



**Active Member**

Dr. Rodrigo González Enríquez



**Leader of the Research Group**

Dr. Germán Eduardo Dévora



**Active Member**

Dr. Jesús Álvarez Sánchez

# Investigation Group CA-036

Water Treatment and  
Materials Technology

# Collaborators



Dra. Reyna Guadalupe Sánchez Duarte



Dra. María del Rosario Martínez Macías



Dra. María Magdalena Armendaríz Ontiveros



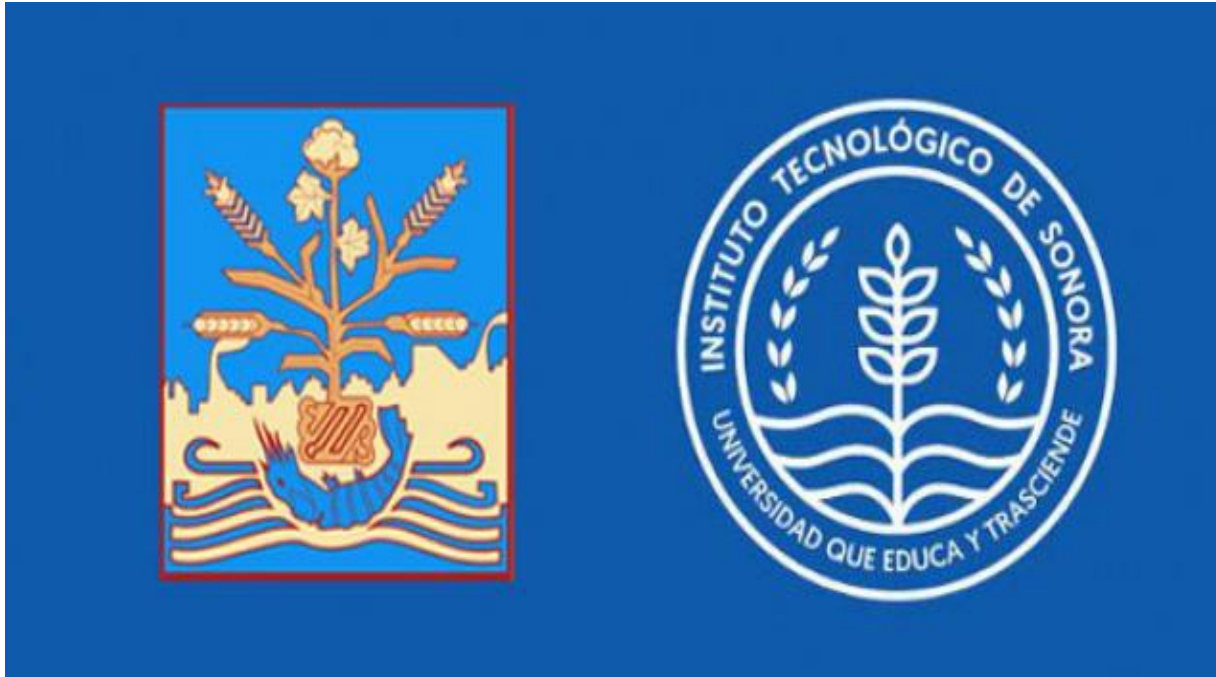
Dra. Ma. Araceli Correa Murrieta

# Investigation Group: Water Treatment and Materials Technology

Researcher	Academic degree	Member of the national system of researchers	Teacher in accredited program of chemical engineer
Germán Eduardo Dévora Isiordia	Dr.	SNI-1	X
Jesús Alvarez Sánchez	Dr.	SNI-1	X
Rodrigo González Enríquez	Dr.	--	X
Reyna Guadalupe Sánchez Duarte	Dra.	SNI-1	X
María del Rosario Martínez Macías	Dra.	SNI-1	X
Ma. Araceli Correa Murrieta	Dra.	SNI-1	X
María Magdalena Armendáriz Ontiveros	Dra.	SNI-C	X
<b>TOTAL</b>	<b>100 %</b>	<b>86 %</b>	<b>100 %</b>

# Instituto Tecnológico de Sonora

Natural Resources



**Departament:** Water Sciences and Environmental  
**Educational Program** Chemical Engineer



# Research Laboratories

1. **Dr. Germán Eduardo Dévora Isiordia**  
Desalination of brackish and marine waters with Renewable Energies
2. **Dr. Jesús Álvarez Sánchez**  
Polymers and materials
3. **Dr. Rodrigo González Enríquez**  
Hydrogeochemical and Environmental Explorations
4. **Dra. Reyna Guadalupe Sánchez Duarte**  
Biopolymers
5. **Dra. María del Rosario Martínez Macías**  
Biopolymers and phytoremediation with microalgae
6. **Dra. Ma. Araceli Correa Murrieta**  
Bioadsorbents
7. **Dra. Maria Magdalena Armendariz Ontiveros**  
Dynamic Biosystems and Renewable Energies

# Research Laboratory:

Desalination of brackish and marine waters with  
Renewable Energies



**Dr. Germán Eduardo Dévora Isiordia**

[german.devora@itson.edu.mx](mailto:german.devora@itson.edu.mx)

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<https://www.itson.mx/oferta/iq/Paginas/german-devora.aspx>

# AUTHORIZED PROJECTS

**CONACYT**

Operation, analysis of the problem and pollution generated in desalination plants located in the Mexican Republic, in order to determine the regulations applicable to this item

**Períod:**  
**2007-2010**

**Amount:**  
**\$163,000 USD**





# Benefits to ITSON



**\$ 107,000 USD**

**A reverse osmosis desalination plant 150 m<sup>3</sup>/d was acquired**

Agricultural productive projects are elaborated in Yaqui Valley



# Products

Before Desalination plant



Brackish water well



4,000 mg/L Salinity

**Yield:** 22 Ton/Ha



Tomato

7.5 Ton/Ha



Sorghum

27 Ton/Ha



Mango

4 Ton/Ha



Ricinus Communis



# Products

After Desalination plant



Brackish water well 4,000 mg/L

Reverse Osmosis

300 mg/L



Tomato



Sorghum



Mango



Ricinus Communis

Before: Yield: 22 Ton/Ha

7.5 Ton/Ha

27 Ton/Ha

4.1 Ton/Ha

After: Yield: 24 Ton/Ha

9.0 Ton/Ha

29 Ton/Ha

5.3 Ton/Ha

**Fundación  
PRODUCE**

Technology on water desalination in wells with saline intrusion problems for reuse in agriculture.

