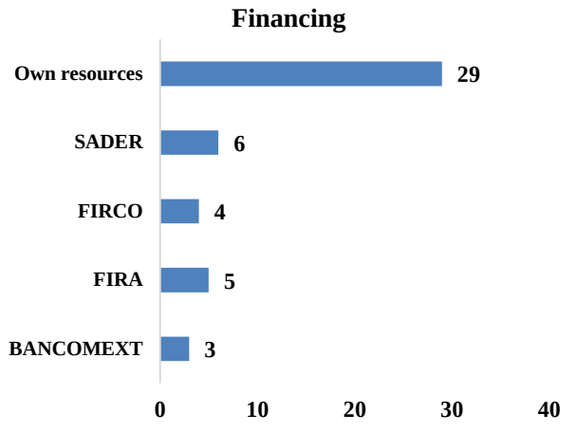
Graphic 4
Source: Own elaboration, obtained in the field, 2021

According to the volume of production, the crop with the highest production in tons is broccoli with 540.8 tons, followed by onion with 419.5 tons, tomato with 374 tons, lettuce with 236.5 tons, carrot with 157 tons and chili with 147 tons, and the rest of the crops produce less than 100 tons. This allows us to analyze the demand among the main products in the market. The main range of hectares per producer is 1 to 5 hectares.

Regarding certifications, 8 producers have ISO 9000, 5 PRIMUS LAB, 3 HACCAP and 3 SESAVE, this shows that most of them do not have certifications.



Graphic 5
Source: Own elaboration, obtained in the field, 2021



Graphic 6
Source: Own elaboration, obtained in the field, 2021

Financing is one of the main obstacles in the process of production and commercialization of vegetables, 29 producers expressed that they carry out operations with their own resources, while only 4 have support from FIRCO and 5 FIRA, 6 from SADER programs and 3 from BANCOMEXT, this indicates that there is very little institutional support from development banks and multiple banks in the agricultural sector.

Annual sales income is mostly determined by sales of less than $100,000 MXN, but 11 cases were also found with sales greater than $100,000 MXN.

Graphic 7
Source: Own elaboration, obtained in the field, 2021

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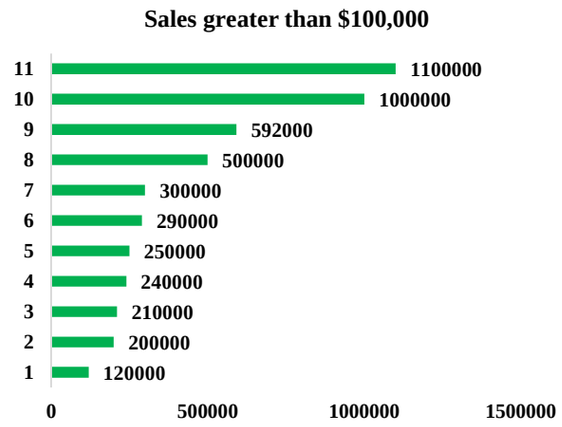
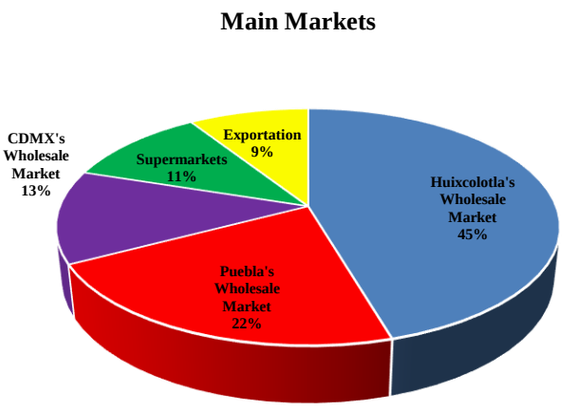


Graphic 8
Source: Own elaboration, obtained in the field, 2021



Graphic 9
Source: Own elaboration, obtained in the field, 2021

Figure 4 Central de Abastos Huixcolotla
Source:
https://earth.google.com/web/search/central+de+abastos+HUIXCOLOTLA/@18.90359623,97.78399063,2017.42073665a,1433.52015029d,35y,3.52147071h,9.89093538t,0r/data=CigiJgokCRIPGg7_RCVAEVYLMhls3iRAGZkd9u9rq1DAIXAle8CLxlDA

Figure 5 Central de abastos Iztapalapa, CDMX
Source:
https://earth.google.com/web/search/central+de+abastos+iztapalapa/@19.3814174,99.0908143,2233.48478268a,989.89732007d,35y,0h,0t,0r/data=CigiJgokCXYOTgLt6TJAEUQz4sNh2jJAGVYgHTPBcVjAISKCFxW2dVjA

Conclusions

The Tecamachalco valley region is very productive in broccoli, onion, tomato, lettuce, carrot, beet, parsley, and cilantro crops; there is an intensive production system with greenhouses and open field, most of the producers have a land extension of 1 to 5 hectares, there are producers that have 15 to 20 hectares, but they are a minority.

The migration factor is present in the participation of women in the production and commercialization of vegetables, 70% are men and 30% are women, this characteristic is very present in the municipalities in the Migratory intensity index.

The main markets of the producers interviewed indicated that 45% sell in the Central de Abastos de Huixcolotla, 22% in the Central de Abastos de Puebla, 13% in the Central de Abastos de Ixtalapa CDMX, 11% in supermarkets and 9% for export, it should be noted that a part is also destined for local markets and retail markets.

One of the serious problems faced by producers is the lack of financing for productive projects; only some producers mentioned that they had financing from FIRA, FIRCO, BANCOMEXT and SADER; most do not have financing, so they carry out their activities with their own resources.

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Another problem faced by producers are certifications, this is due to the fact that in the current legislation at national and international level, the norms that regulate the vegetable markets must meet the quality controls, through laboratory studies for certification, so most of the producers interviewed do not have certifications. The certifications found in the study are ISO 9000, PRIMUS LAB, HACCAPA and SESAVE, which is a limitation for producers to find better markets where they receive better remuneration.

Based on the diagnosis that has been made, it is advisable to design some public policies in the value chains in the marketing channels and see what are the factors that influence finding better markets or the transformation of the products to obtain a higher added value, seeking alternatives to improve the producers' income.

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ISSN-On line: 2414-8830

Article **ECORFAN Journal-Republic of Nicaragua**
June 2022, Vol.8 No.14 11-14

Evaluation of the UV index in the campus UAZ siglo XXI for the year 2019

Evaluación del índice UV en el campus UAZ siglo XXI para el año 2019

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DOI: 10.35429/EJRN.2022.14.8.11.14 Received January 15, 2022; Accepted June 30, 2022

Abstract

The objective of this research is to quantify the UV Index in the city of Zacatecas. The UV Index is a measure of the intensity of UV radiation at the earth's surface and is an indicator of its ability to cause skin damage. UVB radiation is the main cause of skin cancer. The Methodology consisted of collecting ultraviolet radiation data (UVB) in the period from January 1 to December 31, 2019, using a Solar Ligth 501-A Biometer, installed in the Zacatecas_04 solarimetric station belonging to the National Solarimetry System, located in Building E6 of the UAZ Siglo XXI Campus. Subsequently, the data was transformed to the UV Index (2.332 by the Biometer reading in Med/hr to W/m² at IUV). The results that were obtained in the period of time evaluated show that most of the year the radiation received is high and very high according to the sun protection system recommended by the O.M.S. UVB exposure begins with greater intensity at 10:00 am until 4:00 pm. Concluding, that in the city of Zacatecas most of the year there is a high UV Index.

Ultraviolet radiation, biometer, UV Index

Resumen

El Objetivo de esta investigación es cuantificar el Índice UV en la ciudad de Zacatecas. El índice UV es una medida de la intensidad de la radiación UV en la superficie terrestre y es un indicador de su capacidad de producir lesiones cutáneas. En específico la radiación UVB es la principal causante de cáncer de piel. La Metodología consistió en recopilar datos de radiación ultravioleta (UVB) en el periodo comprendido del 1 de enero al 31 de diciembre de 2019, utilizando un Biómetro 501-A de Solar Ligth, instalado en la estación solarimétrica Zacatecas_04 perteneciente al Sistema Nacional de Solarimetría, ubicada en el Edificio E6 del Campus UAZ Siglo XXI. Posteriormente los datos se transformaron al Índice UV (2.332 por la lectura del Biómetro en Med/hr a W/m^2 a IUV). Los resultados que se obtuvieron en el lapso de tiempo evaluado muestran que la mayor parte del año la radiación recibida es alta y muy alta de acuerdo al sistema de protección solar recomendado por la O.M.S. La exposición a los UVB inicia con mayor intensidad a las 10:00 am hasta las 16:00 pm. Concluyendo, que en la ciudad de Zacatecas la mayor parte del año existe un alto Índice UV.

