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Presentation of the Content

In the first chapter we present, *Agronomic behaviour and population densities of inbred lines to form maize hybrids for Mexican tropic*, by SIERRA-MACIAS, Mauro, RODRIGUEZ-MONTALVO, Flavio Antonio, ANDRÉS-MEZA, Pablo and ESPINOSA-CALDERÓN, Alejandro, with ascription in the Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias, as a second article we present, *Phytoplankton biodiversity in the Atlangatepec Dam, a Ramsar Site of international importance*, by VIZCAINO-RODRIGUEZ, Luz Adriana, MICHEL-PARRA, J. Guadalupe, LUJAN-GODINEZ, Ramiro and AVILA-ZARATE, Elia, with secondment in the Universidad Politécnica de la Zona Metropolitana de Guadalajara, Centro Universitario Sur de la Universidad de Guadalajara and Universidad Autónoma de Tlaxcala, as the following article we present, *Thermal crystallization of polyethylene terephthalate (PET) for recycling and caring for the environment*, by SALAZAR-PERALTA, Araceli, PICHARDO-SALAZAR, José Alfredo, PICHARDO-SALAZAR, Ulises and CHÁVEZ, Rosa Hilda, with affiliation at the Tecnológico de Estudios Superiores de Jocotitlán, Centro de Bachillerato Tecnológico Industrial y de Servicios No. 161, Centro de Estudios Tecnológicos Industrial y de Servicios No. 23 and Instituto Nacional de Investigaciones Nucleares, as next article we present, *Hydrogen synthesis from seawater by means of solar energy*, by MONTES-GUTIÉRREZ, Jorge, HERRERA-JIMENEZ, Víctor, RODRIGUEZ-CARVAJAL, Ricardo and GARCIA-GUTIÉRREZ, Rafael, with affiliation at the Universidad Nacional Autónoma de México, Universidad de Sonora and Universidad de Guanajuato.

Content

Agronomic behaviour and population densities of inbred lines to form maize hybrids for Mexican tropic

Comportamiento agronómico y densidades de población de líneas que forman híbridos de maíz para el trópico mexicano

SIERRA-MACIAS, Mauro†*, RODRIGUEZ-MONTALVO, Flavio Antonio, ANDRÉS-MEZA, Pablo and ESPINOSA-CALDERÓN, Alejandro

Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias, INIFAP, Mexico.

ID 1st Author: *Mauro, Sierra-Macias* / **ORC ID:** 0000-0001-6476-2192, **CVU CONACYT ID:** 5116

ID 1st Co-author: *Flavio Antonio, Rodriguez-Montalvo* / **ORC ID:** 0000-0002-7128-4712

ID 2nd Co-author: *Pablo, Andrés-Meza* / **ORC ID:** 0000-0002-0575-0084, **CVU CONACYT ID:** 63157

ID 3rd Co-author: *Alejandro, Espinosa-Calderón* / **ORC ID:** 0000-0002-7128-4712, **CVU CONACYT ID:** 78039

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Abstract

Improved seeds are the most important input in corn production, they represent the genetic yield potential and quality production. The objectives of this research were to know the behavior and seed productivity in maize inbred lines, which participate as parents in three-way hybrids. During spring summer season in 2017, there was carried out in Cotaxtla experimental station, INIFAP, in Veracruz, México, a factorial experiment arranged on split plots design distributed in complete blocks at random, with three replications in plots of one row 5 m long and 80 cm wide. There where evaluated 15 elite inbred lines as Small Plot (SP), with densities of 50,000 and 62,500 pl ha^{-1}, as Big Plot (BP). There were registered treatments: Grain yield, days to tassel and silking, plant and ear height, plant and ear aspect and sanity, plant and ear number, lodging, bad husk cover and ear rot. For grain yield, there were found high signifficant differences for density (D) and lines (L) but there was no found statistical signifficance for interaction DxL. The best yield for lines were: LT160, LT173 and LT166, with 5219, 4225 and 4213 kg ha^{-1}, for each one, respectively; Density of 62,500 pl ha^{-1}, registered grain yield of 3154 kg ha^{-1}, 29% more than 50,000 pl ha-^{1}.

Seed, *Zea mays* L., Parents, Hybrids, Tropic

Resumen

Las semillas mejoradas son el insumo más importante en la producción de maíz, representa el potencial genético para rendimiento y calidad. Los objetivos fueron conocer el comportamiento agronómico y la productividad de semilla de líneas de maíz progenitores de híbridos sobresalientes. Durante primavera verano 2017 se condujo en el Campo Cotaxtla, Ver., INIFAP, México, un experimento factorial con arreglo en parcelas divididas y distribución en bloques completos al azar, con tres repeticiones en parcelas de 1 surco de 5m de largo. Se evaluaron 15 líneas élite como Parcela Chica (PCH), con dos densidades de población 50,000 y 62,500 plantas ha-1, Parcela Grande (PG). Se registraron: Rendimiento, Días a floración, altura de planta y de mazorca, Aspecto y sanidad de planta y mazorca, número de plantas y de mazorcas total, plantas acamadas, mazorcas con mala cobertura y mazorcas podridas. Para rendimiento, se encontró diferencia altamente significativa para Densidades (D) y Líneas (L), no hubo significancia para la interacción DxL. Las mejores líneas fueron LT-160, LT-173 y LT-166, con rendimientos de 5219, 4225 y 4213 kg ha-^{1}, para cada línea, respectivamente; La densidad de 62,500 pl ha-1, registró un rendimiento de 3154 kg ha^{-1}, 29% más en relación con 50,000 pl ha^{-1}.

Semilla, *Zea mays* L., Progenitores, híbridos, trópico

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* Correspondence to Author (E-mail: sierra.mauro@inifap.gob.mx)
† Researcher contributing first author.

Introduction

During 2018, there were sown in México, 7.95 million hectares with maize, 7.345 were for grain production with an average in yield of 3.748 t ha^{-1}, and a total production of 26.67 million tons, which of them 12.6 million tons are utilized in different ways through the direct consume for human consumption (SIAP, 2018). Improved seeds are the most important input in corn production, they represent the genetic yield potential and quality production (Sierra *et al.*, 2016). In the maize breeding program from Cotaxtla experimental station, INIFAP, there have been generated maize hybrids and varieties, which expressed good yield and favourable agronomic characteristics through the tropical region in the southeast of México, but above all, they have been adopted by maize farmers (Sierra *et al.,* 2019).

The three way maize hybrids present the advantage of the heterosis in the maize commercial production, besides, they represent agronomic and economic advantages in certificated seed production because they use as a female parent a single cross with high yield and complete vigor and as a male parent an inbred line with very good *per se* behaviour, general combining ability and enough pollen production, such as the hybrids H-520, H-567 and H-568, whose specific nomenclature is (LT154xLT155)LT156, LT164xLT165)LT166 and (T47xT48)T49, for each hybrid, respectively (Flores and García, 2016; Tadeo *et al*., 2018; Tadeo *et al.,* 2016; Gómez *et al.,* 2017; Sierra *et al*., 2018; Sierra *et al*., 2016; Sánchez *et al.,* 2016; Velez *et al.,* 2018).

For identifying the best inbred lines is necessary to consider their effects of General (GCA) and Specific (SCA) combining ability, the *per se* behaviour and the adaptability (Ramírez *et al.,* 2019; Sierra *et al*., 2018; Sierra *et al*., 2017; Trachsel *et al*., 2016; Cervantes *et al*., 2016; García *et al*., 2018; Rebolloza *et al.,* 2016). Besides, for increasing seed of the parental inbred lines of hybrids, is very important to know the behaviour of these inbred lines under different plant densities, doses of fertilizers for getting the best yield and quality of seed (Reyes, 1990; Tadeo *et al.,* 2018).

The objectives of this research were to know the yield and the agronomic characteristics of the parental inbred lines of élite hybrids, under different plant densities for their maintaining and seed production

Materials and Methods

Localization

This research was carried out in Cotaxtla Experimental Station in Veracruz, which belongs to INIFAP, México, and is located at the Km 34 through the public road from Veracruz-Córdoba in the municipality of Medellín de Bravo, Ver., in the 18° 56' North Latitude and 96° 11' west longitude and altitude of 15 masl. The clime condition is Aw1(w), according with the clime classification described by Köppen modified by García (2004) and correspond to subhumid warm conditions with average annual temperature of 25 °C and annual precipitation of 1400 mm, distributed from june to November with a dry season from December to May. The soil is Vertisol, from alluvial origin, deep, with medium texture troughout the profile, slope less than 1% and good drainage and slightly acid pH (6.6) (INEGI, 2020).

Germplasm used

In the present research, there were evaluated 15 élite inbred lines for the maize breeding program for the humid tropic in the southeast of México, which of them participate on commercial and experimental hybrids and they belong to the Tuxpeño race.

Description of the experiment

During the spring summer season in 2017, under rainy conditions, there was carried out a factorial experiment arranged on split plots design, distributed in complete blocks at random, with three replications in plots of one row 5 m long and 80 cm wide. In this experiment, there were evaluated 15 elite inbred lines as Small Plot (SP), they were sown in two plant densities of 50,000 and 62,500 pl ha^{-1}, that correspond to Big Plot (BP) (Reyes, 1990).

The fertilization was made according to the recommendations of INIFAP, Thus, in this experiment was utilized the formula 161-46-00, applying all the Phosphorus and a third part of Nitrogen at sowing moment, the rest of Nitrogen in bunchy stage using Urea as Nitrogen source; the weeds were controlled by Atrazine applied before emerging and there were controlled pests during developing crop.

Variables and data recording

During the development of the crop and at harvest time, there were recorded in the experiment the following agronomic variables: Grain yield, Plant and ear height, since the base of soil even the highest leaf and the node where is inserted the principal ear, respectively; days to tassel considering 50% of the anthers in anthesis stage, days to silking when stigmas are in receptive stage, total number of plants and ears, qualification of plant and ear aspect and sanity, using a scale from 1 to 5, where, 1 correspond to the best phenotypic expression and 5 for the worst; lodging, ears with bad husk cover, dry matter and ear rot.