**Monto:  
\$37,000 USD**





# Delivered Products

- Know the yield behavior of tomatillo exposed to different concentrations of salinity. Using a reverse osmosis desalination plant



# Innovation stimulus program (PEI) (CONACYT)

Prototype development of solar desalination plant, for rehabilitation of salitrated wells on the coast of Hermosillo, Sonora; Mexico

**Período:**  
**2015-2016**

**Monto:**  
**\$ 198,000 USD**



# Delivered Products

## Reverse Osmosis Desalination Plant



**RO = 40 m<sup>3</sup>/d**



# Delivered Products

## Solar Park ITSON 120 kWh



### 3 sistemas de Generación

24 Panels in fixed system      ~ 30 kWh

36 Panels in 1 axis system      ~ 40 kWh

24 Panels in 2 axis system      ~ 50 kWh

# Delivered Products

Open access peer-reviewed chapter

## Using Desalination to Improve Agricultural Yields: Success Cases in Mexico

By Germán Eduardo Dévora-Isiordia, María del Rosario Martínez- Macías, Ma. Araceli Correa-Murrieta, Jesús Álvarez-Sánchez and Gustavo Adolfo Fimbres-Weihs

Submitted: November 16th 2017 Reviewed: March 28th 2018 Published: November 5th 2018

DOI: 10.5772/intechopen.76847

Research Article



## Evaluation of the effect of the salinity of irrigation water on the yield of castor plant hybrids (*Ricinus communis L.*) in Mexico

### Abstract

The study consists of evaluating the response of three hybrids of castor plant (*Ricinus communis L.*), Zoya 856, Olga 864 and Galit K-93, to four irrigation treatments at different salt concentrations (2.3, 3.12, 3.9 and 4.68 dS m<sup>-1</sup>) simultaneously. The objective was to compare the yield between hybrids for each treatment, as well as to determine the effects caused by excess salt in the stages of germination, flowering and growth of the plant. The research was conducted in Block 1916 of the Yaqui Valley, located in the state of Sonora, Mexico. Irrigation water was obtained from a brackish well with 3,900 mg L<sup>-1</sup> of total dissolved solids adjacent to the study area and subjected to a desalination process by reverse osmosis using a system with an output of 150m<sup>3</sup>d<sup>-1</sup>, equipped with 12 membrane modules (model SWC4-MAX) with dimensions of 0.20mx1.01m. The results showed that the germination and flowering stages were delayed as the concentration of salts increased. In conclusion, the yield of the hybrids increased under irrigation with higher salinity, with the Olga 864 hybrid having the highest production (2.28 ton Ha<sup>-1</sup> with irrigation of 4.68 dS m<sup>-1</sup>).

**Keywords:** castor plant, desalination, reverse osmosis, yield

Volume 2 Issue 5 - 2018

Devora-Isiordia Ge,<sup>1</sup> Valdez-Torres Lc,<sup>1</sup> Granillo-Moreno Ka,<sup>2</sup> Robles-Lizarraga A,<sup>2</sup> Martínez-Macias Mr,<sup>1</sup> Álvarez-Sánchez J<sup>1</sup>

<sup>1</sup>Department of Water Sciences and Environment, Mexico  
<sup>2</sup>Master of Science Program in Natural Resources, Technological Institute of Sonora, Mexico

**Correspondence:** Devora-Isiordia Ge, Department of Water Sciences and Environment, Mexico.  
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**Received:** September 11, 2018 | **Published:** October 22, 2018

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**ISSN Print 1944-3994, ISSN Online 1944-3986**

The journal is dedicated to research and application of desalination technology, environment and energy considerations, integrated water management, water reuse, wastewater and related topics.

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The screenshot shows the journal's interface with the article title, authors (Germán Eduardo Dévora-Isiordia, Rodrigo González-Enriquez, Saúl Ruiz-Cruz), a search bar, and a list of tools for the article (print, metadata, citation, etc.).

IAPE '19, Oxford, United Kingdom  
ISBN: 978-1-912532-05-6

## Application of Photovoltaic Solar Energy for rehabilitation of saline wells in Hermosillo, Sonora, Mexico

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Palo Blanco, Salamanca Guanajuato  
vhjimenez@gmail.com

### ABSTRACT

Water scarcity takes place when the demand exceeds the supply for fresh water in the given area. The three main aspects that characterize the scarcity of water are: the physical lack of available water to satisfy the demand; the level of development of infrastructure that controls storage, distribution and access; and the institutional capacity to provide the necessary water services. In

solar tracking system to increase the efficiency of the photovoltaic system, this to produce >20 cubic meters/day, giving this water production, the feasibility of using the land in disuse for raising livestock, obtaining very efficient results.

### Keywords

Solar Desalination, Photovoltaic Energy, Wells Rehabilitation.

- Indexed Article Published JCR, SCOPUS, WofS
- Participation in congress
- Thesis Master and PhD

# Research Laboratory:

## Polymers and Materials



**Dr. Jesús Álvarez Sánchez**

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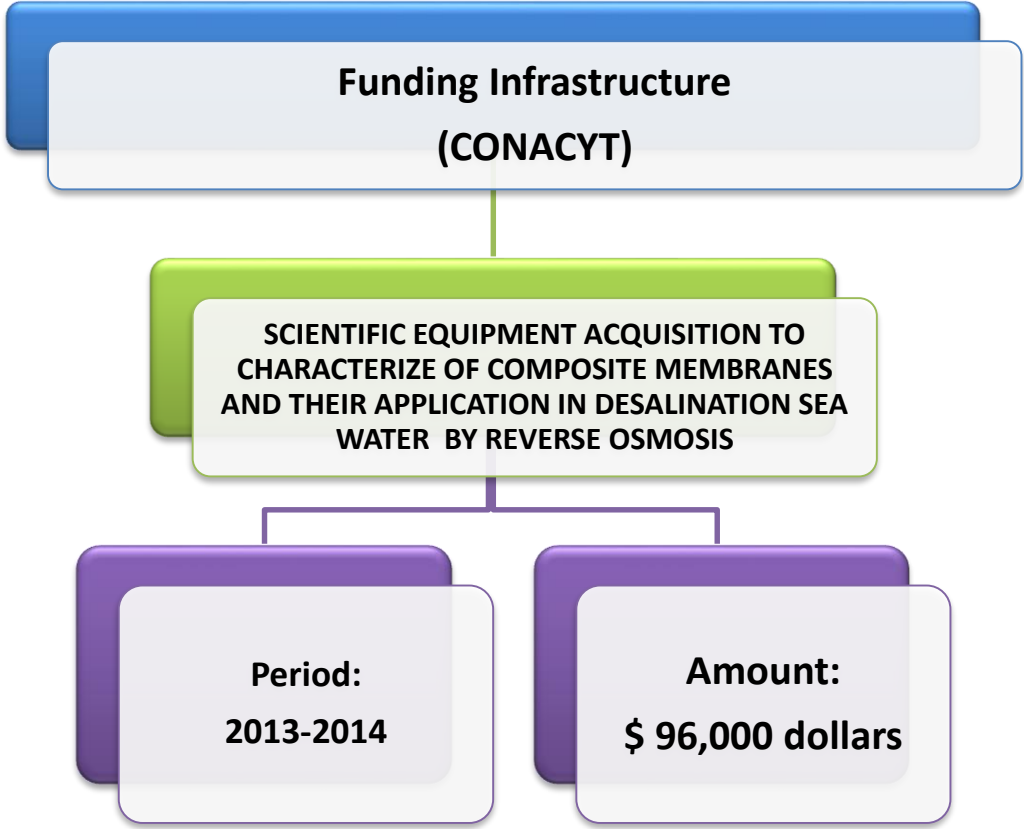
**Teaching Professional Development Program  
(PRODEP)**

**PREPARATION AND CHARACTERIZATION  
OF NEW COMPOSITE MEMBRANES  
CHLORINE RESISTANT AND THEIR  
APPLICATION IN REVERSE OSMOSIS**