Radiación ultravioleta, biómetro, Índice UV

Citation: FRÍAS-HERNÁNDEZ, Juan Daniel, GONZÁLEZ-CABRERA, Adriana Elizabeth, VILLEGAS-MARTÍNEZ, Rodrigo Cervando and GARCÍA-GONZÁLEZ, Juan Manuel. Evaluation of the UV index in the campus UAZ siglo XXI for the year 2019. ECORFAN Journal-Republic of Nicaragua. 2022. 8-14:11-14.

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Introduction

The city of Zacatecas is located at a latitude of 22°46'18" N and a longitude of 102°34'31" W. The average altitude above sea level is 2460 m. The average annual temperature is 17°C, the average maximum temperature is around 30°C and occurs in May, while the average minimum temperature is 3°C and occurs in January. Since if the solar potential is high, therefore, the radiation is high in all its wavelengths including the ultraviolet region (García *et al*., 2020).

Ultraviolet (UV) rays are invisible to the human eye and are classified according to their wavelength. It should be noted that the shorter the wave, the more intense the energy of the sun's rays. These are divided into three types: UVA, UVB and UVC. UVA rays have a long wavelength, between 320 and 400 nm, which pass through the atmospheric layers and are increasingly filtered to a lesser extent by the ozone layer and clouds. They hit the earth's surface throughout the day. These penetrate the deep layers of the skin, activating the production of melanin and causing tanning, but when penetrating the skin, this type of radiation destroys the collagen that gives elasticity to the skin and causes premature aging, spots and precancerous lesions. UVB rays are medium wavelength rays that are in the range of 280 to 320 nm. These are largely absorbed by the ozone layer and moderately blocked by clouds, but nevertheless reach the earth's surface. The time of greatest intensity of this type of radiation is between 11:00 a.m. and 4:00 p.m. and the main cause of skin cancer. And finally UVC rays are short wavelength rays that range between 200 and 280 nm, they are potentially dangerous and extremely aggressive for humans. They do not reach the earth's surface because the ozone layer absorbs and retains them.

Ultraviolet radiation and the damage it causes in humans

The largest organ that the human being has is the skin, it is a non-compacted superficial organ that covers and protects the external surface of the organism, it has a surface area of 1.6 to 2 m2, a thickness of 0.5 to 4 mm and its weight is 4-5kg. Its functions are: protection, emuntory, melanogenesis, thermoregulation, deposits, sensitivity, and so on.

The damage that ultraviolet radiation can cause due to prolonged exposure can produce significant changes in some biological functions, this is due to the high energy of its photons. These changes can manifest as severe damage to living beings, such as DNA replication failure, skin lesions, premature skin aging, melanoma, sunburn, etc. (Figure 1). This is why the population has to be informed of the damage caused by exposure to the sun for a long time and if we are, take the precautions that the protection system sets for us.

Figure 1 Pathologies caused by the interaction of UV rays in the human body

The World Health Organization (WHO) recommends the protection system for the five different levels of radiation, which is presented in Table 1.

UV index	Protection	Solar protective action
0-2	Low	Minimal sun protection. More than one hour exposed to sunlight. Gloves and sunscreen are required.
3-5	Moderate	To take precautions. Wear a hat and sunglasses if exposed to the sun for 45 minutes or more.
6-7	High	Protection such as a hat, sunglasses and sunscreen is required for damage caused to the skin by exposure for more than 30 minutes. Reduce the time you are exposed to the sun between 11:00 and 16:00 hours.
8-10	Very high	Extreme precautions are required. Wear a hat, sunglasses and sun protection cream, otherwise the skin can be damaged and burned if exposed to sunlight for more than 20 minutes. Avoid solar radiation between 11:00 and 16:00 hours.
>11	Extreme	Take all necessary precautions. Unprotected skin damage and burns occur in minutes. Avoid sun exposure between 11:00 and 16:00 hours.

Table 1 Sun protection system recommended by the WHO
Source: (Olarte S, 2015)

ISSN-On line: 2414-8830

Roy *et al*., (1998), used SRM spectroradiometers to measure solar ultraviolet radiation, due to the high rates of skin cancer since the mid-1980s (Roy C.R., 1998). Diffey presented in his work the biological effects of UV radiation, using an optically filtered xenon arc lamp or fluorescent lamps to simulate the UV component of sunlight to have controlled experimentation (Diffey, 2002). Vallejo D. Luís (2003), presented a study of the Ultraviolet Index (UVI) in Chile. In addition, he explained the physical meaning of the IUV, as well as the main factors that affect it (Vallejo Delgado, 2003). Pinedo et al (2006), carried out an analysis of the ultraviolet spectral irradiance recorded in the city of Zacatecas. A Bentham radiometer was used to obtain the spectra. Measurements showed relatively high levels of ultraviolet irradiation (Pinedo V. J. L., 2006).

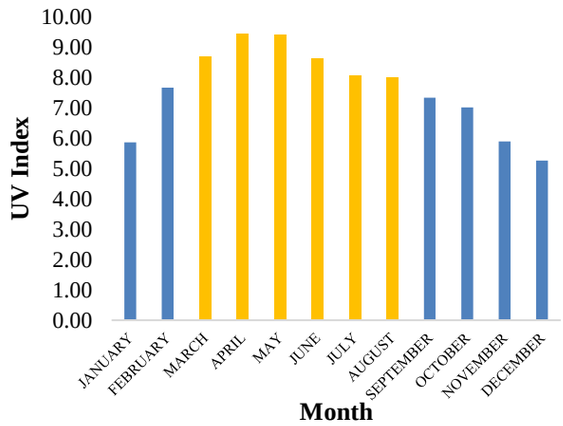
Methodology

Ultraviolet radiation (UVB) data were obtained in the period from January 1 to December 31, 2019. To measure UVB, a Solar Light 501-A Biometer was used (Figure 2), which is installed at the station. solarimetric Zacatecas_04 of the National Solarimetric System, located in Building E6 of the UAZ Siglo XXI Campus. Data was recorded on a Campbell Scientific CR-3000 datalogger, taken every two seconds and recorded every minute (average). The data is then transformed into the UV Index using the conversion factor of 2.332 UVB (1 MED/h = 0.0583 W/m² and 1 IUV = 0.025 W/m²). They are then averaged per hour, per day, per week and per month. The results obtained are analyzed and interpreted.

Figure 2 Solar Light 501-A Biometer

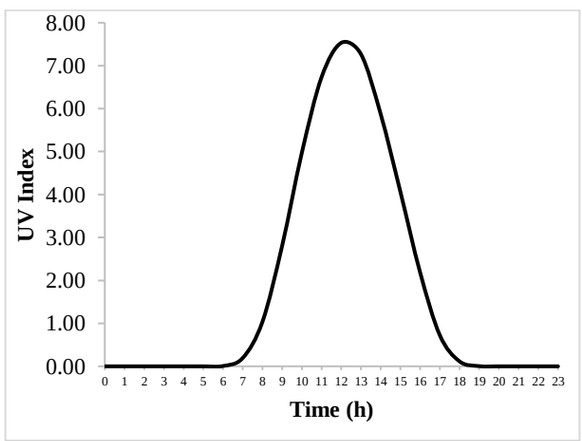
Results

In Graphic 1 it can be seen that during the months of March to August a higher UVB radiation index is registered, where it corresponds to the seasons of the year spring and summer where solar energy reaches the earth with more intensity, also during the months of From June to August there is a decrease that could be due to the rainy season where the clouds block the passage of the sun's rays, therefore the radiation received by the earth is less.



Graphic 1 Period from January 1 to December 31, 2019, showing the highest UVB index of each month

Graphic 2 shows the average UV Index per hour in the evaluated period. It is observed that the geometric shape of the Figure has a negative bias. The incidence of UVB radiation begins at 7:00 am and ends at approximately 7:00 pm. Exposure to UVB radiation with greater intensity is between 10:00 am and 3:00 pm.