Statistical Methods

The agronomic variables recorded were statistically analyzed according with the factorial experiment arranged on split plots design distributed in complete blocks at random, with three replications in plots of one row 5 m long and 80 cm wide, and for the separation of means there was used the Tukey test to 0.05 of probability (Reyes, 1990; SAS versión 9.3, 2010).

Results and discussion

Agronomic behaviour for élite inbred maize lines

Derived of the analysis of variance for the variable grain yield at 12% of moisture content in élite inbred maize lines (Table 1), there were found statistical significance at 0.01 of probability for big plot (BP), which correspond to plant densities, for inbred lines behaviour as Small Plot (SP); However, there was no statistical difference for interaction BP*SP (Reyes, 1990).

In reference to agronomic characteristics, for plant density (BP), there were only statistical significance in variables ear height and plant sanity; On the other hand, in the factor inbred lines (SP), there were found significant differences for all variables; however, for interaction BP*SP in exception with plant height, there was no significance differences for the rest of variables.

The information above, suggest additive effects for the two factors, it means that the plant density and the inbred lines were expressed as independent factors (Reyes, 1990; Tadeo *et al.,* 2018; Tadeo *et al.,* 2016). For variables: Grain yield, plant and ear height, days to tassel, plant and ear aspect and plant and ear sanity, there were gotten Coefficients of Variation of 26.74, 8.39, 14.92, 1.16, 17.44, 15.90, 17.72 and 14.68% for each variable, respectively, values relatively low that suggest that the management of the experiment and the results gotten are reliables (Reyes 1990; SAS 2010, Version 9.3).

Source of variation	Degree Free	Grain yield	Plant height	Ear height	Days to tassel	Plant aspect[1/]	Ear aspect[1/]	Plant sanity[1/]	Ear sanity[1/]
Blocks (BL)	2	5740379.9**	1870.27**	1110.27**	3.51**	0.136NS	5.63**	0.58NS	1.53**
Density (BP)	1	11490949.7**	217.77NS	840.27**	0.90NS	0.01NS	0.4NS	0.71*	0.4NS
BL*BP	2	862355.6 NS	1000.27**	436.94*	0.40NS	1.58**	0.13NS	0.036NS	0.41NS
Lines (SP)	14	7199260.4**	2128.49**	579.08**	4.187**	1.04**	2.12**	0.56**	0.61**
BP*SP	14	666395.7 NS	329.68*	137.89NS	0.638NS	0.11NS	0.16NS	0.16NS	0.14NS
MSE	56	559199.8	150.75	96.82	0.396	0.1736	0.22	0.166	0.1359
Average		2796.79	146.22	65.94	53.92	2.38	2.96	2.3	2.51
CV (%)		26.74	8.39	14.92	1.16	17.44	15.90	17.72	14.68

* and **= Statistical Signifficance for the Sources of Variation at 0.05 and 0.01 of probability of error; 1/ = Qualification scale from 1 to 5 where, 1 correspond to plants and ears with the best phenotypic expression and 5 for the worst; MSE= Mean Square of error; CV= Coefficient of variation

Table 1 Mean square and significance for evaluation of inbred maize lines and plant densities. Cotaxtla Experimental Station. CIRGOC. INIFAP. 2017B

Plant density (BP)

In relation with plant density factor, with 62,500 plants ha^{-1}, there was registered an average grain yield of 3154 kg ha^{-1}, significantly higher in 29% than 50,000 pl ha^{-1}, Besides, in reference to ear height, this was higher in the greater plant density, because of greater competitivity for light (Table 2); The qualification for plant sanity was better under the lowest density, this is due that in this density plants have the optimum conditions in light, nutrients and humidity. On the other hand, density has no effect in the variables: Days to tassel, height of plant, plant and ear aspect and ear sanity (Reyes, 1990; Tadeo *et al.,* 2018; Tadeo *et al.,* 2016).

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Lines (SP)

The élite lines evaluated (table 3), are the parental lines of the hybrids H-520, H-564C, H-567, HE-3B and HE-4B, the first two hybrids are in commercial use, The rest of them in precommercial stage. For grain yield, the inbred lines LT-160, LT-173 and LT-166 were statistically the best lines according with the tukey test at 0.05 of probability, with yields of de 5219, 4225 and 4213 kg ha^{-1}, for each line, respectively.

Entry	Density	Grain yield	% Relative	Days to tassel	Plant height	Ear height	Plant aspect 1/	Ear aspect 1/	Plant sanity 1/	Ear sanity 1/
2	62500	3154a	129	54a	148a	69a	2.4a	3.0a	2.39a	2.6a
1	50000	2439b	100	54a	145a	63b	2.4a	2.9a	2.21b	2.4a
	Average	2797		54	146	66	2.4	3.0	2.3	2.5

CV=26.74%
Treatments with the same letter are statisticaly similar, Tukey to 0.05 of probability; 1/ = Qualification scale from 1 to 5, where 1 correspond to plants and ears with the best phenotypic expression and 5 for the worst; CV= Coefficient of variation.

Table 2 Grain yield and agronomic characteristics of élite inbred maize lines in two plant densities. Cotaxtla 2017B

These inbred lines present favourable agronomic characteristics, particulary in qualification of plant an ear aspect and sanity and they participate as parents for prominent maize hybrids; Besides, these lines have been identified and selected considering their *per se* yield and their General (GCA), and Specific (SCA) combining ability, but overall, lines with capacity for producing high yield and quality of seed that permite in efficient way and competitive, their maintenance and the commercial seed production (Sierra *et al*., 2018; Sierra *et al*., 2017; Sierra *et al*., 2016; Sierra *et al*., 2019; Ramírez *et al.,* 2019; Rebolloza *et al.,* 2016; Flores y García, 2016; Gómez *et al.,* 2017; Trachsel *et al*., 2016; Tadeo *et al*., 2018; Tadeo *et al.,* 2016; Sánchez *et al.,* 2016; Cervantes *et al*., 2016; Velez *et al.,* 2018; García *et al.,* 2018).

Entry	Line	Grain yield	Days to tassel	Plant height	Ear height	Plant aspect 1	Ear aspect 1	Plant sanity 1	Ear sanity 1
6	LT160	5219a	53	162	70	1.7	2.1	1.8	2.3
15	LT-173	4225ab	54	156	73	1.8	2.0	1.9	2.1
10	LT-166	4213ab	53	163	74	2.2	2.3	2.3	2.2
11	LT-169	3280 bc	55	158	65	2.0	2.8	2.1	2.7
3	LT-156	3195 bcd	53	164	73	2.2	2.8	2.2	2.4
2	LT-155	3032 bcde	52	159	76	2.6	2.9	2.3	2.5
12	LT-170	2928 bcde	55	163	73	2.5	2.6	2.3	2.3
14	LT-172	2605 cde	54	174	81	1.8	2.8	2.1	2.0
5	LT-159	2509 cde	54	129	64	2.4	3.0	2.2	2.5
4	LT-158	2166 cde	55	118	47	2.6	3.5	2.2	2.8
7	LT-163	1888 cde	53	134	64	2.8	3.2	2.8	2.4
1	LT-154	1752 cde	54	132	56	2.8	3.5	2.6	2.9
9	LT-165	1742 de	54	138	66	2.8	3.3	2.6	2.7
8	LT-164	1604 e	55	124	51	2.8	3.9	2.7	3.1
13	LT-171	1593 e	55	121	57	3.0	3.9	2.7	2.8
	MSE	559199.8	0.396	150.75	96.82	0.1736	0.2226	0.166	0.1359
	Average	2796.79	53.92	146.22	65.94	2.39	2.97	2.30	2.51
	CV (%)	26.74	1.17	8.39	14.92	17.44	15.90	17.73	14.68

Treatments with same letter are statistically similar with the Tukey test at 0.05 of probability; 1/ =Qualification scale from 1 to 5, where 1 correspond to plants and ears with the best phenotypic expression and 5 for the worst; MSE=Mean square of error; CV=Coefficient of Variation

Table 3 Yield and agronomic characterístics for élite inbred maize lines. Cotaxtla 2017B

Interaction plant density - inbred lines

The results for this interaction, for the grain yield variable at 12% in moisture content, are presented in Table 4, which of them register that the best treatments according with the Tukey test at 0.05 of probability, were: 62,500 x LT-160, 50,000 x LT-160, 62,500 x LT-166, 62,500 x LT-173, 50,000 x LT-173 and 62,500 x LT-169 (Sierra *et al.,* 2018; Sierra *et al.,* 2017; Reyes, 1990; Ramírez *et al.,* 2019; Rebolloza *et al.,* 2016; Gómez *et al.,* 2017; Trachsel *et al.,* 2016; Sánchez *et al.,* 2016; García *et al.,* 2018). The inbred lines LT160 and LT173 expressed high grain yield for the two plant densities, while, LT166 and LT169 were better in the highest density. Such inbred lines present good qualification in plant and ear aspect and sanity, short plant and ear height and intermediate biological cycle with 53 to 55 days to tassel (Reyes, 1990; Sierra *et al.,* 2018; Sierra *et al.,* 2017; Ramírez *et al.,* 2019; Rebolloza *et al.,* 2016; Flores y García, 2016; Gómez *et al.,* 2017; Trachsel *et al*., 2016; Tadeo *et al*., 2018; Tadeo *et al.,* 2016; Velez *et al.,* 2018).