**Period:  
2012-2013**

**Amount:  
\$ 25,000 dollars**





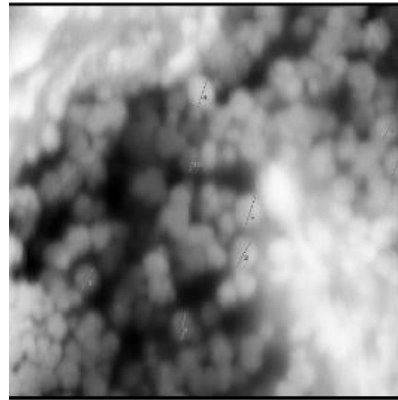


# Delivered Products

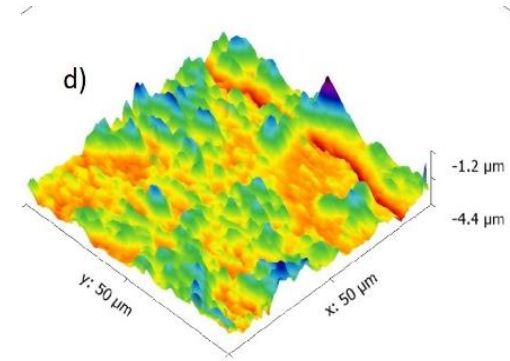
## Atomic Force Microscopy (AFM)



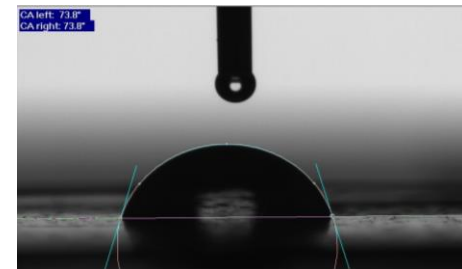
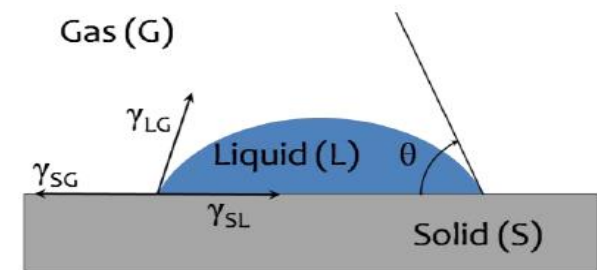
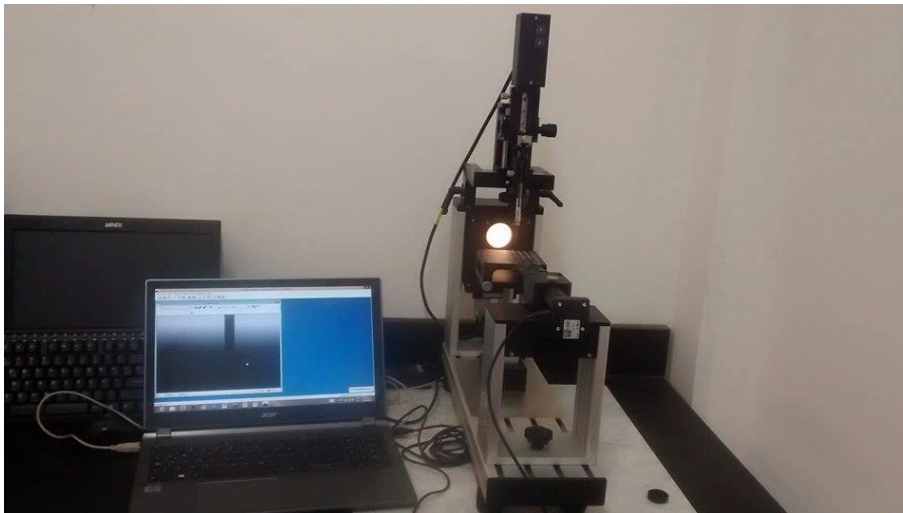
## ZnO Nanoparticle



## Membrane roughness

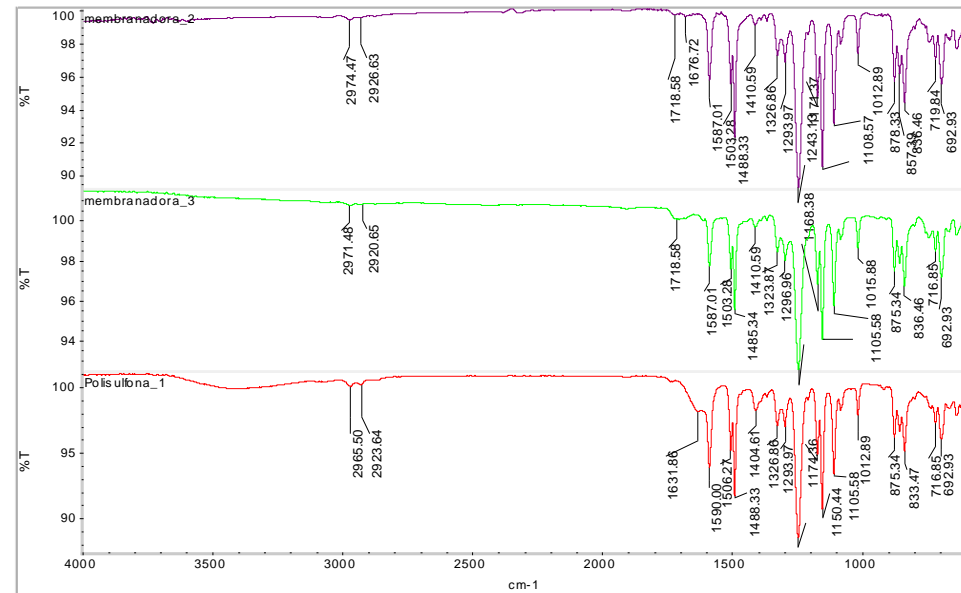


## Contact Angle



# Delivered Products

Infrared spectrophotometer by ATR  
(Attenuate total reflectance)



# Professorship Project CONACYT (CONACYT)

**MODELING OF FOULING AND OPTIMIZATION OF  
THE DESIGN OF MEMBRANE MODULES FOR THE  
DESALINATION OF SEA WATERS AND BRACKISH  
WATERS ON THE PACIFIC COAST**

**Period:  
2014-2015**

**Amount:  
\$ 25,000 dollars**



# Research laboratory at ITSON

## Biopolymers



**Dra. Reyna Gpe. Sánchez Duarte**

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# ***Copper bioadsorption of acidic water from mines in a natural polymer (chitosan)***

Evaluate the chitosan adsorption capacity as bio adsorbent of Allura red dye through kinetics and isotherm of adsorption.

**Time frame:**  
**2016-2017**

**Amount:**  
**\$ 5,200 USD**



Cáscara de camarón



Quitosano





# Production and characterization of chitosan nanoparticles to adsorb dyes

Synthesis chitosan-tripolyphosphate nanoparticles by using the ionic gelation method for the adsorption of food dyes

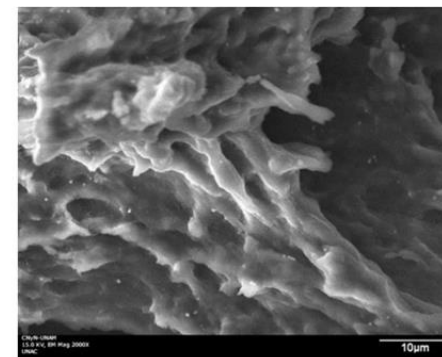
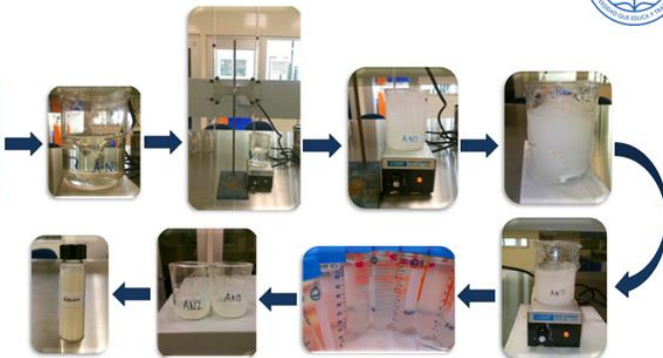
Time frame:  
2018-2019

Amount:  
\$ 5,200 USD

Obtención de nanopartículas de quitosano



Solución de ácido acético 0.05% + Solución de tripolifosfato de sodio



Micrografía electrónica de barrido (SEM) de nanopartículas de plata-quitosano

# Chitosan crosslinked for membrane preparation

Production of chitosan-based membranes with the incorporation of chemical compounds (crosslinkers, plasticizers and/or grafting) in their matrix, for possible use in filtration processes and /or seawater desalination processes.

