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# Water quality evaluation through the Pampean diatom index (PDI) in three different localities in Actopan River, Veracruz.

Estrada-Hidalgo N[1], Obregón-Jiménez I[1], Castillo-Adame IL[1], Jardón-Romero JP[1], Castro-Mejía G[2], Castro-Mejía J[2].

1 Students from Alumnas del Módulo Plagas y Enfermedades de un Recurso Natural. Licenciatura en Biología. Universidad Autónoma Metropolitana Xochimilco.

2 Universidad Autónoma Metropolitana Xochimilco. División de Ciencias Biológicas y de la Salud. Depto. El Hombre y su Ambiente. Área Estrategias Biológicas para el Aprovechamiento de los Recursos Naturales Acuáticos. Calz. del Hueso No.1100. Col. Villa Quietud. CP. 04960. Del. Coyoacán. Ciudad de México. Tel. 54837151.

***Email responsable: gecastro@correo.xoc.uam.mx**

## ABSTRACT

Diatoms are environmental indicators because they respond quickly to factors such as temperature, light, conductivity, nutrients, current speed, inorganic and organic pollution, acidification and herbivory. The following work took place in three localities of Úrsulo Galván municipality: La Gloria, El Zapotito and Jareros. In each locality, diatoms were collected in rocks and plants located at a shallow depth of the river. It was used the IDP (Pampean Diatom Index), which was designed to evaluate the eutrophication and organic pollution in rivers and streams. Most abundant diatom in the three localities was *Cocconeis* sp. with 118 organisms, followed by *Nitzchia* sp. with 77 organisms in Jareros and 12 in El Zapotito. La Gloria presented and IDP of 1.6160 that indicates that the water quality is Acceptable, with moderate pollution and eutrophication with high concentrations of nutrients and organic matter. In the locality of Jareros and El Zapotito the PDI was of 2.2201 and 2.0882 respectively, which indicates that the water quality is Bad and presents strong pollution and eutrophication, with presence of degraded organic matter and high vales of nitrites and ammonium. It is convenient to continue the studies of benthonic diatoms in Actopan River, because it will allow to determine how the water quality fluctuates through time of cultivation and harvesting of sugarcane.

Key Words: Benthonic diatoms, PDI, Actopan River, Veracruz.

## RESUMEN

Las diatomeas son indicadores ambientales porque responden rápidamente a factores tales como la temperatura, luz, conductividad, nutrientes, velocidad de la corriente, polución orgánica e inorgánica, acidificación y herbívora. El siguiente trabajo se llevó a cabo en tres localidades del municipio de Úrsulo Galván: La Gloria, El Zapotito y Jareros. En cada localidad, la colecta de diatomeas se tomaron rocas y plantas que se encontraban situadas a poca profundidad del rio. Se utilizó el IDP (Índice de Diatomeas Pampeano), el cual fue diseñado para evaluar la eutrofización y polución orgánica de los ríos y arroyos. La diatomea con mayor abundancia en las tres localidades fue *Cocconeis* sp con 118 organismos, seguida de *Nitzchia* sp con 77 organismos en Jareros y 12 en El Zapotito. La localidad de La Gloria presenta un IDP de 1.6160 que indica que la calidad de agua es Aceptable, con polución y eutrofización moderada con altas concentraciones de nutrientes y materia orgánica. En la localidad de Jareros y El Zapotito el IDP fue de 2.2201 y 2.0882 respectivamente, que nos indica que la calidad de agua es Mala y que presenta una polución y eutrofización fuerte, con presencia de materia orgánica degradada y valores altos de nitritos y amonio. Es conveniente seguir con los estudios de diatomeas bentónicas en la zona del río Actopan, ya que permitirán determinar cómo fluctúa la calidad de agua a través del tiempo del cultivo y zafra de la caña de azúcar.

Palabras clave: Diatomeas bentónicas, IDP, Río Actopan, Veracruz.

## INTRODUCTION

Diatoms are environmental indicators because they respond quickly to factors such as temperature, light, conductivity, nutrients, current speed, inorganic and organic pollution, acidification and herbivory (Licursi et al. 2006, Tall et al. 2006, Esqiús et al 2008). Also, they constitute the main components of periphyton and benthos, contributing a big part of the total abundancy of these communities (Esquiús et al. 2005).