Entry	Density x Line	Grain yield	Days to tassel	Plant height	Ear height	Plant aspect 1/	Ear aspect 1/	Plant sanity 1/	Ear sanity 1/
21	62,500 x LT-160	5977a	53	153	67	1.5	2.3	1.7	2.5
25	62,500 x LT-166	5503ab	53	167	73	2	2.2	2	2.2
30	62,500 x LT-173	4709abc	53	165	78	1.7	2	1.8	2.2
6	50,000 x LT-160	4462abcd	53	170	73	1.8	1.8	1.8	2
15	50,000 x LT-173	3741abcde	55	147	68	2	2	2	2
26	62,500 x LT-169	3724abcde	54	153	65	2	2.7	2	2.7
17	62,500 x LT-155	3427 bcdef	52	155	78	2.5	3	2.5	2.7
3	50,000 x LT-156	3282 bcdef	53	170	75	1.8	2.3	2	2.2
18	62,500 x LT-156	3109 bcdef	53	158	72	2.5	3.2	2.3	2.7
27	62,500 x LT-170	3026 cdef	55	172	85	2.5	2.8	2.5	2.7
29	62,500 x LT-172	2946 cdef	54	173	87	2	2.7	2.3	2
10	50,000 x LT-166	2923 cdef	53	158	75	2.3	2.5	2.5	2.2
20	62,500 x LT-159	2899 cdef	53	147	77	2.5	3	2.3	2.5
11	50,000 x LT-169	2836 cdef	55	162	65	2	2.8	2.2	2.7
12	50,000 x LT-170	2830 cdef	55	155	60	2.5	2.3	2	2
2	50,000 x LT-155	2636 cdef	53	163	73	2.7	2.8	2.2	2.3
19	62,500 x LT-158	2364 cdef	55	120	48	2.7	3.5	2.3	2.8
14	50,000 x LT-172	2265 def	54	175	75	1.7	2.8	1.8	2
5	50,000 x LT-159	2119 def	55	112	52	2.3	3	2	2.5
28	62,500 x LT-171	2056 def	55	125	62	3	3.8	3	2.7
16	62,500 x LT-154	2010 ef	54	137	55	2.8	3.7	2.8	3.2
22	62,500 x LT-163	1973 ef	53	123	63	2.8	3.2	2.8	2.3
4	50,000 x LT-158	1969 ef	54	115	45	2.5	3.5	2	2.8
24	62,500 x LT-165	1839 ef	54	142	72	2.7	3.3	2.7	2.5
7	50,000 x LT-163	1804 ef	53	145	65	2.8	3.2	2.8	2.5
23	62,500 x LT-164	1748 ef	55	127	53	2.8	4.2	2.7	3.2
9	50,000 x LT-165	1544 ef	54	133	60	2.8	3.3	2.5	2.8
1	50,000 x LT-154	1493 ef	54	127	57	2.7	3.3	2.3	2.7
8	50,000 x LT-164	1461 ef	55	122	48	2.7	3.7	2.7	3
13	50,000 x LT-171	1130 f	55	117	52	3	4	2.3	3
	MSE	559199.8	0.396	150.75	96.82	0.1736	0.2226	0.166	0.1359
	Average	2796.79	53.92	146.22	65.94	2.39	2.97	2.30	2.51
	CV (%)	26.4	1.17	8.39	14.92	17.44	15.90	17.73	14.68

Treatments with the same letter are statistically similar, Tukey at0.05 of probability, 1/ = Qualification scale from 1 to 5, where 1 correspond to plants and ears with the best phenotypic expression and 5 for the worst; MSE= Mean square of error; CV= Coefficient of Variation

Table 4 Grain yield and agronomic characteristics of élite inbred maize lines in two plant densities. Cotaxtla 2017B

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Conclusions

The best inbred lines were LT160, LT173, LT166, LT170 and LT169 because they have high yield and favourable agronomic characterístics.

In the 62,500 pl ha^{-1} plant density, the inbred lines registered an average for grain yield of 3154 kg ha^{-1}, value significantly greater in 29% than the 50,000 pl ha^{-1} density.

There are suggest additive effects for the two factors, lines and plant densities, it means lines and densities were expressed as independent factors.

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Phytoplankton biodiversity in the Atlangatepec Dam, a Ramsar Site of international importance

Biodiversidad de fitoplancton en la Presa de Atlangatepec, Sitio Ramsar de importancia internacional

VIZCAINO-RODRIGUEZ, Luz Adriana†*´, MICHEL-PARRA, J. Guadalupe´´, LUJAN-GODINEZ, Ramiro´ and AVILA-ZARATE, Elia´´´

´Universidad Politécnica de la Zona Metropolitana de Guadalajara
´´Centro Universitario Sur de la Universidad de Guadalajara.
´´´Universidad Autónoma de Tlaxcala.

ID 1st Author: *Luz Adriana, Vizcaino-Rodriguez* / **ORC ID:** 0000-0001-8301-6160, **Researcher ID Thomson:** T-1324-2018, and **CVU CONACYT ID:**175164

ID 1st Co-author: *J. Guadalupe, Michel-Parra* / **ORC ID:** 0000-0002-7017-8360, **Researcher ID Thomson:** T-2648-2018, **CVU CONACYD ID:** 316532

ID 2nd Co-author: *Ramiro, Luján-Godinez* / **ORC ID:** 0000-0003-4138-7590, **arXiv Author ID:** ramiro 5302, **CVU CONACYT ID:** 503875

ID 3rd Co-author: *Elia, Avila-Zárate* / **ORC ID:** 0000-0002-6073-8301, **CVU CONACYT ID:** 339892

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Abstract

The bodies of water provide ecosystem services such as: temperature regulation, hydric recharge, bird, terrestrial and aquatic species habitat, food, oxygen, landscape, tourism, among others. The objective of this work was to generate information on indicators of biological contamination in the Atlangatepec dam, which help to establish the Control and Management Plan (PCyM) for the Ramsar Site. The strategy consisted of determining physicochemical variables *in situ* and conducting a phytoplankton diversity study. The average temperature of the water body was 17.8 ° C, pH 8.23, dissolved oxygen 4.58 ppm and conductivity 215 µS.cm. These conditions favor the growth of cyanobacteria, which predominated in the body of water. The species *Pseudanabaena galeata* was the dominant species, followed by *Plankthorix agardhii*. 11 *Chlorophytas*, 15 *Cyanobacteria*, 1 *Charophyta* and 3 *Bacillariophytas* were identified. The cyanobacterial species identified have the potential to produce blooms and microtoxins, which negatively impact the food chains of the ecosystem. The impact of anthropogenic activities puts the dam's sustainable and sustained development at risk.

***Pseudanabaena galeata*, *Planktothrix agardhii*, cyanobacterial**

Resumen

Los cuerpos de agua aportan servicios ecosistemicos como son: regulación de temperatura, recarga hidríca, habitat de aves, especies terrestres y acuáticas, alimento, Oxígeno, paisaje, turismo entre otros. El objetivo del presente trabajo, fué generar información de indicadores de contaminación biologica en la presa de Atlangatepec, que ayuden a establecer del Plan de control y Manejo (PCyM) para el Sitio Ramsar. La estrategía consistió en determinar variables fisicoquímicas *in situ* y realizar un estudio de diversidad del fitoplancton. La temperatura promedio del cuerpo de agua fue de 17.8 °C, el pH 8.23, el Oxígeno disuelto 4.58 ppm y la conductividad de 215 µS.cm. Dichas condiciones favorecen el crecimiento de cianobacterias, las cuales predominaron en el cuerpo de agua. La especie *Pseudanabaena galeata* fue la especie dominante, seguida de *Plankthorix agardhii*. Se identificaron 11 *Chlorophytas*, 15 *Cyanobacterias*, 1 *Charophyta* y 3 *Bacillariophytas*. Las especies de cianobacterias identificadas, tienen el potencial de producir blooms y microtoxinas, las cuales impactan de forma negativa las cadenas tróficas del ecosistema. El impacto de las actividades antropogénicas pone en riesgo el desarrollo sustentable y sostenido de la Presa.

***Pseudanabaena galeata*, *Planktothrix agardhii*, cianobacteria**

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* Correspondence to Author (Email: adriana.vizcaino@upzmg.edu.mx)
† Researcher contributing as first author.

Introduction

The Atlangatepec dam is located 28 km from the city of Tlaxcala and 10 km from Taxco, in the State of Tlaxcala with coordinates of 19 ° 33'39 " N and 98 ° 10'49 " W, its area is of 1,200 hectares, it was declared a Ramsar site on February 2, 2009. The wetland receives tributaries from streams and the Zahuapan River, as well as discharge of sewage from the municipality of Tlaxco, the change of land use for agricultural and livestock activities, deforestation has caused high levels of siltation and etrophication in the body of water.

The location of the wetland gives it great importance, since it is a habitat for resident and migratory species, records of 125 species of birds associated with the wetland are kept and an average of 27,966 birds per season is estimated. The site is home to the Mexican Duck, Anas diazi, which is in category (A) threatened and endemic for Mexico, “protected” (Pr) the Gray Heron (*Ardea herodias*), Lesser Zambuillidor (*Tachybaptus dominicus*), (Pr), Northern Tular Heron (*Botaurus lentiginosus*) (A), Greyish Barred Ralo (*Rallus elegans*), (Pr) Reddish Barred Ralo (*Rallus limicola*) (Pr) and Axolotl (*Ambystoma tigrinum*) (A). The wetland is valuable in the production of fish, grains, hunting and tourism (I).

Based on the content of chlorophyll and dissolved solids, the water body was classified as eutrophic. Water bodies with eutrophic environments favor the proliferation of phytoplankton, with cyanobacteria being the dominant organisms. Cyanobacteria are unicellular, colonial prokaryotic organisms of great morphological diversity, growing in both terrestrial and freshwater or marine environments. (II)

Cyanobacteria predominate in temperature ranges close to 20 ° C, and have efficient mechanisms for capturing light. The presence of gas vacuoles allows cyanobacteria to move in the water column to access light and nutrients (III).

The warm temperatures and the availability of nutrients favor the establishment of blooms and the production of toxins. As part of phytoplankton, they are also the primary producers of aquatic systems.

They have the ability to fix nitrogen and store phosphorus, they can grow with low light intensity and produce substances that inhibit the growth of other organisms (VII).