Graphic 2 Average UV index per hour in the period from January 1 to December 31, 2019

ISSN-On line: 2414-8830

Table 2 shows what day of the month and at what time the highest UV Index was recorded. Where in the month of April and May a UV Index of 12 was recorded, placing it on the scale that manages the Sun Protection System recommended by the OMS at an EXTREME level, so extreme precautions are required.

Month	Hour	Day	UV Index
January	13:00	9	7
February	13:00	21	10
March	12:00	19	11
April	12:00	17	12
May	12:00	12	12
June	12:00	28	11
July	12:00	6	11
August	13:00	20	10
September	12:00	14	11
October	12:00	8	10
November	12:00	9	8
December	12:00	22	7

Table 2 Day and time where the highest UV index of each month was obtained

According to Vallejo (2003), UV radiation increases with altitude because the amount of absorbers in the atmosphere decreases with height. The measurements made by him showed that UV radiation increases between 6% and 8% for every 1000 m (Vallejo Delgado, 2003). Based on the above, it implies that the altitude of the city of Zacatecas should contribute to increasing UV radiation above 8%.

Conclusions

In conclusion, the cleanliness of the sky, the low presence of atmospheric aerosols, the average height above sea level of the city of Zacatecas, the UV Index throughout the evaluated period is High to Very high. The months with the highest UV Index are from March to August, although extreme instantaneous values are presented in April and May, at solar noon. According to the OMS. Preventive protection is required such as wearing a hat, long sleeves, and in some cases glasses, in addition to sunscreen, otherwise the skin ´can suffer damage and burns if exposed to sunlight and the population must be informed so that they take the necessary and sufficient care. And do everything possible so that society reduces unnecessary sun exposure time between 11:00 and 16:00.

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ISSN-On line: 2414-8830

Article **ECORFAN Journal-Republic of Nicaragua**
June 2022, Vol.8 No.14 15-21

A comparative study between a system of commercial mixed oxide ceramic membranes and a system of mixed oxide ceramic membranes impregnated with porcine gelatin for the removal of emergent pollutants

Estudio comparativo entre un sistema de membranas cerámicas de óxidos mixtos comerciales y un sistema de membranas cerámicas de óxidos mixtos impregnadas con gelatina porcina para la remoción de contaminantes emergentes

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DOI: 10.35429/EJRN.2022.14.8.15.21 Received January 20, 2022; Accepted June 30, 2022

Abstract

A comparison was made between a tangential flow system with mixed oxide ceramic membranes and a tangential flow system with mixed oxide ceramic membranes impregnated with porcine gelatin for emerging contaminants such as tetracycline. For the impregnation of the ceramic membranes, a tangential flow system and a 1% porcine gelatin solution were improved. The surface of the membranes before and after impregnation was characterized by Scanning Electron Microscopy (SEM) to observe the deposition of porcine gelatin in the pores. For the removal tests, ceramic membranes of mixed oxides of 1 KD and 5 KD and a Tetracycline solution of 80 mg/L were used, taking samples at 10, 30 and 60 min, which were analyzed by means of UV-Vis spectroscopy. The objective of this work was to compare the removal capacity of emerging contaminants by means of a membrane system impregnated with porcine gelatin. A removal above 70% of Tetracycline was obtained in the 5KD membranes with impregnation.

Membranes, porcine, emerging, impregnation, removal

Resumen

Se realizó una comparación entre un sistema de flujo tangencial con membranas cerámicas de óxidos mixtos y un sistema de flujo tangencial con membranas cerámicas de óxidos mixtos impregnadas con gelatina porcina para contaminantes emergentes como la Tetraciclina. Para la impregnación de las membranas cerámicas se utilizó un sistema de flujo tangencial y una solución de gelatina porcina al 1%. Se caracterizó la superficie de las membranas antes y después de la impregnación por medio de Microscopia Electrónica de Barrido (MEB) para observar el depósito de la gelatina porcina en los poros. Para las pruebas de remoción se utilizaron membranas cerámicas de óxidos mixtos de 1 KD y 5 KD y una solución de Tetraciclina de 80 mg/L tomando muestras a los 10, 30 y 60 min que fueron analizadas por medio de espectroscopia de UV-Vis. Se obtuvo una remoción arriba del 70% de Tetraciclina en las membranas de 5KD con impregnación. El objetivo del presente trabajo fue comparar la capacidad de remoción de contaminantes emergentes mediante un sistema de membranas impregnadas con gelatina porcina.

Membranas cerámicas, porcino, impregnación, remoción

Citation: ESTRADA-PÉREZ, Jeniffer Giovanna, PÉREZ-MORENO, Víctor, RAMOS-LÓPEZ, Miguel Ángel and RODRÍGUEZ-MORALES, José Alberto. Multiresidual analysis of pesticides in a soil with cacao culture, in Úrsulo Galván, Veracruz. ECORFAN Journal-Republic of Nicaragua. 2022. 8-14:15-21.

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Introduction

Emerging pollutants are poorly regulated compounds that have different negative effects when they enter to different water bodies (Devi *et al*., 2020). Among them are pharmaceutical products, pesticides, personal care products and drugs (Zacarías *et al*., 2017). Different compounds such as antibiotics reach the water through the feces of humans and animals feces and urine (Saremi *et al*., 2020).

Antibiotics are medicines that are used both in humans and in animal production and their consumption has increased in recent years, causing its accumulation on the environment and resulting on negative effects for the different ecosystems (Xuequing Zhong., 2021).

Tetracycline

Among the most used antibiotics is Tetracycline (TC), a broad-spectrum antibiotic used primarily on animal husbandry as a growth promotor and in disease control. TC represents 29 % of the total consumption of antibiotics (Rizzi, *et al*., 2020). TC is not completely metabolized by humans or animals, thus 50-80% its directly discharged to water through urine and feces of animals and humans (Chen, Wang, Duan, Yang, & Gao., 2016).

TC accumulation on water has caused many negative effects on the environment. First, it is related with the disappearance of different kind of aquatic microorganisms as cyanobacteria, protozoa, fungi among others (Grenni *et al*., 2018).

Second, its presence on the environment is related with the generation of bacterial resistance (Roy *et al*., 2021). Then, removing TC of water bodies is an environmental concern, and it has been proposed many technologies for its removal.

Ceramic membranes

Ceramic membranes have turned out to be a low-cost and highly efficient technology in water treatment. Unlike polymeric membranes, ceramic membranes show greater chemical and thermal stability, which increases the useful life of the membrane, allowing it to be washed and sterilized for reuse (Dong & Yiqun, 2021).

Ceramic membranes work through a pressure difference; however, different compounds have been studied to coat them with the intention of improving their hydrophobic properties and increasing their efficiency (Merlet *et al*., 2020).

Within these compounds is the activation of certain functionals such as carboxyls through a layer of porcine gelatin that favors the adsorption of certain compounds (Cazes, Belleville, Mougel, Kellner, & Marcano, 2015).

Methodology

Assembly of tangential flow system

For the assembly of the system, it was necessary to make the selection and coupling of the hoses that connected the tangential flow system to the recirculation vessel. This container is where the synthetic water was deposited. A pump was placed that allowed the flow to pass through the membrane, working at room temperature. In turn, the system of pressure gauges and valves was installed that allowed us to regulate the system pressure. Finally, the membrane was placed in the tangential flow cartridge and the outlet hoses for the permeate were also connected.

For the operation of the system, the following operating conditions were established: temperature: 20°C, pH: 7, pressure: 2 bars, pump power: 90 rpm.

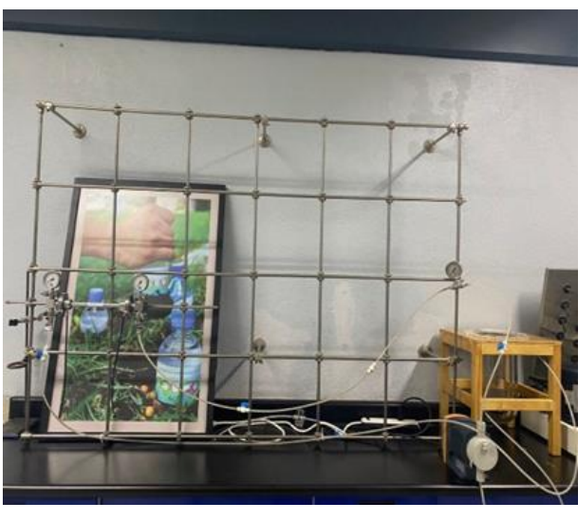

Figure 1 Tangential flow system

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Flow measurement

Once the absence of leaks was confirmed and the system pressure had stabilized, the flow measurements were made. Flow measurement consisted of measuring the time in which a litre of water recirculated through the system. This measurement was made prior to impregnation and again with the impregnated membrane in order to compare the flux through the membrane impregnated with porcine gelatine. Flow measurements were expressed in l/min.