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In Mexico, making studies of water chemistry was considered as the main method to determine water quality in freshwater bodies. The National Water Commission (CONAGUA), regularly monitors the water quality in rivers, damps, lakes and lagoons since the beginning of 1970, using physicochemical parameters and since 2003 using the biological demand of oxygen (BDO), chemical demand of oxygen (CDO) and total suspended solids (Mathuriau et al. 2010). Taking only these parameters gives us a limited idea, because it doesn´t reveal the toxic risk, biotic integrity and the real impact of anthropogenic parameters on aquatic resources (López-Fuerte and Siqueiros-Beltrones 2011). In México, phytoplankton algae records have been made (Novelo 2003, Novelo and Tavera 2011) and specifically of diatoms are the works of Olivia et al. (2005, 2014), Novelo et al. (2007) and Siqueiros (2002); studies about water quality using diatoms is the work of Velázquez (2007), López Fuerte and Siqueiros Beltrones (2011) and Velázques (2007). In Argentina there are works of benthonic diatoms as indicators of water quality, like the ones of Gómez (1998, 1999), Gómez and Licursi (2001); Licursi and Gómez (2002, 2003); in Brazil the works of Salmoni et al. (2006), Rodrigues and Lobo (2000) and Souza (2002), to name a few.

Studies about benthonic diatoms in Actopan River, Veracruz are null, so it is important to make this studies in the zone. This work aims to collect diatoms in three different localities of the river and apply the pampean diatom index (IDP) as a simple, quick and economic way to evaluate de water quality.

## MATERIAL AND METHODS

*Study zone*

This work took place in three localities of the Úrsulo Galván municipality: La Gloria (19°25’47” N, 96°23’30” W), El Zapotito (19°26’47” N, 96°26’14” W) and Jareros (19°26’47” N, 96°28’27” W) (Fig.1).


Fig. 1. Localization map of three localities where samples of benthonic diatoms took place.



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**Table 1. Pampean Diatom Index and its relation to water quality.**

| PDI value | Water quality | Color code | Water characteristics | Disturbance degree |
|---|---|---|---|---|
| 0-0.5 | Very good | Blue | No pollution, natural state, few nutrients, and low organic enrichment | Minimum: low human influence |
| >0.5-1.5 | Good | Green | Slight pollution and eutrophication, low levels of nutrients and organic matter | Slight: extensive cattle raising and agriculture. |
| >1.5-2 | Acceptable | Yellow | Moderate pollution and eutrophication, high concentrations of nutrients and organic matter. | Moderate: industrial activity and/or intensive cattle raising |
| >2-3 | Bad | Orange | Strong pollution and eutrophication, presence of organic matter partially degraded, nitrites, ammonium, and amino acids. | Strong: intensive agriculture and cattle raising, industrial activity and population density. |
| >3-4 | Very bad | Red | Very strong pollution and eutrophication, high concentrations of organic matter, predominance of reductive processes and presence of industrial products. | Very strong: intensive industrial activity and high population density |

*Physicochemical parameters*

In each of the different zones, the temperature, pH, salinity, dissolved oxygen (D.O.) were measured with a multiparametric YSI model M86; the turbidity was measured with a Secchi disc and a water sample was taken to obtain the nitrites ($NO_2$), nitrates ($NO_3$), ammonium ($NH_4$) and phosphates ($PO_4$) with a multiparametric equipment for aquaculture of HANNA®.

*Diatoms collection*

In each locality, for the collection of diatoms rocks and plants located at shallow depths of the river were taken and scraped with a toothbrush and the sample was deposit in plastic jars with formaldehyde at 4% and were stored in a dark and cool place for later identification.

*Identification*

The identification of diatoms took place in the laboratory of Hydrobiology in Universidad Autonoma Metropolitana Unidad Xochimilco, with the aim of a stereoscopic microscope Olympus SZ40. The works of Blanco et al. (2010) and Barrios and Puig (2012) of the Ministry of Agriculture, Alimentation and Environment of the Govern of Spain were used.

*Water quality index: IDP*

The IDP described in the work of Gómez and Licursi (2001) was used, which was designed to evaluate the eutrophication and organic pollution of rivers and streams in the Pampean area in Argentina. To each identified diatom it was assigned a value of sensibility to pollution and eutrophication and the next formula was applied:

$$DP = \frac{\sum_{j=1}^{n} I_{idpj}.A_j}{\sum_{j=1}^{n} A_j}$$

Where:

$I_{idn}$: IDP value for the specie (between 0-4)

$A_j$: relative abundance of specie

The values of the index fluctuate between 0 and 4, <0.5 very good water quality and >3 very bad water quality. To each different water quality, a color is



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assigned for its graphic identification in maps and are related with the more frequent anthropic activities in the study area (Table 1) (Licursi and Gómez 2003).