Toxicological studies carried out with strains of *Pseudanabaena galeata* show that it has the ability to produce toxins in natural environments. Identified as: microtoxins, anatoxin-a and saxitoxin. Extracts prepared from said cyanobacteria with a single oral dose of 1,000 mg.kg-1 of body weight, caused the death of mice in 12 days.

Extracts prepared from laboratory-grown P galeata CCIBt3082 strains are classified in the category of compounds with relatively low toxicity, but with effects on the health of humans exposed to them for long periods of time. The effects it produces are microscopic lesions in the intestine, dilation of lymphatic and intestinal vessels and liver congestion. (IV)

The oscillatorial order is made up of filamentous bacteria, within them the Planktothrix genus is grouped, with the capacity to produce: anatoxins, microcystins and saxitoxins. Its production has been confirmed worldwide (VI).

It is worth mentioning that according to Pineda 2011, P. agardhii does not have the ability to produce cream in bodies of water since its growth is dispersed (II). However, it has been reported as a dominant species in European lakes with a higher toxic capacity compared to other cyanobacteria (VII).

The present work aims to study the temporal diversity of phytopankton in the Atlangatepec Dam and its trophic status, in order to generate scientific knowledge that helps define the complementary measures for the Development of the Conservation and Management Plan of the dam of Atlangatepec.

Hypothesis the eutrophication conditions reported for the Atlangatepec Dam favors the establishment of cyanobacteria and negatively affects the diversity of phytoplankton and the structure of trophic networks.

Methodology

The present study was carried out in the Atlangatepec Dam, located in Tlaxcala, Mexico on November 3 and 4, 2021.

The environmental monitoring consisted of the monitoring of physicochemical parameters: pH, temperature, conductivity, dissolved oxygen, with the use of a HANNA Instruments brand multiparametric probe, model HI9829.

In each monitoring station (See Table 1) samples were collected for biodiversity analysis by dragging with a 20 µm mesh (1 minute), the samples were kept in a sterile flask and formaldehyde was used to preserve them.

The classification was carried out based on the traditional morphological characters with the use of a compound microscope brand Leica and lugol. The study was carried out at the Microbiology Laboratory of the Polytechnic University of the Guadalajara Metropolitan Area (UPZMG). Located in Tlajomulco de Zuñiga Jalisco. In collaboration with the students of the UPZMG Biotechnology career.

Station	Location
1.- Zacacuexco	19°33´01" N 98°10´30.9" W
2.- The Shearing	19°33´00.09" N 98°10´30.9" W
3.- Airport	19°32´58.7" N 98°10´31.6" W
4.- San José Atlangatepec	19° 33´34.7" N 98° 11´56.8" W
5.- Santa Clara	19° 34´37.3" N 98° 11´04.6" W
6.- Embarcadero	19° 33´42.4" N 98° 12´04.2" W

Table 1 Coordinates of the monitoring stations at the Atlangatecpec dam, phytoplankton biodiversity analysis
Source: Own elaboration

Phylogenetic analysis. The search for gene and protein sequences was carried out based on NCBI data. BLAST (Basic Local Alignment Search Tool) was used using a cyanobacterial protein of 275 aa Oxidoreductase as zone. Sequence cleansing was performed visually, removing the sequences that did not contain conserved sites or the repeated ones. NCBI diagrams were used.

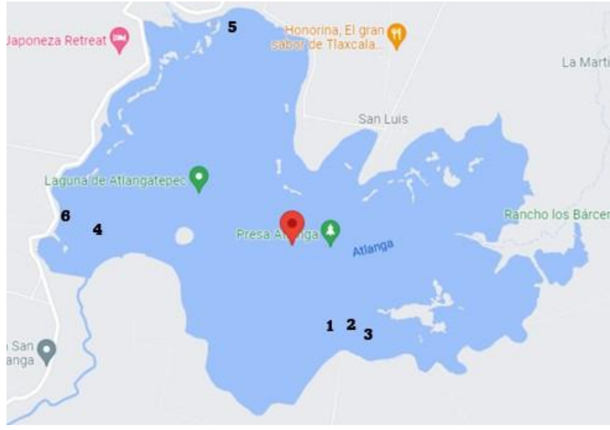

Figure 1 Monitoring points in the Atlangatepec Dam Tlaxcala Mexico, phytoplankton Biodiversity analysis
Source: Own elaboration

Results

Figure 2 shows the physical-chemical data collection and samples at the Santa Clara monitoring station.

Figure 2 Record of physicochemical variables and phytoplankton sampling at the Santa Clara station
Source: Own elaboration

Table 2 contains the results of the monitored physicochemical variables. The pH presented an average value of 8.23 with a range of 7.98 to 8.45. The average dissolved oxygen was 4.58 ppm. The conductivity range was from 215 to 245 µS.cm. The average temperature was 17.87 ° C.

The temperature varies according to the geographic location and climatic conditions, its impact determines the availability of dissolved oxygen in the body of water, influencing the diversity of microorganisms in the water column and seasonal succession of aquatic communities (VIII).

The oxygen concentration is determined by the temperature, the atmospheric pressure, the aquatic organisms that, due to the photosynthesis process, release it in the euphotic zone and the supersaturation in the surfaces is associated with high concentrations of phytoplankton. However, in the aphotic zone, the decomposition of organic matter by microorganisms consumes oxygen and releases $C0_2$.

When the pH is neutral or slightly alkaline, in the range of 7.5 and 10 and the temperatures are warm, they favor the growth of cyanobacteria and the development of blooms since it allows them to assimilate the inorganic carbon in the form of bicarbonate (II).

Electrical conductivity is a numerical expression of the ability of water to conduct electric current and is related to the presence of ions in the water, in the study carried out the range was found from 215 to 245 µS.cm (VIII).

Variable	1	2	3	4	5	6
pH	8.1	8.2	8.1	8.4	7.9	8.0
OD ppm	4.6	4.9	5.3	4.6	3.3	4.6
Conductivity (µS.cm)	244	215	222	224	245	238
Temperature (°C)	17.5	17.8	17.5	19	16.4	18.9
Atmospheric pressure (psi)	11.02	11.07	11.09	11.04	11.037	11.09

Table 2 Physico-chemical variables determined in situ at the Atlangatepec Dam, Tlaxcala, Mexico, November 2021
Source: Own elaboration

Regarding the biodiversity of phytoplankton, filamentous cyanobacteria predominated (see Figure 3). These results agree with those reported by Romo et al., 2008, in the Albufera Lake of Valencia during the period 1980-2006; filamentous cyanobacteria predominated, representing 76% abundance; It is worth mentioning that between 1985 and 1988 P. agardhii represented 67% of the average annual biovolume in the lake and was not found when the nutrient supply was diverted to the water body. During 1998-2006 *P. gaelata* predominated with 34% of total mean abundance (V).

Similar results were found in three lakes in Mexico in which cyanobacteria predominated: *Microcystis* sp., *Planktothrix*, *Anabaenopsis*, *Pseudanabaena* and *Phormidium*, all of them with the capacity to produce microcystins (I).

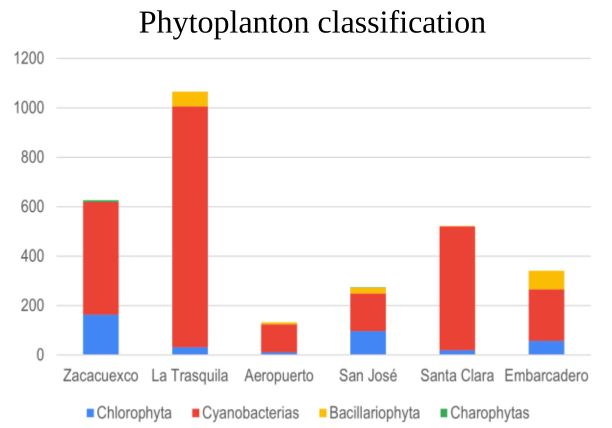

Figure 3 Classification of phytoplankton present in the Atlangatepec dam, Tlaxcala, Mexico, November 2021
Source: Own elaboration

Morphologically, 10 chlorophytes were identified: *Pediastrum simple var. duodenarium, Pediastrum simplex Meyen, Pediastrum duplex Meyen, Volvox sp, Chlorella saccharophila, Scenedesmus opoliensis, Sphaerocystis agardhiii, Tetraëdron, Ankistrodesmus falcatus, Ulotrhrix tenuissima.* Fifteen cyanophytas were classified: *Dolichospermun planctonicum, Planktothrix agardhii, Pseudanabaena moliniformis. Pseudanabaena galeata, Pseudanabaena linmetica, Anabaena, Coelosphaerium, Aphanizomenom gracile, Aphanizomenom issatschenkoi, Chroococcus limneticus Lemmermann, Lyngbya, Microcystis pulverea f. incerta, Aphanocapsa incerta, Anabaena Spiroides, Raphidiopsis mediterranea.*

A species of Charophyta: *Zyg. and four Bacillariophyta species: Coscinodiscus Ehrenberg, Aulacoseira granulata var. angustissima, Guinardia flaccida, Asterionellopsis glacialis* (see Figure 4).

It is worth mentioning that in a study of diatom biodiversity carried out in 2011, in the Atlangatepec Dam, 16 species were identified: *Achnanthidium exiguum, Amphora copulate, Aulacoseira granulate, Cocconeis placentula, Cymbella Mexicana, Encyonema silesiacum, Epithemia sorex Kützingzing, Gomphonema affine Kützing , Hantzschia amphioxys, Navicula gregaria Donkin, Nitzschia amphibia Grunow, Nitzschia filiformis, Rhoicosphenia abbreviate, Sellaphora pupula, Tryblionella apiculata W. Gregory, Ulnaria ulna (IX).*

Our results with less diversity of diatoms differ from those reported, this is because the monitoring of these species is generally carried out in the littoral zone and our study was carried out in the limnetic zone of the body of water.