Preparation of solutions for membrane impregnation

For the preparation of the solutions, type A pork skin gelatin (Sigma-Aldrich Co., St. Louis, MO), grade II glutaraldehyde at 25% in H_2 O (Sigma-Aldrich Co., St. Louis, MO) and Tetracycline 98.0-102% (HPLC) (Sigma-Aldrich Co., St. Louis, MO).

- Preparation of the phosphate solution: A phosphate solution was prepared with deionized water and 5.43 g of dibasic sodium phosphate dihydrate and 4.56 g of monobasic sodium phosphate dihydrate. This solution served us to maintain the pH in the preparation of the other solutions.

- Preparation of porcine gelatin solution for impregnation: for this case, 10 g (1%) of pork skin gelatin was added to a liter of phosphate solution at a temperature of 40 °C and left under stirring for 10 hours.

- Preparation of tetracycline solution: 100 mg were added to 1 liter of deionized water and left under stirring for 20 minutes at room temperature.

- Glutaraldehyde solution: 2 ml of glutaraldehyde solution in 25 ml of deionized water were added.

Membrane preparation and tetracycline removal capacity evaluation

The ceramic membranes used (TAMI industries, ZrO_2/TiO_2, 250 mm long, 6 mm internal Ø, 10 mm external Ø, surface area of 0.0047 m^2 and 0.4 µm pore diameter) were prepared according to the procedure proposed by the European Membrane Institute (Cazes *et al*., 2015).

Figure 2 Ceramic membrane TAMI Industries

One of the membranes was subjected to morphological characterization by Scanning Electron Microscopy to see the surface structure and be able to compare it with the already impregnated membrane. For this technique, the membrane was crushed to be able to analyze it in the equipment.

Four membranes were used for the experiments, two 1KD membranes, one unimpregnated and the other impregnated, and two 5KD membranes, one unimpregnated and the other impregnated with porcine gelatin. The impregnation was carried out with the phosphate gelatin solution prepared at 1% (10 g/L).

Membrane impregnation with porcine gelatin solution

For the preparation of the membrane, the gelatin solution was first heated at 40 °C for 30 minutes. Deionized water was passed through the membrane for 20 min to fill the pores and saturate them.

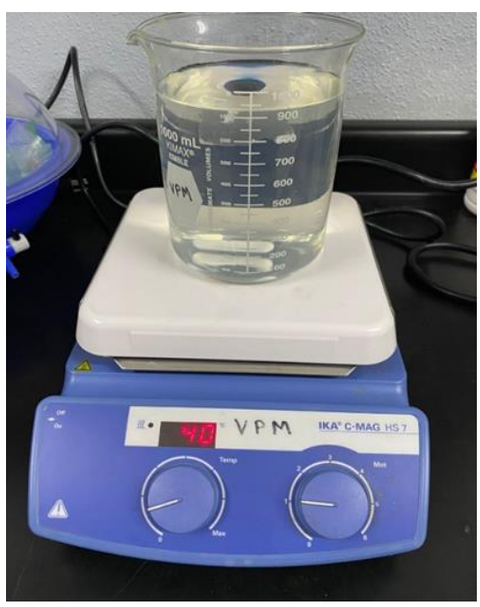

Figure 3 Porcine gelatin solution

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Subsequently, the gelatin solution was passed through the membrane for 25 minutes at 20 °C and with a transmembrane pressure of 2 MPa (2 bars) with a tangential speed of 1 m/s to give rise to the formation of the gelatin layer.

Then, the membrane was washed with pH 7 phosphate buffer solution. A 2% (w/v) glutaraldehyde solution was prepared with pH 7 phosphate solution. The membrane was placed vertically, and one end was covered with a stopper. then the interior of the membrane was filled with the prepared glutaraldehyde solution for 30 min at 20°C. This process was what allowed the carboxyl group in the ceramic membrane to be activated.

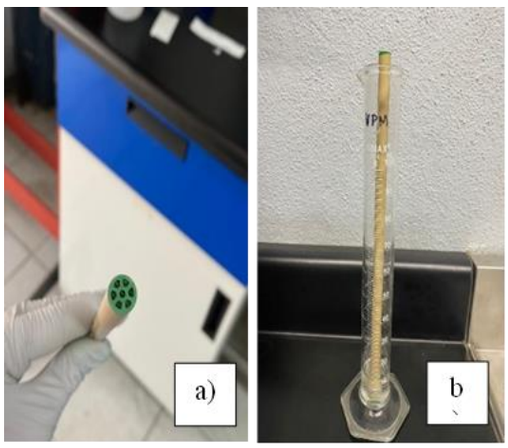

Figure 4 Incorporation of glutaraldehyde a) covered membrane pores, b) vertical location of the membrane

Flow measurement

Recirculation times of 1 liter of water were taken to determine the change over time as the water passed through the system with the membranes without impregnation and with the membranes impregnated.

Tetracycline removal assays

Once the membranes were prepared, tetracycline removal tests were carried out in synthetic water. For this, the membrane was placed in the circulation system, taking samples every 10 minutes for 1 hour to quantify the decrease in tetracycline.

Figure 5 Membrane permeates for sampling

The samples taken were analyzed by UV Vis spectroscopy at a wavelength of 234 to determine the decrease in the concentration of tetracycline over time. Removal tests were carried out with impregnated membranes of 1 KD and 5 KD and unimpregnated membranes of 1 KD and 5 KD to check the adsorption mechanism in the impregnated membranes and verify if the efficiency is higher than in the membranes without the treatment. Both assays were performed in triplicate.

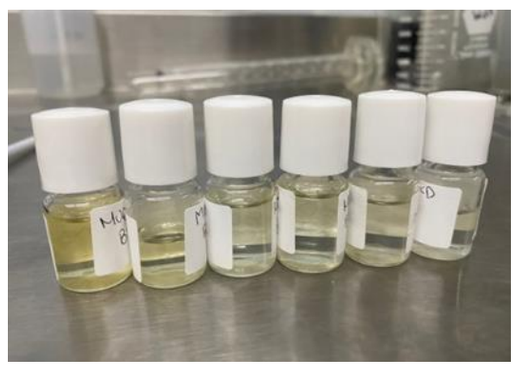

Figure 6 Samples after removal essays

Results

Change in the surface morphology of ceramic membranes after impregnation with porcine gelatin.

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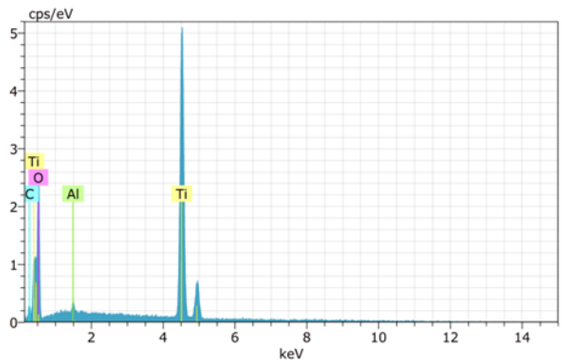
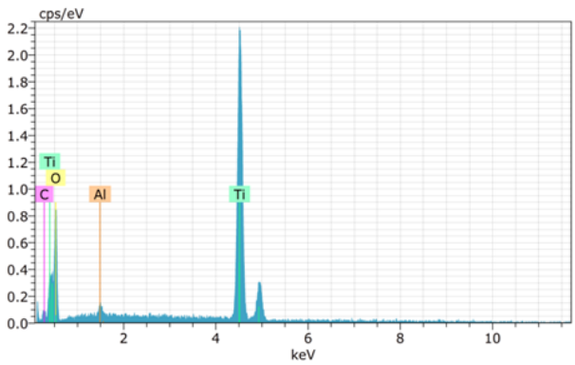
Figure 7 shows the initial structure of the membrane and its chemical composition. In figure 5 Titanium, Aluminum, Carbon, and Oxygen are present. This confirms the characteristics of the membrane composed of mixed oxides (Aluminum Oxide and Titanium Oxide).