*Abundance and diversity*

The Shannon-Weaver index $(H' = (\sum pi\ x \ln(pi))$ was applied to measure the biodiversity and also the similitude coefficient of Jacard $IJ = \frac{c}{(a+b+c)}$) where the value of 0 means that the stations doesn't present common species, and tends to 1 as the number of shared species increases).

*Statistical analysis*

A one-way ANOVA analysis was made to determine significant differences (P<0.05) between the three zones of study regarding to the studied physicochemical parameters. When finding significant differences, it was made a comparison of multiple measures through a Tukey test.

## RESULTS

In Table 2 are shown the values of the physicochemical parameters in the three sampled localities. In the locality of El Zapotito, ammonium, nitrites and phosphates values were highest (0.61, 27.33 y 2.50 respectively), in the locality of Jareros, nitrates were the highest (15.38). The temperature, salinity and pH presented very similar values. By applying the ANOVA there weren't significant differences (P>0.05).

Regarding to diatoms, the locality of La Gloria was the only one with three species (Table 3). The most abundant diatom in the three localities was *Cocconeis* sp. with 118 organisms, followed by *Nitzchia* sp. with 77 organisms in Jereros and 12 in El Zapotito.

By applying the diversity, equitability and similarity index between the stations, the highest diversity value was presented in the locality Jareros with 1.319, while La Gloria and El Zapotito presented similar diversity values (1.04 and 1.079 respectively). Whit the Jacard similarity index only the localities of Jareros vs El Zapotito obtained values of 0.1428, between the localities of La Gloria vs Jareros and El Zapotito it didn't present common species (Table 4).

The locality of La Gloria presented an IDP of 1.6160 which indicates that the water quality is acceptable, with moderate pollution and eutrophication and high nutrient and organic matter concentration. In the locality of Jareros and El Zapotito the IDP was of 2.2201 and 2.0882 respectively, which indicates that the water quality is Bad, and it presents strong pollution and eutrophication, with presence of degraded organic matter and high values of nitrites and ammonium.

## DISCUSSION

Round (1991) mentions that the study of phytoplankton, both in benthos and in the water column of the river tributaries and other water bodies, allows to evaluate the water quality; the determination of the type of periphyton in a zone have proven to be a good indicator of the water quality; Lane and Brown (2007) used only the periphyton in a wetland area of the USA and found that the community was more sensitive to human perturbation than phytoplankton; Potapova and Charles (2003) also used only periphyton as indicator and obtained good results; Reavie et al. (2010) mentions that the study of all the phytoplankton is useful for the monitoring of rivers when the set of algae in the area is evaluate. Therefore, in this work was focused in the evaluation of the periphyton of aquatic grass and rocks.

It should be noted that in the area there are two sugar mills, in La Gloria, and another one upstream in the village of Santa Rosa, which affects the river due to waste discharge; also, on the margin of the Actopan River there are growing areas mainly of sugar cane. This explains the values of nitrites, nitrates and phosphates which are above the permissible limit stablished by NOM-001-SEMARNAT-1996.

Velásquez et al. (2006) mentions that the distribution of some microalgae genera, are highly related to the variation of biotic and abiotic factors, according to Velázquez (2007) the tolerant individuals to contamination includes the genus *Nitzchia* and *Gomphonema* both present in the zone



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**Table 2. Physic-chemical values obtained from three localities of River Actopan.**

| Locality | $NH_3$ | $NO_3^-$ | $NO_2^-$ | $PO_4^-$ | Temperature (°C) | Salinity ($gL^{-1}$) | pH |
|---|---|---|---|---|---|---|---|
| **Jareros** | 0.44 | 15.38 | 14.33 | 1.37 | 25.12 | 0.23 | 9.66 |
| **El Zapotito** | 0.61 | 12.17 | 17.33 | 2.50 | 24.57 | 0.19 | 9.99 |
| **La Gloria** | 0.25 | 13.57 | 15.33 | 1.15 | 24.54 | 0.20 | 8.32 |