Figure 4 Fitoplanton recovered from the Atlangatepec dam. From left to right *Pediastrum duplex*, *Raphidiopsis mediterranea*, *Anabaena*, *Scenedesmus opoliensis*, zig, *Aulacoseira granulata*, *Pediastrum simple*. 40X compound microscope, lugol was used as contrast.

In the study carried out, the dominant species was *Pseudanabaena galeata*, and it predominated at the 6 monitoring points, followed by *Planktothrix agardhii* (see Figure 5). These results differ from a study carried out in three urban lakes in Mexico in which *Microcystis* sp., As well as *Arthrospira* sp. and *Planktothrix agardhii*, were found in abundance (II).

According to the literature (II), the genus *Pseudanabaena* has unmistakable morphological characteristics, which clearly distinguish it from other filamentous cyanobacteria, such as its solitary and short growth as well as constrictions on its walls.

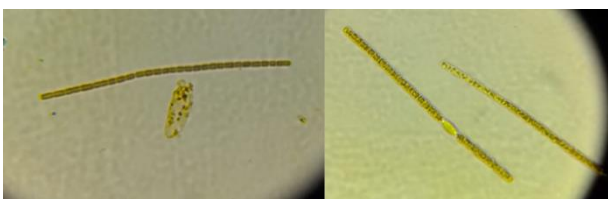

Figure 5 Photograph obtained with a Leica microscope, with a 40X objective, *Pseudanabaena galeata* and *Plankthotrix*, recovered from the Atlangatepec dam
Source: Own

Figure 6 shows the phylogenetic tree of the identified cyanobacterial species. In the topology of the tree, two main branches can be observed, which separates *Plankthotrix agardhii* from the rest of cyanobacteria. In the second bifurcation *Holothece* sp. At the next level of branching it is possible to distinguish *Pseudanabaena* from another group of cyanobacteria.

Abiotic (physical-chemical) and biotic (biological) criteria define water quality and its potential use. However, when the permitted limits of some parameters are exceeded, they infer the conservation of the aquatic ecosystem and the protection of human health.

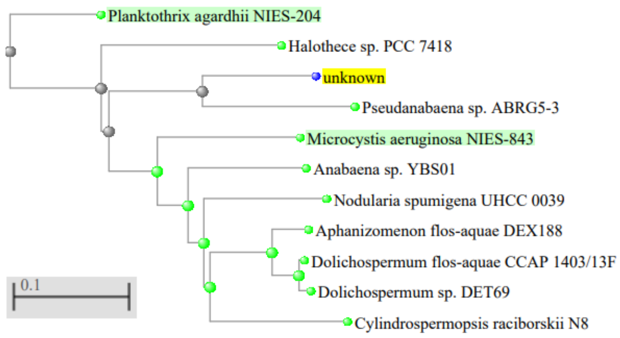

Figure 6 Phylogenetic tree obtained by Blastn, of cyanobacterial species and their accession numbers of the identified sequences, in the Atlangatepec dam, Tlaxcala, Mexico, November 2021

Cyanobacterial blooms have negative impacts on aquatic systems, they inhibit the growth of other microalgae and macrophytes due to the formation of secondary metabolites that are toxic to other species. The degradation of the algal flowering decreases the oxygen concentration in the water body promoting the death of fish, therefore the formation of blooms affects the aquatic diversity and the ecosystem (VII).

The monitoring activities carried out, on the one hand, allowed to know the impact of anthropogenic activities in the dam by obtaining data and using them, they will help in taking actions for the sanitation and sustainable use of the dam.

The dominance of cyanobacteria implies risks that must be known and managed, because they retain the ability to produce microtoxins, considered freshwater pollutants that outweigh heavy metals and pesticides (VI).

It is necessary to reduce the entry of phosphorus into the body of water since it promotes the massive growth of cyanobacteria. It is necessary to establish a conservation and sustainable management plan (PCyM), which promotes sanitation activities and compromises the participation of society for the establishment of good environmental practices and avoids the direct discharge of wastewater, which increases the content of organic matter and eutrophication processes.

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Conclusions

The predominance of *Pseudanabaena galeata* and *Plancthotrix agardhii* puts the diversity of phytoplankton and the balance of trophic chains in the water body at risk because these species are potentially cyanotoxin-producing.

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Thermal crystallization of polyethylene terephthalate (PET) for recycling and caring for the environment

Cristalización térmica del tereftalato de polietileno (PET) para el reciclaje y el cuidado del medio ambiente

SALAZAR-PERALTA, Araceli†*´, PICHARDO-SALAZAR, José Alfredo´´, PICHARDO-SALAZAR, Ulises´´´ and CHÁVEZ, Rosa Hilda´´´´

´Tecnológico de Estudios Superiores de Jocotitlán, Carretera Toluca Atlacomulco km 44.8, Ejído de San Juan y San Agustín, Jocotitlán, México.
´´Centro de Bachillerato Tecnológico Industrial y de Servicios No. 161, Exhacienda la Laguna S/N Barrio de Jesús 2a Sección, San Pablo Autopan, Toluca. Estado de México
´´´Centro de Estudios Tecnológicos Industrial y de Servicios No. 23. Avenida, Del Parque s/n, 52000 Lerma de Villada, México.
´´´´Instituto Nacional de Investigaciones Nucleares, Carretera México-Toluca s/n. La Marquesa, Ocoyoacac, 52750, México.

ID 1st Author: *Araceli, Salazar-Peralta* / **ORC ID:** 0000-0001-5861-3748, **Researcher ID Thomson:** U-2933-2018, **CVU CONACYT ID:** 300357

ID 1st Co-author: *José Alfredo, Pichardo-Salazar* / **ORC ID:** 0000-0002-8939-9921

ID 2nd Co-author: *Ulises, Pichardo-Salazar* / **ORC ID:** 0000-0002-3758-2038

ID 3rd Co-author: *Rosa Hilda, Chávez* / **ORC ID:** 0000-0002-2460-3346

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Abstract

Mexico is one of the main consumers of PET worldwide. In Mexico, urban solid waste has not received adequate attention due to a series of factors of various kinds, among which are: Collection of mixed garbage (in 95% of the national territory) [I, II], public services insufficient and inefficient cleanliness, poor coordination between the different levels of government, incomplete legal framework and legislative work with a particular vision, passivity in ecological matters and little culture of recycling in society [III, IV, V]. Sustainable development, as it is currently disseminated, begins in 1983, when the United Nations (UN) created the Commission on Environment and Development, chaired by Gro Harlem Brundtland, who was Prime Minister of Norway. The Brundtland Commission, carried out studies, analyses, and public consultations [VI], all over the world, for approximately three years, ending in April 1987, with the publication and dissemination of the report called Our Better Common Future known as The Brundtland Report [VII, VIII, IX]. The objective of this study was to determine the temperature at which polyethylene terephthalate (PET) in the form of granules, changes from amorphous to crystalline, since recrystallization improves the properties, which is necessary for the reuse of the material.

Recycling, Polyethylene terephthalate, Thermal crystallization

Resumen

México es uno de los principales consumidores de PET a nivel mundial. En México, los residuos sólidos urbanos no han recibido una atención adecuada debido a una serie de factores de diversa índole, entre los que se encuentran: Recolección de basura mixta (en el 95% del territorio nacional) [I,II], servicios públicos de limpieza insuficiente e ineficiente , mala coordinación entre los diferentes niveles de gobierno, marco legal incompleto y trabajo legislativo con una visión particular, pasividad en materia ecológica y poca cultura del reciclaje en la sociedad [III, IV, V]. El desarrollo sostenible, tal como se difunde actualmente, comienza en 1983, cuando las Naciones Unidas (ONU) crearon la Comisión de Medio Ambiente y Desarrollo, presidida por Gro Harlem Brundtland, quien fue Primera Ministra de Noruega. La Comisión Brundtland llevó a cabo estudios, análisis y consultas públicas [VI] en todo el mundo durante aproximadamente tres años, finalizando en abril de 1987, con la publicación y difusión del informe titulado Our Better Common Future conocido como The Brundtland Report [VII], [VIII, IX]. El objetivo de este estudio fue determinar la temperatura a la que el tereftalato de polietileno (PET) en forma de gránulos, pasa de amorfo a cristalino, ya que la recristalización mejora las propiedades, lo cual es necesario para la reutilización del material.

Reciclado, Polietileno tereftalato, Cristalización térmica

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* Correspondence to Author (Email: araceli.salazar@tesjo.edu.mx)
† Researcher contributing as first author.

Introduction

The increase in plastic and medical waste is a reality around the world and existing recycling systems have collapsed in some places. In Singapore, during an eight-week shutdown, an additional 1,470 tons of plastic waste was generated from take-out packaging alone. In Wuhan, China, medical waste rose six times to 240 tons per day during the pandemic, overloading the city's incineration capacity by 49 tons per day.

Mexico is one of the main consumers of PET worldwide. In Mexico, urban solid waste has not received adequate attention due to a series of factors of various kinds, among which are: Collection of mixed garbage (in 95% of the national territory) [I, II], public services insufficient and inefficient cleanliness, poor coordination between the different levels of government, incomplete legal framework and legislative work with a particular vision, passivity in ecological matters and little culture of recycling in society [III, IV, V].

PET is a high-quality plastic (thermoplastic). It is a condensation polymer produced by a continuous melt phase polymerization process.

It is a transparent material and very impervious to air, which makes it widely used for containers of soft drinks, mineral waters, vinegars, edible oils, cosmetics, etc.

It is identified with the number one, or the acronym PET or PETE, surrounded by three arrows at the bottom of the containers made with this material (SPI identification system (Society of Plastic Industries)).

Most PET is recyclable if it is separated from the rest of the garbage. The manufacture of PET consumes a lot of energy, and its incineration produces a lot of heat or electricity thanks to its high calorific value. PET is light, so transporting PET bottles saves 40% of energy cost compared to transporting glass bottles. Chemically stable.