Spectrum: SG

El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]
C	6	K-series	1.66	1.51	2.97	0.48
O	8	K-series	53.70	48.87	72.30	7.52
Al	13	K-series	0.55	0.50	0.44	0.06
Ti	22	K-series	53.97	49.12	24.28	1.61
Total:			109.88	100.00	100.00	

Figure 7 Elemental analysis of the ceramic membrane without the impregnation performed by EDS



Spectrum: CG

El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]
C	6	K-series	1.64	1.54	3.25	0.65
O	8	K-series	44.91	42.38	66.87	7.82
Al	13	K-series	0.84	0.80	0.74	0.09
Ti	22	K-series	58.57	55.28	29.14	1.79
Total:			105.96	100.00	100.00	

Figure 8 Elemental analysis of the ceramic membrane with the impregnation performed by EDS

The SEM images (fig 8) of the membranes before (a) and after impregnation (b) with gelatin show that there is no homogeneous layer of the polymer on the surface of the support. However, once the membrane is impregnated, the porcine gelatine agglomerates seem to have penetrated the porosity of the ceramic support.

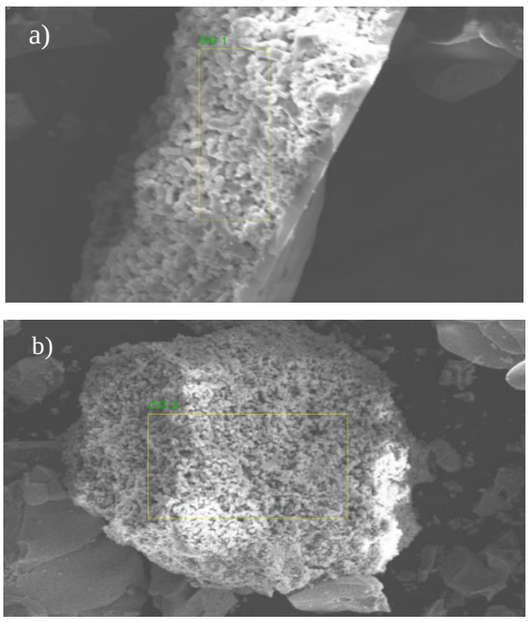


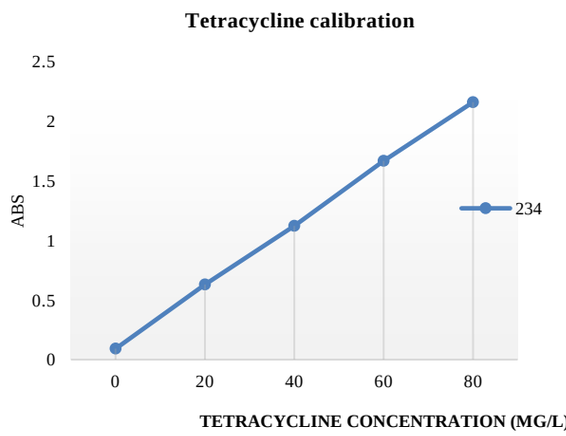
Figure 9 Superficial structure of ceramic membrane after impregnation with porcine gelatin

Before impregnation		After impregnation	
Time (min)	Volume (L)	Time (min)	Volume (L)
5	1.01	5	0.78

Table 1 Flow measurement on crossflow system before and after the impregnation.

Tetracycline quantification curve by UV Vis

Figure 11 shows the absorbances obtained from the standard curve made in UV vis, we can see that linearity is maintained at X concentrations and the most significant are between 0 and 80 mg/L, which gave us guidelines to select the concentration of 80 mg/L as the initial concentration to carry out the removal.



Graphic 1 Tetracycline calibration curve

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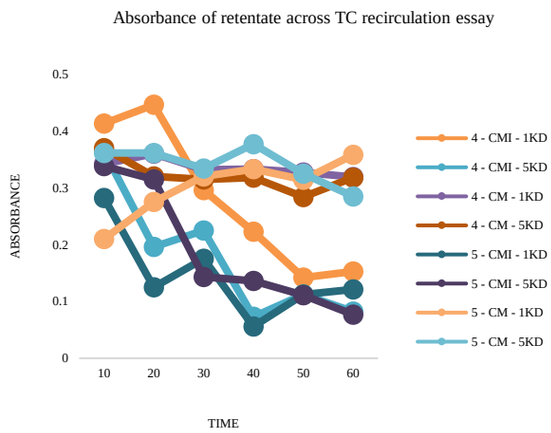
Tetracycline removal essays

As shown in figure 12 at the end of the assays there are two clear groups of results, ceramic membranes impregnated (CMI) and ceramic membranes (CM). To test the statistical difference amongst the groups a two-way ANOVA with repetition was performed using EXCEL 365® statistics package using treatment as columns and pore size as row and .05 alfa. There was a mild significant difference between pore size and absorbance at 60 minutes of the essay (p= .035), also there was a highly significant difference (p=.0001) for the membrane treatment Which shows that the decrease in TC concentration is highly linked to the treatment, which points to porcine gelatine being a great option to increase the removal of TC in treatment.



Graphic 2 Tetracycline concentration across the essays

Conclusions

Ceramic membranes were successfully impregnated with the porcine gelatine via crossflow. Optimal conditions for the system were pH 7 and room temperature. The action mechanism of the impregnation of porcine gelatine was adsorption and this was proved by the absorbance obtained on the impregnated membranes. The results on the TC absorbance shows that the treatment with porcine gelatine had a significant relationship on the removal on the compound. The minimum absorbance obtained was 0.73 AU on the ceramic membrane impregnated of 5 KD. The impregnation of porcine gelatine tests has proved to be an efficient treatment for ceramic membranes and demonstrates that it improves the removal of TC in water.

These impregnated membranes have promising potential for the removal of lower or higher molecular weight like Sulfadiazine, Ciprofloxacin, Erythromycin and others or separation of mixtures of low and high molecular weight antibiotics.

Discussion

A FTIR analysis is recommended to confirm the mechanism of interaction between the porcine gelatine and the tetracycline.

Acknowledgement

We thank Universidad Autónoma de Querétaro for the support of the FONDEC-UAQ -2021 project and CONACYT for providing the funding of the scholarship.

Funding

This work has been funded by CONACYT (scholarship number: 769143)

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Article **ECORFAN Journal-Republic of Nicaragua**
June 2022, Vol.8 No.14 22-29

Cenote Chen ha, and water quality indicators

Cenote Chen ha, e indicadores de calidad de agua

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DOI: 10.35429/EJRN.2022.14.8.22.29 Received January 25, 2022; Accepted June 30, 2022

Abstract

The cenotes of the Yucatan Peninsula are characterized by karstic relief, warm temperatures, and transparency of their water bodies. The mixture of fresh water from infiltrations of rainwater and runoff coupled with underground rivers or marine intrusion, make up the habitat of aquatic, amphibian, and terrestrial species. The Chen ha cenote, located in Chocholá, was used for tourist purposes, however, the lack of an environmental culture and some anthropogenic activities cause deterioration and contamination of the wetland, which putting its conservation at risk. The objective of the present work was to carry out a limnological analysis in Cenote Chen ha, to determine the level of fragility of the ecosystem. The variables analyzed were pH, dissolved oxygen, temperature, conductivity and phytoplankton biodiversity. Results. 2600 µS/cm of conductivity, 8.25 pH and 2.8 ppm of dissolved Oxygen. Phytoplankton: Diatoms 46.2%, Cyanobacteria 38.1%, Chlorophytes 8.1%, Euglenas 5.5%, and Dinoflagellates 2.1% predominated. *Asterionella* was identified as an indicator species of environmental health. *Microcystis aureginosa*, *Planktothrix agardhii*, and *Cyanosarcina caribeana*, *Pseudanaena*, *Peridium* and *Gonyaulax* species are shown as indicators of environmental contamination. No dominance of any species was observed; however, frequent monitoring of indicator species is recommended.