**Time frame:**  
**2019-2020**

**Amount:**  
**\$ 2,080 USD**

Producción de quitosano

Caracterización de quitosano

Preparación de membranas

Caracterización de membranas

**Obtención de membranas a base de quitosano**



# Delivered Products

- Articles published in international journals and chapter of the book
- Presentations at national and international congresses
- Thesis Topics

Article

## Study of a fixed-bed column in the adsorption of an azo dye from an aqueous medium using a chitosan-glutaraldehyde biosorbent

Jaime López-Cervantes, Dalia I Sánchez-Núñez, Reyna G Sánchez-Duarte and Ma A Correa  
 Instituto Tecnológico de Sonora, Mexico

### Abstract

A continuous adsorption study in a fixed-bed column using a chitosan-glutaraldehyde biosorbent for the removal of the textile solution. The biosorbent was prepared from shrimp shells by chemical modification. X-ray diffraction, and nuclear magnetic resonance

Adsorption  
 Science &  
 Technology

## Development, Characterization, and Applications of Capsaicin Composite Nanofiltration Membranes

Jesús Álvarez-Sánchez,  
 Griselda Evelia Romero-López, Sergio Pérez-Sicairos,  
 German Eduardo Devora-Isiordia,  
 Reyna Guadalupe Sánchez-Duarte and  
 Gustavo Adolfo Fimbres-Weihs

Additional information is available at the end of the chapter

<http://dx.doi.org/10.5772/intechopen.76846>

### Abstract

Biofouling in reverse osmosis (RO) membranes is a severe problem, causing a decrease in both permeate flux and salt rejection and increasing transmembrane pressure. Capsaicin extract inhibits bacterial growth and is therefore used in this study to prepare a thin-film composite membrane and membrane support. Four types of nanofiltration (NF) membranes were prepared by interfacial polymerization onto a porous support prepared by the phase inversion method. Membrane A was the control membrane with no capsaicin extract, membrane B contains capsaicin in the polyamide thin film, mem-

El Departamento de Ciencias del Agua y Medio Ambiente del Instituto Tecnológico de Sonora, a través de sus programas Educativos de Ingeniero en Ciencias Ambientales y de Ingeniería Química.

OTONGA LA PRESENTE  
**CONSTANCIA**

A:

REYNA GUADALUPE SÁNCHEZ DUARTE, MA. ARACELI CORREA MURRIETA, MARÍA DEL ROSARIO MARTÍNEZ MACÍAS, GERMAN EDUARDO DEVORA-ISIORDIA, EDNA ROSALBA MEZA ESCALANTE



El Instituto Tecnológico Superior de Cajeme otorga el presente

## RECONOCIMIENTO

a

Rosario Martínez Macías, Susana Quintero Pérez, Patricia Candia Molina, Reyna Sánchez Duarte, Jorge Saldivar Cabrales y Yedidia Villegas Peralta  
 Por su presentación titulada:

*Remoción de metales pesados de aguas ácidas de minas mediante tratamiento biológico con microalgas*  
 en el marco del "3er Congreso Internacional de Ingeniería Ambiental" realizado en la ciudad de Guaymas, Sonora, los días 17 y 18 de Marzo del 2016.

Lic. Gabriel Baldenegro Patrón  
 Director General



# Research Laboratory:

Biopolymers and phytoremediation with microalgae



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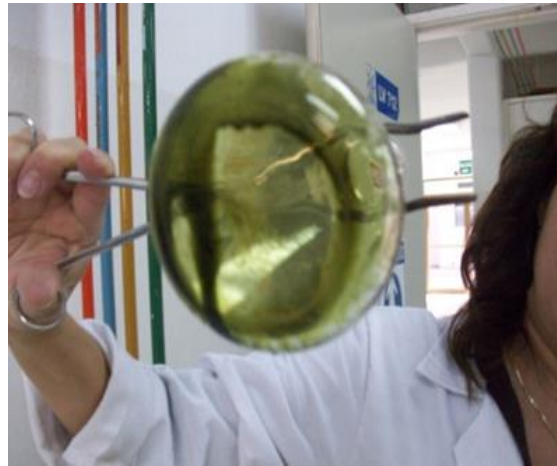
<https://www.itson.mx/oferta/iq/Paginas/maria-martinez.aspx>

# Obtaining Biodiesel from Microalgae ( PROFAPI 2010)

integrate the methodology of growth, separation, drying and extraction of bioenergetics for the production of biodiesel from microalgae.

**Time**  
2010-2011

**Available money**  
\$ 5,200 USD





25 de Enero del 2011.

A quien corresponda:

PRESENTE

Por este medio y a solicitud del interesado ratifico la acción tutorial que realizó: **Maria del Rosario Martínez Macías**, en el periodo **Agosto – Diciembre de 2010**, en modalidad de tutoría individual, atendiendo a los estudiantes de la **Maestría en Ciencias en Recursos Naturales**:

Nombre	ID
Carlos Abraham Díaz Quiroz	07219

Sin otro particular y quedando a sus órdenes para cualquier duda respecto a la información solicitada.

Atentamente

**Mtra. Elizabeth Del Hierro Parra**  
Coordinadora de Desarrollo Académico

C.c.p. Archivo del Área de Formación Integral del Alumno  
C.c.p. Archivo Coordinación de Desarrollo Académico



## The best recovery of *Nannochloropsis oculata* from the culture broth and effect on content of lipids

M. R. Martínez,<sup>1</sup> G. Ulloa,<sup>2</sup> J. Saldívar,<sup>1</sup> R. Beristain,<sup>3</sup>  
and E. R. Meza-Escalante<sup>1,a)</sup>

<sup>1</sup>Departamento de Ciencias del Agua y Medio Ambiente, Instituto Tecnológico de Sonora, Av. 5 de Febrero 818 Sur. Ciudad Obregón, Sonora 85000, Mexico

<sup>2</sup>Departamento de Biotecnología y Ciencias Alimentarias, Instituto Tecnológico de Sonora, Ave. 5 de Febrero 818 Sur. Ciudad Obregón, Sonora 85000, Mexico

<sup>3</sup>Departamento de Recursos de la Tierra, Universidad Autónoma Metropolitana-Lerma, Av. Hidalgo Pte. 46, Lerma de Villada, Edo. de México 52006, Mexico

(Received 13 September 2013; accepted 2 January 2014; published online 14 January 2014)

*Nannochloropsis oculata* is an interesting microorganism in the field of marine biotechnology because of its high lipid content. Biodiesel from this microorganism has been demonstrated to be a feasible replacement of petroleum-derived fuels. The effect of pH, flocculant dosage ( $\text{FeCl}_3$ ), and cell density has been studied in order to maximize biomass recovery and lipids. A partial factorial design was used to screen the main factors involved in the maximal biomass recovery from the culture broth, indicating that the best harvesting efficiency of 94.2% was obtained at pH 7,  $47.6 \times 10^6$  of cell density and flocculant dosage of 13 mg  $\text{FeCl}_3/\text{l}$ . Oleic acid, palmitic acid, and palmitoleic acid (omega-7) were identified inside the microalgae harvested. Omega-7 fatty acid is five times more potent than omega-3 at lowering triglycerides. The lipids identified had lower degree of unsaturation; this makes microalgal lipids a potential replacement for fossil fuel. 0.76% of reduction in eicosapentaenoic unsaturated fatty acid (EPA) was observed probably due to flocculant addition and that is beneficial for providing an increased lipid stability. In summary, this work is devoted to demonstrate that the optimization of the separation of microalgae from culture broth is mostly dependent on the pH, cell density, and flocculants dosage. © 2014 AIP Publishing LLC. [<http://dx.doi.org/10.1063/1.4862209>]

- Indexed article.
- Congress presentation.
- Master and bachelor thesis.