Due to its exceptional chemical resistance, it is not possible to apply adhesives with solvents on it. It acts as a gas barrier.

Excellent fire resistance, does not transmit flame.

Excellent transparency and gloss.

Excellent formability.

Good machinability.

In general recyclable.

Environmentally friendly; its combustion does not generate polluting substances (only in the presence of chlorine it forms dioxins).

It does not generate gases that are harmful to the ozone layer.

Reduces the transmission of noise.

It does not present risks of severe impacts, it is not considered toxic, although in the synthesis of PET, substances that cause irritation of the eyes and respiratory tract are used, its manufacture is also associated with a small increase in the incidence of cancer. Heavy metals can be used as catalysts during the process of production and finally these end up in the environment, being pollutants.

It is suitable for direct food contact applications as it is odorless and tasteless and due to its self-adhering properties. In the case of the film (layer), in the handling process or in the very act of unwinding it, negative charges are induced on the plastic, so when it is brought closer to other bodies, it generates positive charges by induction, and this causes it to attract. The plastic material is insulating and maintains its state of charge for a long time, unless the environment is very humid.

Regarding stability against heat, they are thermoplastic; Articles made with this product should not be exposed to continuous use at temperatures above 65/70 ° C, since they soften by action of the heat. The objective of this study was to recrystallize PET, by means of thermal treatment to improve its properties and be able to reuse it, contributing to the reduction of plastic waste and to the economy.

The subject of this article is addressed in 7 sections. Section 1 presents the introduction. Section 2 describes the method used. In section 3 the results are analyzed and discussed. Section 4 acknowledges the support received. In section 5 the conclusions of the study are presented. In section 6 the references consulted are cited.

1. Description of the method

The methodology used for the thermal treatment of PET was the following:

1. Small pellet-shaped samples of polyethylene terephthalate were photographed before and prior to heat treatment.

2. The density of the PET pellets was measured before heat treatment by means of the pycnometer method.

3. The formula used for the calculation was:

$$\delta\, PET = \frac{P2-P0}{(P1-P0)-(P3-P2)/\delta H2O} \qquad (1)$$

Where: δPET = Density of polyethylene terephthalate in g/cm^3

δ H_2O = Density of water in g/cm^3 = 1g/cm^3

P_0 = weight of empty pycnometer in grams

P_1= weight of picnometer with wasser in grams

P_2= weight of picnometer with sample de PET

P_3 = weight of picnometer with sample and water in grams.

The density before heat treatment was of 0.7 to 0.8 g / cm^3.

3. The material was placed in a Memmert brand oven, at 170 ° C, for 1 hour.

4. The samples after heat treatment were allowed to cool for half an hour in a desiccator.

5. The samples were weighed on a balance Brand Ohaus.

4. The density of the samples or pellets was calculated after heat treatment. And the results were of 1.3 to 1.33g/cm^3

5. Photographs were taken of the pellets after the heat treatment.

6. The pellets were characterized by Scanning Electron Microscopy, with a scanning electron microscope (SEM), JEOL brand, as well as by Infrared transmission spectroscopy with a Nicolet brand spectrometer before and after heat treatment.

4. Results

1. The variation of the density in the Poliethylene terephthalate (PET) before the heat treatment was of 0.70 to 0.80 g/cm^3. Table 1.

No. of Sample	Density in g/cm^3
1	0.72
2	0.70
3	0.75
4	0.80
5	0.78

Table 1 Density of pellets of PET before the Heat Treatment

The samples of the pellets before heat treatment showed a transparent appearance, characteristic of amorphous material. Figure 1.

Figure 1 Pellets of PET, without Heat Treatment

2. The sample changed color after being subjected to 170 ° C for 1 hour. The transparent color showed in Figure 1, turned out to be milky white. Figure 2.

Figure 2. Pellets with Heat Treatment (170°C 1 hour)

4. The result of the density, after the treatment, turned out to be 1.3 to 1.33 g / cm^3. Table 2.

Number of Sample	Density in g/cm³
1	1.31
2	1.30
3	1.32
4	1.33
5	1.32

Table 2 Density of material PET after Heat Treatment

Wavelength (cm⁻¹)	% of Transmittance
723	96.08
873	97.93
1079	97.25
1091	97.05
1237	96.19
1409	98.53
1719	96.96
2961	99.7
2966	99.73

Table 3. Transmittance values in percentage and Wavelengths in (cm^{-1}) of the PET without Heat Treatment

Longitud de onda (cm⁻¹)	% de Transmitancia
721	94.72
872	97.49
1082	96.3
1240	95.55
1341	98.36
1409	98.40
1712	96.44
2849	98.55
2918	98.37

Table 4. PET with Heat Treatment 1 hour at 170°C

5. Both the color and the change in density after heat treatment are characteristics of a crystallized material.

6. With respect to the results obtained by Infrared Spectrometry, a change in transmittance was observed in the material after heat treatment, which shows that the material transformed from amorphous to crystalline. Tables 3 and Table 4. Figure 3 and Figure 4.

About the Morphology the samples before heat treatment showed an amorphous appearance, and after heat treatment show a crystalline structure. Figures 5 and 6, respectively.

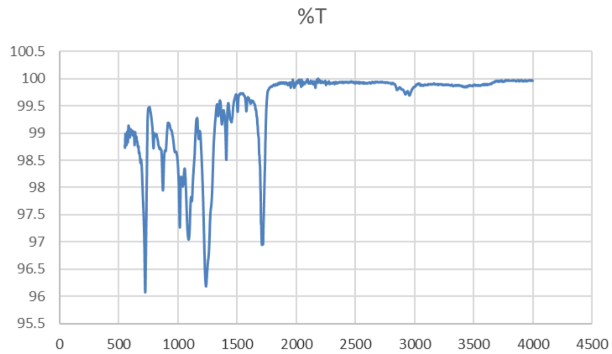

Figure 3 FTR de Pellets of PET without Heat Treatment

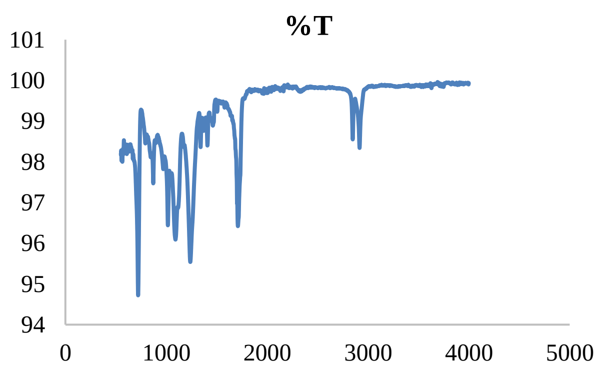

Figure 4 Pellets of PET with Heat Treatment 1hour to 170°C

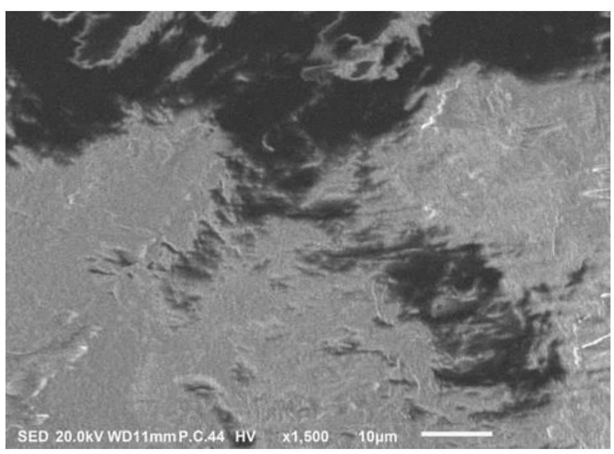

Figure 5 PET without heat treatment to 1500X

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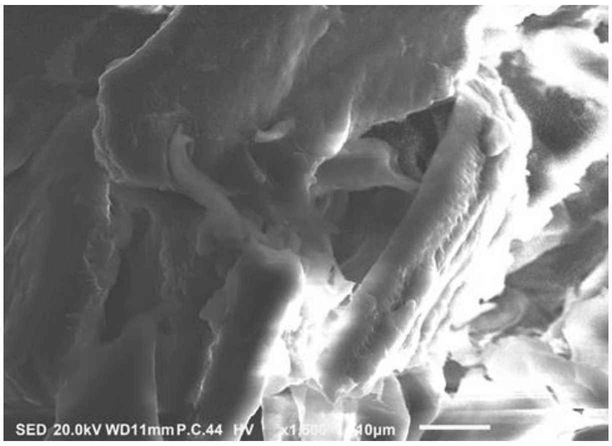

Figure 6 PET with heat treatment. 1500X

4. Thanks

I. I thank the Tecnológico de Estudios Superiores de Jocotitlán for the trust placed in me to carry out hours of research at the institution.

2. To all my collaborators for their support.

5. Conclusions

This study shows that the heat treatment applied to the pellets, for 1 hour at 170ºC, was sufficient to transform the PET from amorphous to crystalline, which was also verified with the change in density, change in color of the material, change in the morphology of material as well as in the change in the percentage of transmittance obtained in the corresponding infrared spectrum, whose procedure can be applied specifically to PET and give greater value in its use and efficiency to the use of solid urban waste, thus contributing to Sustainable development.

Besides, the heat treatment used is accessible and cheap, since it does not need sophisticated instruments, only a furnace with the necessary capacity according to the amount of material to be crystallized.

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Hydrogen synthesis from seawater by means of solar energy

Síntesis de hidrógeno a partir de agua de mar mediante energía solar

MONTES-GUTIÉRREZ, Jorge†´, HERRERA-JIMENEZ, Víctor´´, RODRIGUEZ-CARVAJAL, Ricardo´´´ and GARCIA-GUTIÉRREZ, Rafael*´´´´

´Centro de Nanociencias y Nanotecnología, Universidad Nacional Autónoma de México. Ensenada, B.C., 22860, México.
´´Departamento de Ingeniería Industrial, Universidad de Sonora. Rosales y Luis Encinas, Hermosillo, Sonora, 83000, México.
´´´Departamento de Ingeniería Química, Universidad de Guanajuato, Guanajuato, Gto., 36000, México.
´´´´Departamento de Investigación en Física. Universidad de Sonora. Rosales y Luis Encinas, Hermosillo, Sonora, 83000, México.