Anthropogenic, Intrusión, Enviromental

Resumen

Los cenotes de la península de Yucatán se caracterizan por relieve cárstico, temperatura cálida y transparencia de sus cuerpos de agua. La mezcla de agua dulce procedente de infiltraciones de agua de lluvia y escorrentías con ríos subterráneos o intrusión marina, conforman el hábitat de especies acuáticas, anfibias y terrestres. El cenote Chen ha, localizado en Chocholá, se empleó con fines turísticos, sin embargo, la falta de cultura ambiental y actividades antropogénicas ocasionan deterioro y contaminación del humedal, ello pone en riesgo su conservación. El objetivo del presente trabajo fue realizar un análisis limnológico en el Cenote Chen ha, para determinar el nivel de fragilidad del ecosistema. Las variables analizadas fueron: pH, oxígeno disuelto, temperatura, conductividad y biodiversidad de fitoplancton. Resultados. 2600 µS/cm de conductividad, 8.25 de pH y 2.8 ppm de Oxígeno disuelto. Fitoplancton: predominaron las Diatomeas 46.2 %, Cianobacterias 38.1%, Clorofitas 8.1%, Euglenas 5.5 % y Dinoflagelados 2.1 %. Se identificó *Asterionella* como especie indicadora de salud ambiental. *Microcystis aureginosa*, *Planktothrix agardhii*, y *Cyanosarcina caribeana*, *Pseudanaena*, *Peridium* y *Gonyaulax* como indicadores de contaminación ambiental. No se observó dominancia de alguna especie, sin embargo, se recomienda monitorear con frecuencia las especies indicadoras.

Antropogénico, intrusión, ambiental

Citation: VIZCAINO-RODRIGUEZ, Luz Adriana, RAVELERO-VAZQUEZ, Víctor, LUJAN-GODINEZ, Ramiro and CANUL-GARRIDO, Divino Miguel. Cenote Chen ha, and water quality indicators. ECORFAN Journal-Republic of Nicaragua. 2022. 8-14:22-29.

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Introduction

Freshwater water resources in the Yucatan Peninsula are limited. Devoid of rivers, lakes and lagoons, 97% of its freshwater is located underground and the surface blooms called cenotes are the main sources that provide the vital liquid to the population (Cortes Campos, 2018). However, the whole karst aquifer of the State has a positive balance, that is, the amount of water that is extracted, does not exceed the natural recharge (Estrada Medina, Jimenez Osornio, Alvarez Rivera , & Barrientos Medina, 2020).

The word "Cenote" comes from the Mayan word d'zoot, which means a natural well of water. In the Peninsula, limestone rocks are abundant, and the presence of a large number of fractures and faults favors a highly permeable surface with the formation of a huge hydraulic complex of caverns and underground rivers (Fragoso-Servon & Alberto Pereira , 2016).

Open-air cenotes receive water from rainfall, surface runoff and/or groundwater inputs. Although the influence of tides is associated with high levels of salinity and the halophilic species found in these environments, they can also be freshwater depending on the magnitude of the rainfall discharge or entry of seawater currents.

It is worth mentioning that the biodiversity of the existing species and their distribution change with the reigning environmental conditions, trophics variables throughout the year, nutrient limitations, or water circulation patterns.

The cenotes provide the Mayan community not only water, but also a revered space for the celebration of myths, beliefs and religious rituals. Currently they are of great economic value for the establishment of irrigation systems and the selling of tourist services due to the beauty of their waters, their cavernous formations and their relationship with archaeological sites (Fragoso-Servon & Alberto Pereira , 2016).

According to the related literature and interviews conducted with users, the main contaminants of these bodies of water come from activities like pig farming, poultry farming, corn nixtamalization, fertilizer residues, open dumps, septic tanks leaks, among others (Cervantes-Martinez, Mezeta-Barrera, & Gutierrez-Aguirre, 2009).

In accordance with the regulatory framework of the National Water Commission (CONAGUA), cenotes are treated as groundwater resources. In the State of Yucatan, the selling of ejido lands is feasible and therefore the commercialization of these bodies of water is also possible. It is worth mentioning that many cenotes are owned by individuals or of an ejido or communal social character, such is the case of the Chen há cenote. (Cortes Campos, 2018).

This wetland was used for recreational purposes, and it was the headquarter of ecotourism activities, such as camping and swimming; however, the lack of an environmental culture added to the use of bad practices caused environmental deterioration and put at risk the loss of biodiversity of the body of water.

Chen ha is an open cenote type waterbody with an 85 m diameter and 27 m depth. It belongs to the municipality of Chocholá, and is located about 40 minutes from Mérida, Yucatan, with coordinates 20º 41 '22.3" N and 89º 52' 33.8" W.

The present work is part of a monitoring study of water quality and biodiversity of phytoplankton that will be carried out during the different seasons of 2022 and 2023.

Its purpose is to seek indicators of environmental pollution, directed to take actions that cap help to restore the environmental balance of the ecosystem, as well as the sustainable use of the ecosystem services provided by the waterbody such as recreational, cultural, hiking, habitat for species, protection and conservation of the body of water among others.

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The first monitoring event was carried out during the spring seson (May 2022) and the present work describes the results found. Diatoms are the dominant species, however, a great diversity of cyanophytes characteristic forms of the Mexican Caribbean were observed, as well as the presence of dinoflagellates with bioluminescence capacity are some of the species identified. The diversity of species that cohabit these environments are usually tolerant to high concentrations of salts and temperature close to 30 º C.

Methodology

This document includes the results of the analysis conducted during the spring 2022 season. Continuity will be given in summer, autumn and winter periods.

With the help of a multiparameter probe, the folowing environmental variables were recorded: Temperature, pH, conductivity, total suspended solids, and % of dissolved oxygen.

For the study of biodiversity, samples were recovered from the coastal zone, using the technique of horizontal dragging for 1 minute with a phytoplankton net of 30 cm in diameter, 50 cm in length and 20 micrometers thinck mesh.

The samples were fixed with 1% lugol solution and transferred to the Microbiology laboratory of the Polytechnic University of the Metropolitan Area of Guadalajara.

The morphological characterization was carried out with a Leica compound microscope and 10x and 40x lenses. The literature consulted for the identification of the species was based on studies by different authors cited in the bibliographic references.

Plylogenetic analysis

The search for gene and protein sequences was carried out based on NCBI data. Blast (Basic Local Alignment Search Tool) was used using 18s ribosomal RNA gene secuence de *Navicula viridula* for diatomeas and *Gloeothece* 16r RNA gene for cianobacterias. The cleasing Secuence was visually performer, removing the sequences that did not contain conserved sites or the repeated ones. NCBI diagrams were used.

Results

The Chen ha cenote is characterized by calm and transparent waters, with emerging vegetation such as *Phragmites autralis* and floating species within which *Nymphaea ampla* stands out.

Figure 1. Limnological monitoring, biodiversity of phytoplankton Cenote Chen Ha. May 11, 2022
Source: Vizcaino et al., 2022

The pH values recorded in May ranged from 7.65 to 8.58; similar to those reported for the cenotes of Cholul, Seminario, Vergel, X'caamal, Xoclán and Variance locations, with values of 7, 7.3, 8.2, 8.0 and 7.0, respectively during the dry season (Tavera, Novelo, & Lopez, 2013). It is worth mentioning that according to the literature the pH value is related to the dissolution of calcite from rocks and when it has values of 6.53 to 7.56 soluble forms of bicarbonate (HCO_3^-) predominate.

Dissolved oxygen was found in the range of 2.7 to 2.8 ppm. These results are low compared to those reported in Cholul, Seminario, Vergel, X'caamal, Xoclán and Variance sites, with values of 5, 7.2, 11, 6.8 and 7. $mg.l^{-1}$. As well as for those reported in 2005, for the Cenote Azul with values between 8 and 8.8 ppm, in the dry season.

The conductivity recorded was from 2594 to 2969 $\mu S.cm^{-1}$. Similar values were reported for the Blue cenote: 2.4 to 2.6 $mS.cm^{-1}$. However, they are high compared to those reported for Cholul, Seminario, Vergel, X'caamal, Xoclán, Variance cenotes, with values of 1250, 1990, 1400, 1900, 1800 $\mu S.cm^{-1}$ respectively.

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The origin of high levels of conductivity are multifactorial or due to the presence of high levels of ions such as calcium, potassium, magnesium, sulfate, chloride, carbonate and bicarbonate, coming from the dissolution of rock calcites, and the infiltration of groundwater, seawater or wastewater leaks. It is worth mentioning that the ppm values of total suspended solids ranged from 2293 to 1306.