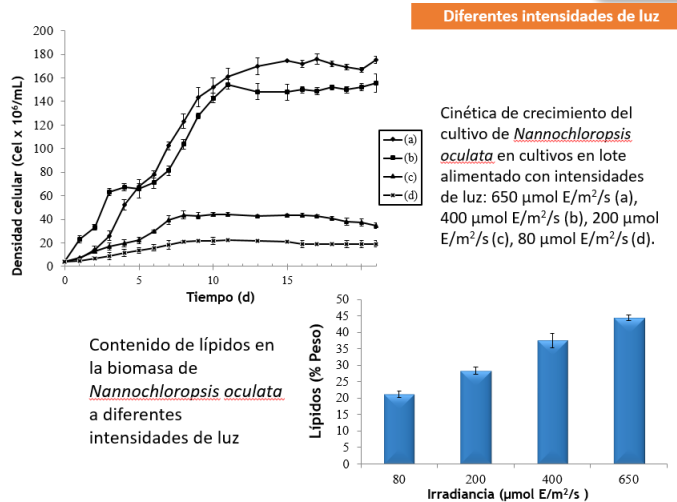


# Effect of light intensity on kinetic growth rate and lipid content on microalgae *Nannochloropsis oculata*.

Evaluate the effect of different light intensities on lipid content and biomass productivity on *Nannochloropsis oculata*.

Time:  
2011-2012

Available money  
\$ 5,200 USD



- Indexed article in Journal International of environmental engineering.
- Congress presentation in International of environmental engineering .
- Support of Master and bachelor thesis.

Rev. Int. Contam. Ambie. 33 (Especial sobre Ingeniería Ambiental. Universidad Estatal de Sonora) 85-91, 2017  
DOI: 10.20937/RICA.2017.33.esp02.08

**SÍNTESIS DE LÍPIDOS DE LA MICROALGA *Nannochloropsis oculata* PARA SU USO POTENCIAL EN LA PRODUCCIÓN DE BIODIÉSEL**

María del Rosario MARTÍNEZ MACIAS\*, Reyna Guadalupe SÁNCHEZ DUARTE,  
Edna Rosalba MEZA ESCALANTE, Ruth Gabriela ULLOA MERCADO y Jorge SALDÍVAR CABRALES

Instituto Tecnológico de Sonora. Calle 5 de febrero 818 sur, Colonia Centro, Ciudad Obregón, Sonora, México, C. P. 85000  
\*Autor para correspondencia: maria.martinez@itson.edu.mx

(Recibido junio 2015; aceptado agosto 2016)

Palabras clave: ácidos grasos, productividad, luz, biocombustibles



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85000 Ciudad Obregón, Sonora, México

Acta de Examen de Grado No. 1432

En \_\_\_\_\_ Ciudad Obregón \_\_\_\_\_, Sonora, México, siendo las 16:00 horas del día \_\_\_\_\_ veintiocho \_\_\_\_\_ del mes de febrero de \_\_\_\_\_ dos mil trece \_\_\_\_\_, se reunieron en la Sala de Exámenes del Instituto Tecnológico de Sonora, los miembros del síndico:

Presidente: Mtra. María del Rosario Martínez Macías  
Secretario: Dr. Pablo Gutiérrez Moruycón  
Vocal: Dra. Edna Rosalba Meza Escalante

Para proceder al Examen de Grado de: Maeistro en Ciencias en Recursos Naturales de: Carlos Abraham Díaz Quiroz quien desarrolló el tema: "Efectos de la intensidad de la luz en productividad y composición lipídica de microalga *Nannochloropsis oculata*"

Firma \_\_\_\_\_

Terminada la exposición los síndicos cuestionaron al sustentante y después de deliberar entre sí, de acuerdo con el resultado de la votación lo declararon:  
APROBADO POR UNANIMIDAD

Acto continuo el Presidente del Síndico le hizo saber el resultado del Examen de Grado, y el sustentante emitió la Protesta de Ley.

Presidente  
Mtra. María del Rosario Martínez Macías

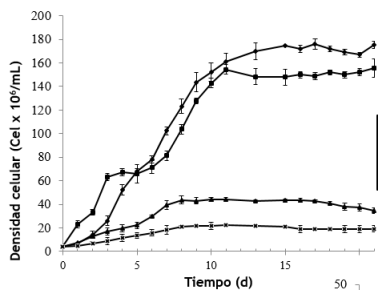


# Effect of fed-batch and semicontinuous regimen on *Nannochloropsis oculata* grown in different culture media to high-value products.

Evaluate different grown system and different culture media on microalgae *N. oculata*.

Time  
2013-2014

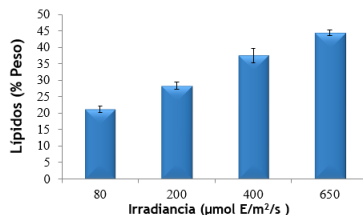
Available money  
\$ 3,130 USD



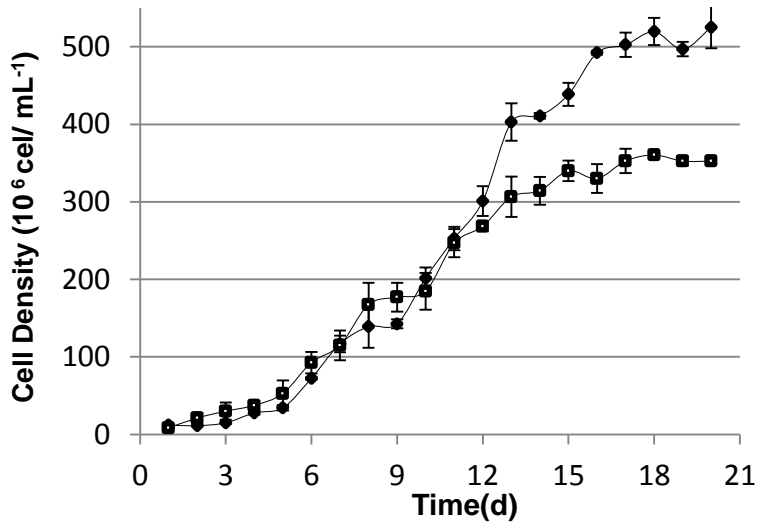
Diferentes intensidades de luz

Cinética de crecimiento del cultivo de *Nannochloropsis oculata* en cultivos en lote alimentado con intensidades de luz: 650  $\mu\text{mol E/m}^2/\text{s}$  (a), 400  $\mu\text{mol E/m}^2/\text{s}$  (b), 200  $\mu\text{mol E/m}^2/\text{s}$  (c), 80  $\mu\text{mol E/m}^2/\text{s}$  (d).