ID 1st Author: *Jorge, Montes-Gutiérrez* / **ORC ID:** 0000-0002-3078-6548

ID 1st Co-author: *Víctor, Herrera-Jimenez* / **ORC ID:** 0000-0002-82722378

ID 2nd Co-author: *Ricardo, Rodriguez-Carvajal* / **ORC ID:** 0000-0003-3105-9809

ID 3rd Co-author: *Rafael, García-Gutiérrez* / **ORC ID:** 0000-0001-5030-326X

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Abstract

In the electrolysis of seawater as a source of hydrogen, two options exist for the performance of the electrolysis process. The first option is the total desalination of the sea water and then add alkalis for the process of electrolysis to produce hydrogen in the cathode and oxygen in the anode. The disadvantages of this approach are the high cost of desalination and the water treatment to make it alkaline. The main advantage is the ability to use developed technology for the direct electrolysis of fresh water. The second option is to design an electrolyze system capable of utilizing sea water for direct electrolysis at a low power density and electrolyze only a small portion of the water in contact with the electrodes. The advantage of this method is the lower capital required for the system and natural elimination of the waste brine which is only slightly enriched with salts. Also using this technic is possible to produce important amounts of chlorine as a sub-product and also magnesium and sodium as hydroxides that have many uses in the chemical industry. In this research we produced hydrogen via electrolysis from simply natural resources, seawater and solar energy. In order to carry out this experiment we used water from Bahia of Kino Sonora, a place no too far from the University of Sonora, only 100 kilometers away, and a 100-W solar panel that generate DC electricity using directly sunlight that is an abundant resource in the coasts of Sonora. In this work we have been able to produce about 2 liters of hydrogen per hour and nearly 1.2 liters of chlorine per hour with a normal direct radiation of 900 W/m^2. This technique could be the solution to the fuels problematic of the ethnicities that inhabit the shores of Sonora and other states of México.

Hydrolysis, Hydrogen, seawater, Solar Energy

Resumen

En la electrólisis del agua de mar como fuente de hidrógeno, existen dos opciones para la realización del proceso de electrólisis. La primera opción es la desalinización total del agua de mar y luego añadir álcalis para el proceso de electrólisis para producir hidrógeno en el cátodo y oxígeno en el ánodo. Las desventajas de este enfoque son el alto coste de la desalinización y el tratamiento del agua para hacerla alcalina. La principal ventaja es la posibilidad de utilizar la tecnología desarrollada para la electrólisis directa del agua dulce. La segunda opción consiste en diseñar un sistema de electrólisis capaz de utilizar el agua de mar para la electrólisis directa con una baja densidad de potencia y electrolizar sólo una pequeña parte del agua en contacto con los electrodos. La ventaja de este método es el menor capital requerido para el sistema y la eliminación natural de la salmuera residual que sólo está ligeramente enriquecida con sales. Además, utilizando esta técnica es posible producir cantidades importantes de cloro como subproducto y también magnesio y sodio como hidróxidos que tienen muchos usos en la industria química. En esta investigación produjimos hidrógeno por electrólisis a partir de recursos simplemente naturales, agua de mar y energía solar. Para llevar a cabo este experimento utilizamos agua de la Bahía de Kino Sonora, un lugar no muy lejano a la Universidad de Sonora, a sólo 100 kilómetros de distancia, y un panel solar de 100 W que genera electricidad en corriente continúa utilizando directamente la luz solar que es un recurso abundante en las costas de Sonora. En este trabajo hemos sido capaces de producir unos 2 litros de hidrógeno por hora y casi 1,2 litros de cloro por hora con una radiación directa normal de 900 W/m^2. Esta técnica podría ser la solución a la problemática de los combustibles de las etnias que habitan las costas de Sonora y otros estados de México.

Hidrólisis, hidrógeno, agua de mar, energía solar

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* Correspondence to Author (Email: rafael.gutierrez@unison.mx)

† Researcher contributing as first author.

Introduction

Global warming and fuel shortages are two dilemmas facing humanity as the world's population increases. The exploitation and consumption of fossil fuels such as coal, oil and natural gas are the main factors that aggravate air, water and soil pollution. To reduce said pollution and reduce the greenhouse effect, it is necessary to promote and increase the use of clean energies, such as wind, geothermal, maritime and solar, since these do not generate polluting substances to the environment nor do they damage the layer of ozone which protects us from ultraviolet rays from the Sun. The Earth is mostly covered by salty water from the oceans, it covers approximately three quarters of the planet's surface, it is for this reason that we seek to use this natural resource almost inexhaustible to generate fuels such as hydrogen. A water molecule contains one oxygen atom and two hydrogen atoms, which can be separated from oxygen by electrolysis using electrical energy. In this work it is proposed to use seawater from Bahía de Kino and solar energy to extract hydrogen and then use it as fuel or as reactant gas in various industrial processes. For this process, the use of solar cells to generate the electrical energy necessary to carry out electrolysis is also proposed, since solar energy is also an abundant natural resource in the region.

Problem statement and theoretical foundations

In this research, the aim is to produce hydrogen by the seawater electrolysis method, which mainly consists of the electrolysis of a solution of sodium chloride (NaCl). The electrodes, the cathode and the anode, are placed in the solution and generate the movement of electrons. Hydrogen forms at the cathode while chlorine forms at the anode. To improve the production of hydrogen, the composition of the water is usually varied by means of electrolysis, generally with the addition of salts, to increase the reaction rate; in this case, seawater is used, which naturally contains sodium chloride, so the process is more efficient. [1]

As is well known, 96.5% of the total water in the world is salt water and only 3% is fresh water. Dissolved salts in the ocean constitute almost 50 billion tons and are made up of 10 main elements to be found in greater proportions: chlorine, sodium, magnesium, sulfur, calcium, potassium, bromine, strontium, boron and fluorine. Chlorine and sodium are the main elements dissolved in seawater and are found as sodium chloride, which is known as common salt, which represents 80% of the salts in the solution. [2]

Electrolysis of sea water

The electrolysis of seawater consists mainly of the electrolysis of a solution of sodium chloride (NaCl). From a thermodynamic point of view, the species with the lowest reduction potential will be oxidized at the anode and the species with the highest potential will be reduced at the cathode. Given this particular case where the electrolysis of seawater occurs by means of graphite electrodes, it can be assumed that the polarization by mass transfer of the participating ion molecules Na^+, Cl^- and H_2O is negligible. Under these conditions it can be assumed that only charge transfer polarization influences the oxidation of the chlorine ion and the reduction of water. Suppose that the concentration of ions and cations Cl^-, OH^-, Na^+ and H^+ is enough to allow them to participate in an electrochemical reaction. [3] The sodium chloride present in seawater is dissolved, so it dissociates into Cl^- ions and Na^+ cations, Figure 1a. If a potential difference is applied to the solution, the positive ions dissolved in the electrolyte approach the negative pole and the negative ones approach the positive pole, Figure 1b. For every two Cl^- ions found at the anode, two electrons are released and a molecule of chlorine gas (Cl_2) is formed, Figure 1c. Electrons are drawn to the cathode by the voltage source and decompose a water molecule into hydrogen gas (H_2) and hydroxyl OH-, Figure 1d. Finally, the hydroxyl ion combines with the Na^+ ion to form sodium hydroxide (NaOH).

The overall reaction for the electrolysis of the brine is therefore:

$$2\mathrm{NaCl}_{(aq)} + 2\mathrm{H_2O} \rightarrow \mathrm{Cl}_{2(g)} + \mathrm{H}_{2(g)} + 2\mathrm{N_aOH}_{(aq)} \quad (1)$$

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Apparently at the anode the water molecules should be oxidized, however, experience shows that the chlorine ion oxidizes instead of it. This is due to polarization phenomena that hinder the formation of oxygen. [4]

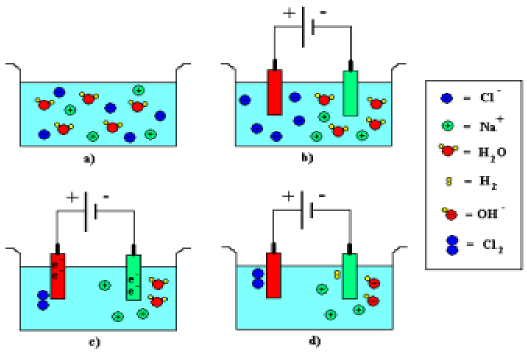

Figure 1 Schematic representation of the electrolysis of a sodium chloride solution

Table 1 shows the enthalpy, entropy and Gibbs free energy formation values for each compound present in the reaction.

Compound	ΔH° (Kcal/mol)	ΔG° (Kcal/mol)	ΔS° (Cal/mol °C)
H_2O	-68,320	-56,689	16,716
NaCl	-97,302	-93,939	27.6
Cl_2	0	0	53,286
H_2	0	0	34,602
NaOH	-112,236	-100,184	11.9

Table 1 Standard thermochemical values of the compounds involved in electrolysis

Oxidation Potential

The oxidation potential is the electrical potential required to transfer electrons from an oxidant to a reducing agent, expressed in volts. The following is the calculation of the oxidation potential of our main reaction from the half reactions presented in this, together with their standard potentials at 25 °C.

$$2\ Cl^-{}_{(aq)} \rightarrow Cl_{2(g)} + 2e^-$$

E°= -1.36V (33)

$$2H_2O_{(l)}\ + 2e^-\ \rightarrow H_{2(g)} + 2OH^-_{(aq)}$$

E°= -0.83V

$$Na^+ + 1e^- \rightarrow Na_{(s)}$$

E°= -2.71V (35)

Global reaction:

$$2N_aCl_{(aq)} + 2H_2O \rightarrow\ Cl_{2(g)} + H_{2(g)} + 2N_aOH_{(aq)}$$

E°= -4.9V (36)

Methodology to be developed

Once the production of hydrogen at the cathode and chlorine at the anode was demonstrated in the laboratory under controlled conditions, the system was scaled up. A system to produce hydrogen was designed where two graphite electrodes of 12 cm each were used, connected to a photovoltaic panel of 100 Watts, the electrodes contained in two 100 ml test tubes each one filled with salt water with 17 cm were placed separation and inverted submerged into seawater in 87,520 cm^3 clear acrylic container. The purpose of using inverted test tubes was to quantify the gases generated. In figure 2 the experimental arrangement can be observed.