According to the literature, temperature values of 32 °C, 29 °C for Vergel, X'caamal, 30 °C in Xolul, respectively, and 28 in Seminario were reported for the Xoclán cenote. On the other hand in the Cenote Azul the average temperature was 29.2 +/- 0.9 ºC, which is classified as warm-tropical (Cervantes-Martinez, Mezeta-Barrera, & Gutierrez-Aguirre, 2009).

The temperature recorded in Chen Ha was 32.2 °C at 50 cm depth and 31.7 °C at 1 m depth. The decrease from 0.5 ºC to 1 m deep, the levels of detected oxygen and the conductivity values (higher than those reported) suggest low water mixture in the wetland. It is worth mentioning that the results obtained should be corroborated by making a vertical profile of temperature and salinity in future determinations.

The entry and exit of water from the wetland, regulates the variables of salinity concentrations, temperature, oxygenation, and this, together with the luminous intensity, determines the biological diversity (Pratolongo , Piovan, Zapperi , & L. Negrin, 2013). Inside the Cenote Chen ha the percentage of relative species abundance from highest to lowest was: Diatoms 46.2%, Cyanobacteria, 38.1%, Chlorophytes 8.1%, Euglenas 5.5% and Dinoflagellates 2.1%. See figure 2.

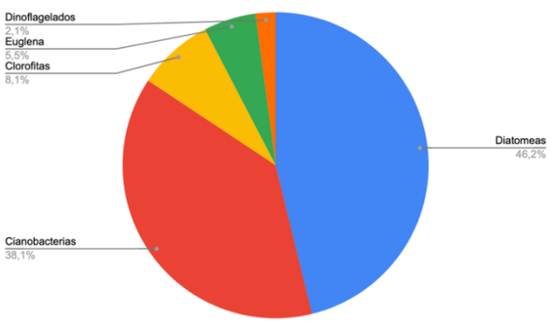

Figure 2 Relative abundance of phytoplankton detected in the Chen ha cenote, during the monitoring carried out in May 2022.
Source: Vizcaino et al., 2022

Primary productivity and phytoplanktonic populations change with environmental conditions and spatial-temporal variability (Obeso-Nieblas, Gaviño-Rodriguez, Obeso-Huerta, & Muñoz-Casillas, 2014). It is expected that in the rainy season the abundance and diversity of the reported species will decrease as well as the environmental variables, along with an increase in dissolved oxygen and a decrease in temperature values. Figure 3 shows some specimens of diatoms and cyanobacteria observed.

Regarding diatoms, *Surirella, Navicula viridula, Aulacoseira Italica, Aulacoseira sp, Gomponema angustatum, Melosira varians* and *Asterionella* were identified.

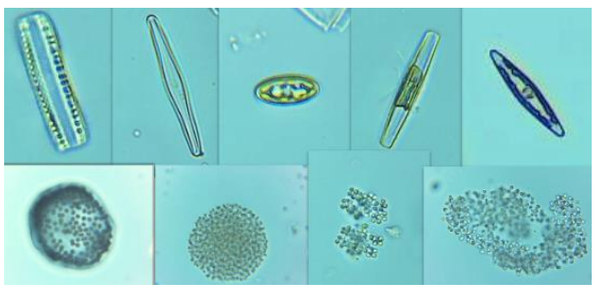

Figure 3 Diversity of diatoms and cyanobacteria observed in the Chen há cenote during May 2022. Mérida Yucatan
Source: Vizcaíno et al., 2022

Figure 4 shows the photograph of a *Melosira varians* specimen, an algae known as "water collars' ' in which the presence of chlorophylls and drops of oil provide the green and gold color.

Figure 4. *Melosira varians*, recovered from Cenote Chen ha, Yucatan Mexico, observed with optical microscope, 40X target
Source: Vizcaino et al., 2022

It is estimated that in Mexico, records from 5000 species of marine diatoms are found in waters of the Pacific and Gulf of Mexico.

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Among the diatoms with environmental importance, it is worth mentioning *Asterionella* which is used as an excellent indicator of water, due to its ability to synthesize molecules with antimicrobial activity. Extracts prepared with acetone from their biomass have antimicrobial activity against *Staphylococcus aureus*, *P. aeruginosa and E. coli.* The phytochemical profile of such algae extracts includes essential oils, alkaloids and phenolic compounds (Najera Arce, Alvarez-Fitz, Perez-Castro, Toribio-Jimenez, & Castro Alarcon , 2018).

Regarding cyanobacteria, the following species were identified: *Coelosphaerium, Microcystis flos aquae, Plankthotrix agardhii, Pseudanabaena Limnética, Microcystis aureginosa, Oscillatoria Subtilissima, Lyngbia, Planktolyngbia Limnética, Merismopedia Tenuissima, Microcystis incerta, Sinechocystis, Chroococcus sp, Oscillatoria, Asteriocapsa xcaamalensis, Cyanosarcina Caribeana, Aphanocapsa holsática, Limnothrix borgertii, Microcystis wesenbergii and Gloeothece.*

According to studies carried out in lentic water bodies in Yucatan, 206 species of cyanoprocarionts classified in 84 genera, 31 families and 7 orders have been identified: *Synechococcales* (31.06%), *Chroococcales* (26.69%), *Oscillatorial* (26.69%), *Nostocales* (11.16%), *Spirulinales* (2.48%), *Pleurocapsales* (1.49%) and *Chroococcidiopsidales* (0.49%), respectively (Arana-Ravell, Barrientos-Medina, & Lopez-Adrian, 2019).

Some species of cyanobacteria have potential biotechnology applications, due to their nutritional properties. Some of them produce secondary metabolites with industrial application and others are used as indicators of environmental pollution.

In our work, most of the cyanobacteria observed are characteristic of freshwater bodies, however species characteristic of the Caribbean were also identified. For example, our results coincide with those recorded for the Xcaámal cenote: the *Cyanosarcina Caribeana* algae , was identified in the drought season but in the rainy season the authors report that they observed the massive proliferation of it in the Xoclán, X caámal and Seminario cenotes.

Records of the presence of *Asteriocapsa xcaamalensis* are found in the cenotes of Xoclán and X'caamal (Tavera, Novelo, Lopez, 2013)).

The species of chlorophytes detected were: *Crucigenia cuadrata, Staurodesmus extensus, Pandorina sp, Closterium, Tetrastrum, Kirchneirella, Botryococcus, Chlorella, Volvox sp, Selenastrum gracile.*

Chlorophytes species yield an ample diversity of bioactive compounds used for commercial purposes like proteins, lipids, carbohydrates, carotenoids, vitamins, cosmetics goods, and energy productions by-productos (Blanco, 2019).

The presence of *Euglena Spirogyra, Euglena geitieri, was observed.* Regarding the dinoflagellates, the following species were identified: *Peridium Cinctum* and *Gonyaulax sp.* They belong to toxic phytoplankton microalgae.

Peridium is a freshwater dinoflagellate, it is an alga that has two flagella, and its morphological classification is not always adequate due to the great similarity between species, for example *P. gatunense* and *P. cinctum* which have been reported in the Caribbean. In Argentina P. *gatunense* was reported as responsible for the formation of blooms in lakes (Boltovskoy, 1983).

Gonyalaux is confused with another species of the same genus, within which *Lingulodinium polyedrum is a* cosmopolitan species, frequent in coastal areas with bioluminescent capacity. Records are found regarding its ability to produce Yesotoxins (YTX) with cytotoxic and cardiotoxic effects. However, under current conditions there were no mass proliferation events (Maciel-Baltazar, 2015).

Figure 4 shows the evolution of cyanobacteria according to the genome data obtained in the Genbank. Because no significant similarity was found between the different groups, 2 dendograms were elaborated, one for cyanophytes and one for diatoms (the most abundant species).

The phylogenetic tree of cyanophytes is classified into 2 clades, the first allows to distinguish Lyngbya from the rest of organisms. There is greater similarity between *Synechocystis* and *Microcystis*, with respect to *Gloeothece* which is classified in another clade.