Contenido de lípidos en la biomasa de *Nannochloropsis oculata* a diferentes intensidades de luz







Research Article



Received: 9 February 2017

Revised: 26 July 2017

Accepted article published: 8 August 2017

Published online in Wiley Online Library: 9 October 2017

(wileyonlinelibrary.com) DOI 10.1002/jctb.5405

## Effect of fed-batch and semicontinuous regimen on *Nannochloropsis oculata* grown in different culture media to high-value products

Rosario Martínez-Macias,<sup>a</sup> Edna Meza-Escalante,<sup>a</sup> Denisse Serrano-Palacios,<sup>a</sup> Pablo Gortáres-Moroyoqui,<sup>b</sup> Patricia Elizabeth Ruíz-Ruiz<sup>b</sup> and Gabriela Ulloa-Mercado<sup>b\*</sup>

### Abstract

**BACKGROUND:** High cell density in cultures of microalgae is a key factor to recover biomass and extract metabolites of interest. A fed batch tubular reactor (FBTR) and semi-continuous reactor (SCR) with f/2 Guillard Medium (f/2GM) and algal medium (AM) were evaluated. Both modes were operated under completely defined conditions to assess their effect on cell density, and lipid, protein and carbohydrate productivity of the microalgae *Nannochloropsis oculata*.

**RESULTS:** Results show that the FBTR promotes the highest cell density for both culture media, achieving  $525 \pm 1.84 \times 10^6$  cell mL<sup>-1</sup>. With AM in the SCR, specific growth rate, productivities of biomass and lipids were the highest, as well as content of protein (48%), lipid (52.1%) and carbohydrates (17%). No significant differences were found in saturated fatty acids composition, whereas unsaturated fatty acids composition was affected by the operating regimen, this being higher in the FBTR.

**CONCLUSION:** The use of AM in both operating modes, FBTR and SCR, increased the cell density and improved the lipid content of *N. oculata*. A good option would be to combine both culture modes; first, use the FBTR to obtain high cell densities and then apply the SCR mode to increase lipid productivity; finally, an important quantity of high-value products could be recovered.

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**Keywords:** microalgae; productivity; lipids; biomass; culture-medium; bioreactors



**Effect of removal of heavy metals from acid mine water on biomass and lipid productivity to improve biofuels production (PROFAPI 2016)**

**Biosorption of heavy metals from acid mine water by marines microalgae (PROFAPÍ 2017)**

**Determine the adsorption capacity of copper in acid mine water, using lyophilized biomass of microalgae as adsorbent.**

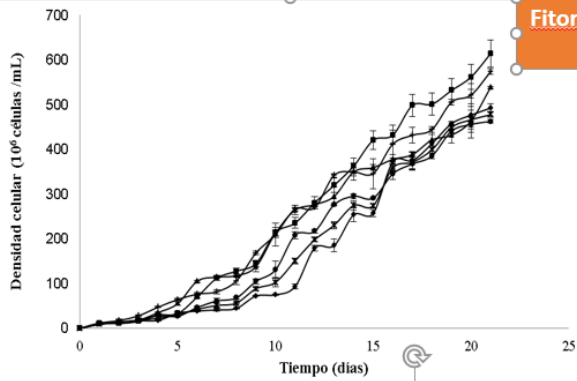
**Time  
2016-2017**

**Available money  
\$ 2,810 USD**





Fitorremediación de aguas ácidas de minas reactor tubular ( 7L)



Aguilar, et al., 2018

Figura 12. Cinéticas de crecimiento de *N. oculata* a diferentes concentraciones de metales (Cu y Fe); control (cuadrado); con 1.16 mg Cu L<sup>-1</sup> (más); 1.74 mg Cu L<sup>-1</sup> (triángulo); 2.32 mg Cu L<sup>-1</sup> (rombo); 3.48 mg Cu L<sup>-1</sup> (asterisco); 4.64 mg Cu L<sup>-1</sup> (círculo).

Concentración de metales pesados (mg Cu L <sup>-1</sup> )	Densidad celular (x10 <sup>6</sup> cel mL <sup>-1</sup> )	Velocidad específica de crecimiento (d <sup>-1</sup> )	Productividad de biomasa (g L <sup>-1</sup> d <sup>-1</sup> )	% Lípidos	Productividad de lípidos (g L <sup>-1</sup> d <sup>-1</sup> )
Control	614.25±30.71a	0.331±0.018a	0.261±0.002	33.058±5.398a	0.086±0.001a
1.16	573.96±6.51b	0.312±0.019ab	0.244±0.003b	29.497±2.578a	0.072±0.001a
1.74	538.56±2.48b	0.278±0.020b	0.229±0.001	71.594±1.649b	0.164±0.001b
2.32	492.71±8.87c	0.303±0.012ab	0.210±0.004	75.302±3.933b	0.158±0.003b
3.48	477.81±6.47c	0.260±0.017b	0.115±0.001a	68.157±4.287b	0.078±0.001a
4.64	462.92±4.07c	0.308±0.023ab	0.197±0.002	77.039±2.604b	0.152±0.002b

Environmental Science and Pollution Research  
<https://doi.org/10.1007/s11356-018-3963-1>

RESEARCH ARTICLE



Uptake of copper from acid mine drainage by the microalgae *Nannochloropsis oculata*

Maria del Rosario Martínez-Macias<sup>1</sup> · Ma. A. Correa-Murrieta<sup>1</sup> · Yedidia Villegas-Peralta<sup>1</sup> · Germán Eduardo Dévora-Isiordia<sup>1</sup> · Jesús Álvarez-Sánchez<sup>1</sup> · Jorge Saldivar-Cabrales<sup>1</sup> · Reyna G. Sánchez-Duarte<sup>1</sup>

Received: 2 May 2018 / Accepted: 10 December 2018  
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Abstract

The removal of heavy metals from acid mine drainage is a key factor for avoiding damage to the environment. The microalga *Nannochloropsis oculata* was cultured in an algal medium with 0.05, 0.1, 0.15, 0.2, and 0.25 mM copper under completely defined conditions to assess its removal capacity; the effects of copper on the cell density and lipid productivity of *N. oculata* were also evaluated. The results showed that *N. oculata* was able to remove up to 99.92 ± 0.04% of the copper content in the culture medium. A total of 89.29 ± 1.92% was eliminated through metabolism, and 10.70 ± 1.92% was removed by adsorption. These findings are favorable because they indicate that a large amount of copper was extracted due to the ability of the microalga to metabolize copper ions. The cell density, growth rate, and lipid content decreased with increased concentrations of copper in the culture medium. A positive effect on the fatty acid profile was found, as the saturated fatty acid (SFA) and monounsaturated fatty acid (MUFA) content improved when the copper concentration was higher than 0.1 mmol L<sup>-1</sup>, which can potentiate the production of high-quality biodiesel. *N. oculata* is a good option for the treatment of acid mine drainage due to its ability to eliminate a substantial percentage of the copper present. Moreover, combining different culture systems such that heavy metals are removed to non-toxic levels in the first stage and high cell densities, which promote lipid production, is obtained in the second stage would be an advantageous strategy.

Martínez et al., 2019.

Keywords Microalgae · Lipids · Biodiesel · Heavy metals · Acid mine drainage





# Synthesis of cellulose and alginates from microalgae as Bioadsorbents (PROFAPI 2018)

## Strategies to increase lipid production in microalgae (PROFAPI 2019)

## Copper adsorption isotherms using marine microalgae biomass (PROFAPI 2019)

Synthesize polysaccharides, cellulose and alginates from marine microalgae to be used as bioadsorbents in heavy metal decontamination.