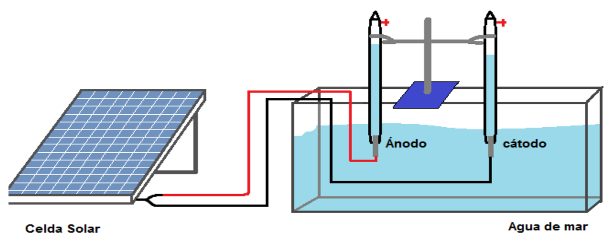

Figure 2 Schematic of the electrolysis process with seawater using a silicon solar cell

The seawater was obtained 250 meters from Av. Mar de Cortés, in Bahía de Kino, Sonora (see Figures 5a) at the discharge ramp (28.867056, -112.030846) Figure 3b, and was stored in a Rotoplas water tank of 250 L (Figure 3c). The seawater was transferred to the University of Sonora where analyzes continued. PH measurements were made in the water with the JENCO 1671 instrument, designed to measure the pH, conductivity and oxidation-reduction potential of a liquid.

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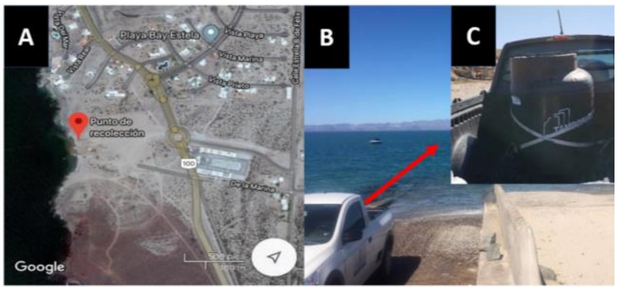

Figure 3 Seawater collection A) Satellite image of the seawater collection point in Bahía de Kino, Sonora. B) Seawater collection point, on the discharge ramp 250 meters from the extension of Av. Mar de Cortés, in Bahía de Kino, Sonora. C) Rotoplas of 250 liters capacity, where the collected seawater was stored

The transparent acrylic container was filled with 40 liters of seawater and the arrangement was assembled by connecting the electrodes to the solar cell, adding a toggle switch (see figure 3b) to be able to interrupt the passage of electrical current, this to be able to mount the pipettes and insert the electrodes into them, without the process being carried out, to obtain more specific measurements. The electrodes were fitted to an electrical eye-type copper terminal, soldered using 50-50 tin lead, to a 14 AWG copper wire (2 meters), applying a liquid insulating tape to prevent water from coming into contact with them. as seen in Figure 3c. The complete hydrogen generating experimental system is shown in Figure 3a. The PV panel was secured to a metal rod for better stability of the cell Figure 3a and was placed on a metal base (see Figure 3).

Figure 3 Experimental arrangement A) Experimental arrangement of the seawater electrolysis process in operation using a PV panel. B) On / Off toggle switch connected between the PV panel and the graphite electrodes. C) Graphite electrodes positioned inside the pipettes in the acrylic with seawater in the electrolysis process

Results and Discussions

The first measurement was performed under normal conditions on March 25, a sunny day where an irradiance of 949 W/m² was recorded at 12:50 p.m. Hermosillo time, is presented in table 1.

When using the PV panel, the amperage of the system increases to 5.1 which causes the production time of 100 ml of hydrogen to decrease, which influences the electrical efficiency, this increased by 37%, having an efficiency of the photovoltaic module of 14.78%.

The second measurement on March 26 was made using a solar controller. It is observed that when using the controller, the efficiency of the cell decreases, in the same way does the maximum power of the cell, from a value of 92.96 to 69.56 watts, the electrical efficiency as well as the electrical production time decrease by 65%. It is observed that the efficiency of the module also decreases from 14 to 11%. Which tells us that using the solar controller is not favorable for the process.

The next measurement was carried out on March 27, which was a totally cloudy day, with an average irradiance of 627 W/m² at 12:10 p.m. This caused the decrease in the measured values, this due to the amperage that the cell presents, which was 3.1 amps, it is not similar to that of the other days as it has a lower irradiance, and the temperature of the cell is also lower, the production time of 100 ml increases to 8 minutes, and the electrical efficiency decreases in a small amount (0.09%). Despite the conditions, a cell efficiency of 14% is observed.

A last measurement was made on July 4 at 1:30 pm with an irradiance of 980 W/m^2 to compare the efficiency of the process during the summer season where high values of irradiance and temperature were registered, as can be seen in the Table 1a and 1b.

In this measurement the highest values are observed compared to the previous measurements, having an amperage of 5.32 A, an average production of 1.75 lt of H_2 per hour, which shows an increase of 66% compared to the production values of the day March 7, under controlled conditions using the 13.8-volt, 4.87-amp power supply. And making the comparison of March 25, which the environmental conditions were similar to those of July 4, a difference in efficiency of 11% is observed, the maximum power of the cell also increases from the value of 92 to 95 watts, however, the efficiency value of the solar panel remains at 14%.

I_{sc} *	V_{oc} *1	I_{max}*2	V_{max} *3	P_{max} *4	FF*5	PV PE*6	Date*7
5.1	19.9	5.08	18.3	92.964	0.915	14.782	03/25/19
5.1	14.7	5.08	13.7	69.596	0.928	11.066	03/26/19
3.1	21.2	3	19.3	57.9	0.881	13.935	03/27/19
5.32	19.97	5.32	17.9	95.228	0.896	14.662	07/04/19

*Short circuit current (I_{sc} in ampere), *1 open circuit voltage (V_{oc} in voltage), *2 maximum current (I_{max} in ampere), *3 maximum voltage (V_{max} in voltage), *4 maximum power point (P_{max} in Watts), *5 Cell Fill Factor (FF), *6 Photovoltaic panel efficiency (PV PE), *7 Date (MM/DD/YY)).

Table 1a PV panel parameters on different days

Time *	H_2 *2	Moles H_2 *3	H_2 *4	EFF *5	Date *6
4.47	1.342	0.0531	0.107	73	03/25/19
7.41	0.809	0.032	0.064	44	03/26/19
8	0.75	0.030	0.061	67	03/27/19
4.13	1.452	0.056	0.113	76	07/04/19

* Time in minutes, *2 H_2 produced in liter/hour, *3moles of H_2 produced per hour, *4 H_2 produced grams/hour, *5 EFF efficiency, *6 Date (MM/DD/YY))

Table 1b Hydrogen production on different days

pH measurements were also made in seawater after having been subjected to the electrolysis process in order to know the effect of the electrolysis process in a closed system. The pH of seawater was observed to increase. This means that seawater becomes more alkaline, and therefore the concentration of hydroxyl ions (OH-) also increases. This is due to the secondary reaction that takes place during electrolysis between hydroxyl ions and sodium ions. The increase in pH can be avoided if the production system is open and very large like the ocean, which would maintain a constant pH in the vicinity of the system.

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Conclusions

On a small scale, this experiment turned out to be an excellent alternative for the production of hydrogen, since using a 100 Watt solar panel it is possible to generate 1.75 liters of hydrogen in an hour with a voltage of 14.4 V; Taking into account that a liter of hydrogen contains the energy of 3.5 liters of diesel, this option would save us a large amount of fossil fuels and avoid polluting the atmosphere since burning hydrogen only produces water vapor. On the other hand, by increasing the number of photovoltaic panels, the amounts of hydrogen produced would be much greater without the need to pollute the environment and investing only in an initial amount for the acquisition of the equipment, since it does not need maintenance and has a time of long life, approximately 20 years. This project opens the great sustainable solution for big problems induced by hydrocarbon pollution, and Sonora State in Mexico could be a potency taking advantage of the sun like your principal natural resources, mineral graphite and seawater.

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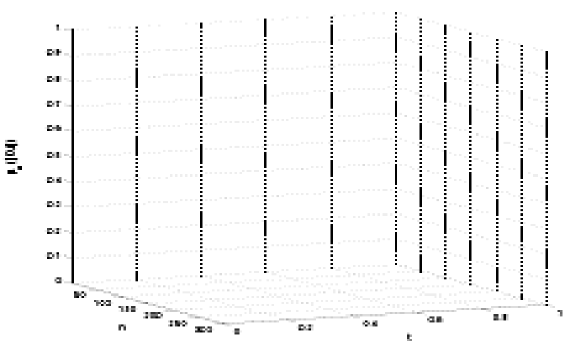

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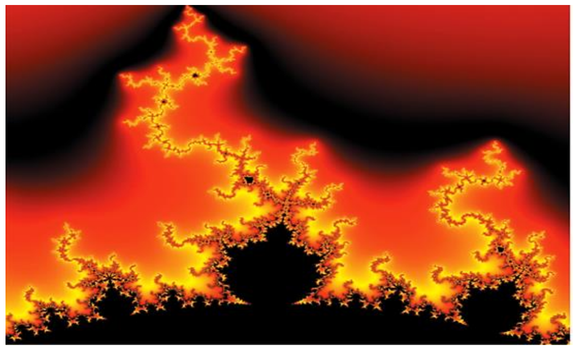

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