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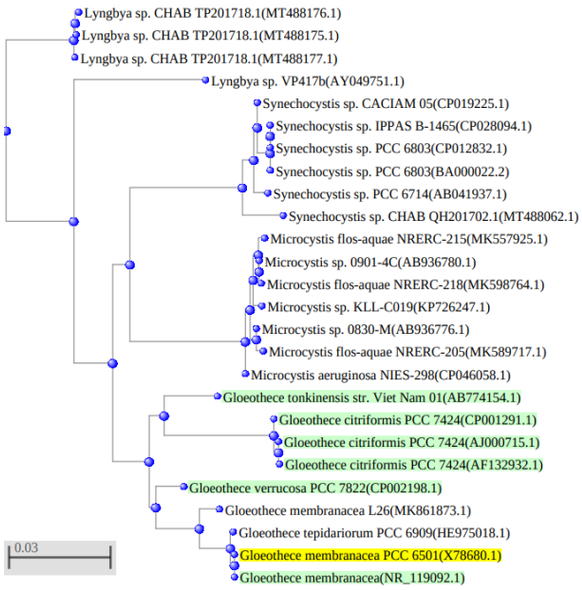

Figure 4 Phylogenetic tree of cyanobacteria identified in limnological monitoring in the Chen Ha cenote, Yucatan México, 2022.
Source: Vizcaino et al., 2022

According to the phylogenetic tree obtained for diatoms, these are classified into 3 main clades, in the first of *Aulacoseir*a and in the second asterionella. The third is subdivided into 3 clades: greater similarity was observed between *Surirell*a and *Gomphonema*, with respect to Navicula. See Figure 5.

The different types of algae did not evolve from a common ancestor, so there is no single basic structural pattern. Phytoplankton diversity is observed as a taxonomic and evolutionary unit from different ancestors with levels of organization determined by responses to natural selection pressures (Gonzalez, 1978).

When the cell density of a particular species is equal to or greater than 10^6 cells per liter, nutrient availability, temperature, oxygenation and luminous intensity are triggering factors that allow an algae bloom to develop form. However, a bloom can be harmless, harmful, or toxic.

There is a great diversity of toxins produced by algae as an adaptive response to the environment, such as ichthyotoxins with hemolytic activity, which cause the death of fish and marine organisms. As well as those that are accumulated and transferred through the trophic chain. All have an impact on health and the economy.

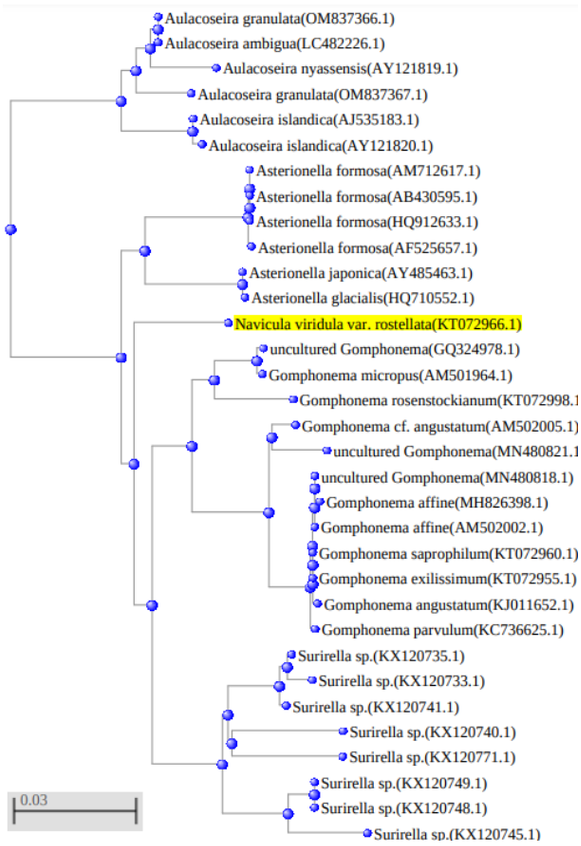

Figure 5 Phylogenetic tree of diatoms observed in the limnological monitoring of the Chen Há cenote during May 2022.
Source: Vizcaino et al., 2022

It is necessary to continue studies in different seasons, since physical phenomena such as rainfall, runoff and increase in sea level will change the availability of nutrients, water mixing and oxygenation.

The arrival of Sargassum to the Caribbean coasts generates a negative impact on tourism, its accumulation and degradation causes the production of unpleasant aromas such as methane as well as deterioration of the landscape. In response to this problem, several research centers developed a series of strategies to use it as a biomaterial with applications in the production of biofuels such as bioethanol; cellulose extraction for paper production, alginates, fucoxanthines, biostimulants or biofertilizers production, as well their use in the production of construction materials, among others. (Roussillon-Druker, J.; Calixto-Perez, E.; Escobar-Briones, E.; González-Cano, J.; Masiá-Nebot, L.; Córdova-Tapia, F. , 2022).

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The origin of the production of Sargassum is unknown for sure, however the most accepted theories include the eutrophication of runoff water from river discharges that reach the sea (which increase both organic and inorganic nutrients and favor the production of macroalgae in the ocean), as well as climate change, it is therefore important to know the state of the art of the water quality of the aquifers that communicate with the sea, for the taking of preventive or corrective actions.

The cenotes provide numerous ecosystem services, such as landscape, temperature regulation, habitat for aquatic, amphibians and birds species, so it is very important to conserve and make a sustainable use of them s in accordance with the indicators for a sustainable development: good quality water for all. It is worth mentioning that these bodies of water are intimately connected via groundwater and therefore a pollution source will have an impact on the entire basin, meanwhile a clean water point will have a positive impact.

Tourism development, as a strategy of economic growth of the Yucatan Peninsula in regions such as Cancun, Playa del Carmen and Bacalar increased the number of hotels and jobs, however, the economic spillover has made the gap between rich and poor larger. The wealth was accumulated in a few hands, investors and transnationals benefit from the possession of land and groundwater concessions, leaving communities and settlers in marginalization. (Angel, Reyes Maya, Barradas Miranda, & Castellanos Martinez, 2022) that is why this work is an integral part of a macroproject and aims to train the ejido community so that through the sustainable and sustainable use of its natural resources they develop tourist activities that allow them to benefit from this activity.

The results presented above are only the beginning of the activities necessary to integrate a network of collaboration among research, science, academic entities, and the general community, which will allow the taking of actions to mitigate the environmental deterioration product of anthropogenic activities carried out consciously or unconsciously and to preserve the legacy of humanity.

Annexes

Tables and suitable fonts.

Gratitude

Thanks to the University Politécnica de la Zona Metropolitana de Guadalajara and to Master Juan Luis Caro Becerra for his contribution in the edition of this work.

Financing

This work has been funded by the Universidad Politécnica de la Zona Metropolitana de Guadalajara (UPZMG) and the Universidad Tecnológica del Poniente (UTP).

Conclusions

Chen Ha is the habitat of species that indicate environmental health conditions such as *Asterionella*, species with biotechnological applications and others with toxic potential such as cyanobacteria and dinoflagellates. It is important to value them and to find strategies for their conservation.

It is necessary to promote and start environmental culture campaigns directed to the users of the Cenote Chen há.

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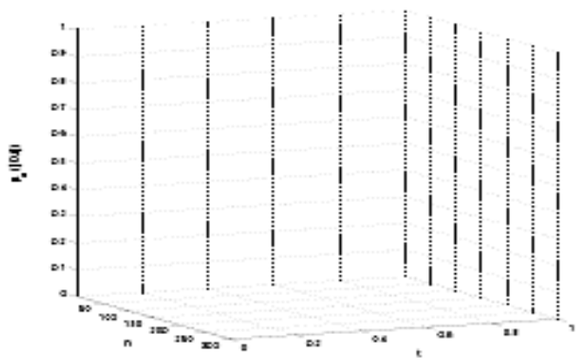

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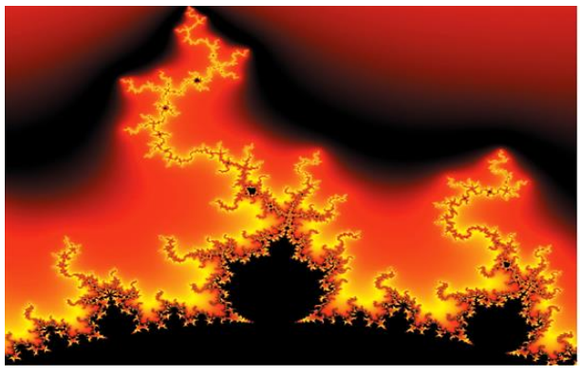

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ECORFAN Journal-Republic of Nicaragua

2414 8830
ISSN 2414 - 8830

www.ecorfan.org