Time

2019-2020

Available money

\$ 7,400 USD

1 Removal of heavy metal improves the lipid content in *Nannochloropsis*

2 *oculata*

3 Aguilar-Ruiz Rocio Janeth<sup>a</sup>, Martínez-Macias Maria del Rosario<sup>b</sup>, Dévora-Isiordia Germn  
4 Eduardo<sup>c</sup>, Sánchez-Machado Dalia Isabel<sup>c</sup>, López-Cervantes Jaime<sup>c</sup>.

5 <sup>a</sup>Departamento de Biotecnología y Ciencias Alimentarias, Instituto Tecnológico de Sonora,  
6 Cd. Obregón Sonora, 85100, México.

7 <sup>b</sup>Departamento de Ciencias del Agua y Medio Ambiente, Instituto Tecnológico de Sonora,  
8 Cd. Obregón Sonora, 85100, México.

9  
10 **Abstract**

11 The extraction of metals is an important activity to development economic of Mexico, but, this activity  
12 produces toxic residues that pollution of the water and environmental. Remove this source of heavy metals in  
13 situ is the main activity that must be key to avoid environmental contamination. The microalga *Nannochloropsis*  
14 *oculata* was cultured in an algal medium with of 1.16, 1.74, 2.32, 3.48, 4.64 mg Cu<sup>2+</sup> L<sup>-1</sup> in the culture, using  
15 acid mine water, to assess its removal capacity and the effects of copper and iron on the cell density and lipid

Strategies to increase the biodiesel production from microalgae

Maria del Rosario Martínez-Macias<sup>1</sup>, Germán Eduardo Dévora Isiordia<sup>1</sup>, Jesús Álvarez Sánchez<sup>1</sup>,  
Rocio Janeth Aguilar Ruiz<sup>2</sup>, Omar Nateras Ramirez<sup>2</sup>, Carlos Abraham Díaz-Quiroz<sup>2</sup>.

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<sup>2</sup>Departamento de Biotecnología y Ciencias Alimentarias, Instituto Tecnológico de Sonora, Cd. Obregón  
Sonora, 85100, México

**Abstract**

Global warming is caused by the high quantity of greenhouse gases that are emitted into the atmosphere by burning fossil fuels. This requires priority attention; we must change to alternative energies based on renewable processes. One option is the use of microalgae culture to obtain biofuels like biodiesel. However, this technology has limitations to achieve sustainable commercial production, because high specific growth rates and high

PRODUCTS IN PROCESS

# Research Laboratory:

## Bioadsorbents



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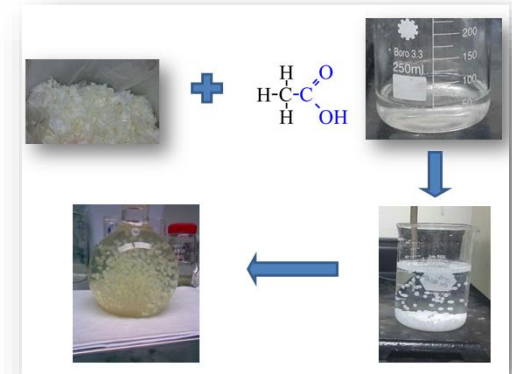
<https://www.itson.mx/oferta/iq/Paginas/araceli-correa.aspx>

**Hexavalent chromium removal from wastewater  
using aquaculture waste.  
(PROFAPI: 2015 y 2016)**

Evaluate the adsorption of chromium (VI)  
from synthetic water using beads of chitosan  
and chitosan modified with glutaraldehyde.

**Project Period:  
2015-2016**

**Funding:  
\$ 6,250 USD**





# Delivered Products

- Congress Presentations: International Congress of Environmental Engineering (May, 2015), III National Congress of Biotechnology and Food Sciences (October, 2015), XXXVII Congress of AMIDIQ (May, 2016), and 3rd National Congress of Technologies and Environmental Sciences (October, 2016).
- Congress' memories, book chapter, and journal papers (indexed by JCR).

2297

© IWA Publishing 2016 Water Science & Technology | 74.10 | 2016

## Modeling of breakthrough curves for aqueous iron (III) adsorption on chitosan-sodium tripolyphosphate

Dalia I. Sánchez-Machado, Jaime López-Cervantes,  
**Ma. A. Correa-Murrieta** and Reyna G. Sánchez-Duarte

## Capítulo XVII. Remoción de cromo hexavalente por quitosano entrecruzado

Correa Murrieta M. A. \*, Sánchez Duarte R. G., Álvarez Sánchez J., Dévora Isirdia G. E. y Velázquez G. M.  
[\\*macorrea@itson.edu.mx](mailto:macorrea@itson.edu.mx)



***Shrimp wastes to remove manganese from aqueous solutions /  
Treatment of waste from COD analyses using biopolymers.***  
**(PROFAPI: 2017 y 2018)**

Evaluate the adsorption of Manganese (II) from synthetic water on chitosan beads modified with sodium tripolyphosphate.

Evaluate the elimination of chromium contained in the residues from the COD analysis by protonated chitosan beads modified with glutaraldehyde.

**Project Period:  
2017-2018**

**Funding:  
\$ 5,750 USD**



# Delivered Products

- Congress Presentations: XXXVIII National Meeting of AMIDIQ (May, 2017), IV National Congress of Biotechnology and Food Sciences (September, 2017), XXXIX National Meeting of AMIDIQ (May, 2018), and Sixth International Symposium on Environmental Biotechnology and Engineering (November, 2018).
- Congress' memories and book chapter



## ELIMINACIÓN DE MANGANESO (II) POR RESIDUOS DE CAMARÓN

Ma. Araceli Correa-Murrieta<sup>a</sup>, Germán Eduardo Dévora Isordia<sup>a</sup>, Jesús Álvarez Sánchez<sup>a</sup>, Yedidia Villegas Peralta<sup>a</sup>  
<sup>a</sup>Departamento de Ciencias del Agua y Medio Ambiente, Instituto Tecnológico de Sonora, 5 De Febrero 818 Sur, Centro, Cd. Obregón, Sonora, 85000, México.  
<sup>a</sup>email: [maria.correa@itson.edu.mx](mailto:maria.correa@itson.edu.mx)

Memorias del XXXVIII Encuentro Nacional de la AMIDIQ  
9 al 12 de Mayo de 2017, Ixtapa-Zihuatanejo, Guerrero, México

## TRATAMIENTO DE DESECHOS DE DQO POR BIOADSORCIÓN

Ma. Araceli Corre-Murrieta<sup>a</sup>, Reyna Guadalupe Sánchez Duarte<sup>b</sup>, María del Rosario Martínez Macías<sup>a</sup>, Yedidia Villegas Peralta<sup>a</sup>, Germán Eduardo Dévora Isordia<sup>a</sup>, Jesús Álvarez Sánchez<sup>a</sup>  
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Memorias del XXXIX Encuentro Nacional de la AMIDIQ  
1 al 4 de mayo 2018, San José del Cabo, BCS.



## Chapter 4.2 Chitosan

Dalia I. Sánchez-Machado<sup>a</sup>, Jaime López-Cervantes<sup>a</sup>, Ma. A. Correa-Murrieta<sup>a</sup>, Reyna G. Sánchez-Duarte<sup>a</sup>, Paola Cruz-Flores<sup>a</sup> and Gabriela Servín de la Mora-López<sup>a</sup>  
<sup>a</sup>Instituto Tecnológico de Sonora, Ciudad Obregón, Sonora, Mexico, <sup>\*\*</sup>Universidad Autónoma de Sinaloa, Culiacán, Sinaloa, Mexico



# Research Laboratory:

Dynamic Biosystems and Renewable Energies



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# AUTHORIZED PROJECTS

**CONACYT**

“Optimization of synergies between photovoltaic solar cells and reverse osmosis membranes for the desalination of marine and brackish waters

**Período:**  
**2016-2019**

**Monto:**  
**\$78,000 USD**



# Delivered Productss

Article published

Participation in congress




Desalination

Volume 451, 1 February 2019, Pages 45-58



## Biofouling performance of RO membranes coated with Iron NPs on graphene oxide

M.M. Armendáriz-Ontiveros <sup>a</sup>, A. García García <sup>b</sup>, S. de los Santos Villalobos <sup>c</sup>, G.A. Fimbres Weihs <sup>c</sup>  

 Show more




<https://doi.org/10.1016/j.desal.2018.07.005>

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Article

## Biofouling of FeNP-Coated SWRO Membranes with Bacteria Isolated after Pre-Treatment in the Sea of Cortez

María Magdalena Armendáriz-Ontiveros <sup>1</sup>, Gustavo A. Fimbres Weihs <sup>2,\*</sup> , Sergio de los Santos Villalobos <sup>2,\*</sup>  and Sergio G. Salinas-Rodríguez <sup>3</sup> 

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<sup>2</sup> CONACYT-Instituto Tecnológico de Sonora, 5 de Febrero 818 Sur, Cd. Obregón, Sonora, C.P. 85000, Mexico

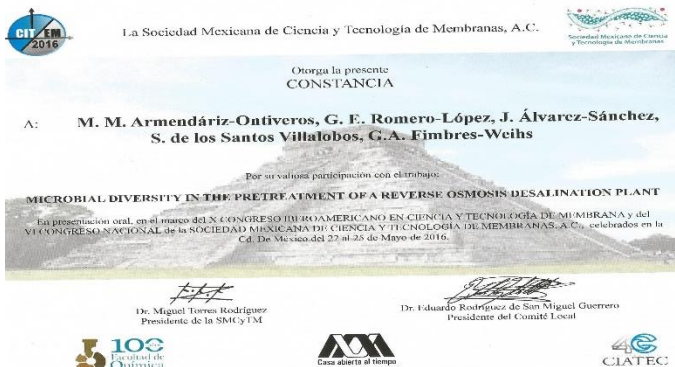
<sup>3</sup> IHE Delft Institute for Water Education, Environmental Engineering and Water Technology Department, Westvest 7, 2611 AX Delft, The Netherlands

\* Correspondence: [gustavo.fimbres@itson.edu.mx](mailto:gustavo.fimbres@itson.edu.mx) (G.A.FW.); [sergio.delossantos@itson.edu.mx](mailto:sergio.delossantos@itson.edu.mx) (S.d.l.S.V.)

Received: 14 June 2019; Accepted: 19 July 2019; Published: 23 July 2019



**Abstract:** Commercial seawater reverse osmosis (SWRO) membranes were coated with iron nanoparticles (FeNPs) and biofouled with a bacterium strain isolated from the Sea of Cortez, Mexico. This strain was selected and characterized, as it was the only cultivable strain in pretreated





# AUTHORIZED PROJECTS

**CONACYT**

Optimum concentration of FeNPs in the coating of reverse osmosis membranes for the reduction of bio-fouling ”

**Período:**  
**2019**

**Monto:**  
**\$1,460 USD**



# Delivered Products

Article published

Participation in congress



La Sociedad Mexicana de Ciencia y Tecnología de Membranas  
Otorga el presente  
**RECONOCIMIENTO**  
a:  
M.M. Armendariz-Ontiveros y G.A. Fimbres Weihs

Por su valiosa participación en el VIII Congreso Nacional de la Sociedad Mexicana de Ciencia y Tecnología de Membranas A.C. con el trabajo titulado  
**Comparación del efecto anti-bioensuciamiento de FeNPs en membranas de OI en dos sitios: México y Chile**

Dra. Jennifer Bañuelos Díaz  
Presidenta del Comité Organizador

IMTA, CIATEC, TECNOLÓGICO DEL VALLE DEL YAQUI



Article

## Anti-Biofouling and Desalination Properties of Thin Film Composite Reverse Osmosis Membranes Modified with Copper and Iron Nanoparticles

M. Armendariz Ontiveros <sup>1</sup>, Y. Quintero <sup>2</sup>, A. Llanquilef <sup>2</sup>, M. Morel <sup>3</sup>,  
L. Argente Martínez <sup>1,4</sup>, A. García García <sup>5</sup> and A. García <sup>2,\*</sup>

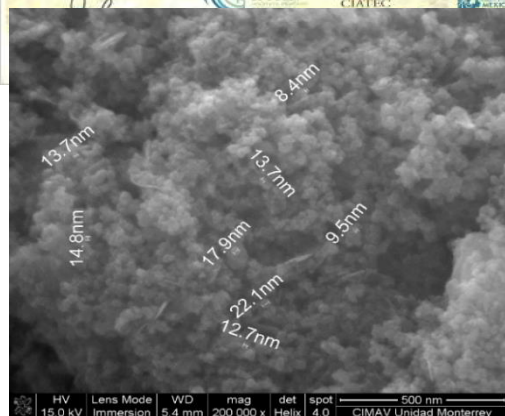
- <sup>1</sup> Instituto Tecnológico de Sonora. 5 de Febrero 818 Sur, Sonora 85000, Mexico
  - <sup>2</sup> Advanced Mining Technology Center (AMTC), Universidad de Chile, Santiago 8370451, Chile
  - <sup>3</sup> Facultad de Ciencias Naturales, Departamento de Química y Biología, Universidad de Atacama, Copiapó 1531772, Chile
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- \* Correspondence: andreina.garcia@amt.c; Tel.: +56-2-29771015

Received: 4 June 2019; Accepted: 26 June 2019; Published: 28 June 2019

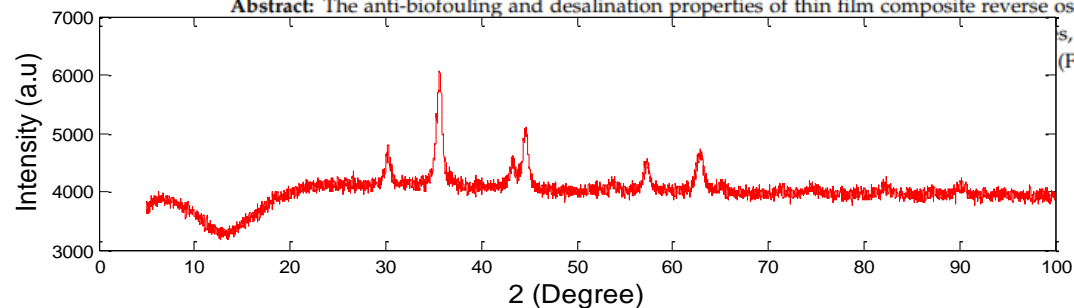


**Abstract:** The anti-biofouling and desalination properties of thin film composite reverse osmosis membranes modified with copper and iron nanoparticles, were

(Fe and Cu)



FeNPs



XRD de FeNPs



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Educar para Trascender

**Thanks!**