**Table 3. Abundance and Diatom PDI obtained from River Actopan from three localities.**

| Locality | Order | Family | Genus | Abundance | Sensibility | PDI value |
|---|---|---|---|---|---|---|
| **La Gloria** | Fragilariales | Fragilariacea | *Fragilaria* sp. | 56 | I-III | 1.5 |
| | Naviculales | Diploneidaceae | *Diploneis* sp. | 63 | I-II | 1 |
| | Achnanthales | Cocconeidaceae | *Cocconeis* sp | 118 | I-III | 2 |
| | | | **Total** | **237** | | |
| **Jareros** | | Surirellaceae | *Surirella* sp | 57 | I-III | 1.25 |
| | | Amplhipleuraceae | *Amphipleura* sp. | 3 | I-III | 3 |
| | | Naviculaceae | *Navicula* sp. | 21 | I-III | 2.75 |
| | | Bacillariaceae | *Nitzschia* sp | 77 | II-III | 2.5 |
| | | Fragilariacea | *Diatoma* sp. | 26 | I-II | 3 |
| | | | **Total** | **184** | | |
| **El Zapotito** | Surirellales | Surirellaceae | *Campylodiscus* sp. | 1 | II-III | 2.25 |
| | | | *Surirella* sp. | 1 | I-III | 1.25 |
| | | | *Stenopterobia* | 1 | I | 1 |
| | Rhizosoleniales | Rhizosoleniaceae | *Rhizosolenia* sp. | 1 | | N.D. |
| | Cymbellales | Gomphonemataceae | *Gomphonema* sp. | 1 | 0-III | 1 |
| | Bacillariales | Bacillariaceae | *Nitzschia* sp | 12 | II-III | 2.5 |
| | | | **Total** | **17** | | |

**Table 4. Diversity values, equitability, and Jaccard similarity values at three sample localities from River Actopan.**

| | La Gloria | Jareros | El Zapotito |
|---|---|---|---|
| Taxa | 3 | 5 | 6 |
| Abundance | 237 | 184 | 17 |
| Shannin diversity | 1.04 | 1.319 | 1.079 |
| J- Equitativity | 0.934 | 0.7479 | 0.4904 |
| Jaccard similarity | **La Gloria vs Jareros** | **La Gloria vs El Zapotito** | **Jareros vs El Zapotito** |
| | 0.00 | 0.00 | 0.1428 |

of El Zapotito and Jareros. Lane and Brown (2007), found in a study made in the Florida Everglades that diatoms of genus *Anomoeoneis*, *Eunotia*, and *Frustulia* are considered a highly sensitive taxon to human perturbation, which is related to this work, because none of this genus were found; while *Gomphonema*, navicular and *Nitzschia*, are considered more tolerant to perturbation and make up the 78% of the tolerant diatom taxa (U.S. EPA, 2002). In this study, these three genera were present in the sampled localities, and are indicators of eutrophication of the aquatic medium.

Mirande and Tracanna (2005), elaborated a study to characterize the water quality according to



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phytoplanktonic group species and their densities, found in 1998 and 1999, selecting five sites according to the discharge zone of domestic and factory effluents, using IDP and they obtained that two sites had an IDP between 0.6 and 1.5, while other sites had values between 0.7 and 2.4, whit tendency to increase in the months of June-October, in these months the water quality was bad, highlighting a water improvement by the end of the sugar harvest and posterior rains, among other factors. Regarding to the study made in Actopan River, the IDP results in the three zones showed values between 1.6 and 2.2, indicating waters with acceptable-bad quality. Mirande and Tracana (2005) mention that the presence of fluctuations of ammonium and phosphate are positively related to high-levels of PDI, this resulting in poor water quality, comparing this to the obtained results it can be said that there is an increase in nitrites and phosphates in the zones of Jareros and El Zapotito.

It is convenient to continue with benthic diatom studies around Actopan River, because it will allow to determine how the water quality fluctuate through the time of the cultivation and harvesting of sugarcane in the area and their effects on water quality, also the changes in the populations of other aquatic organisms that are commercially important for fishermen in the zone.

## BIBLIOGRAPHY

Barrios BE y Puig IA. 2012. ID-Tax. Catálogo y claves de identificación de organismos fitobentónicos utilizados como elementos de calidad en las redes de control del estado ecológico. Ministerio de Agricultura, Alimentación y medio Ambiente. Gobierno de España. 440 p.

Blanco LS, Álvarez BI, Cejudo FC y Bécares ME. 2010. Guía de diatomeas de la Cuenca del Duero. Ministerio de Agricultura, Alimentación y medio Ambiente. Gobierno de España. 206 p.

Environmental Protection Agency. 2002. U.S. Environmental Protection Agency (EPA)Methods for Evaluating Wetland Condition: Using Algae to Assess Environmental Conditions in Wetlands Office of Water, U.S. Environmental Protection Agency, Washington, DC, USA. 42 pp (EPA-822-R-02-021).

Gómez N. 1999. Epipelic diatoms of a high contamined basin from Argentina (Matanza-Riachuelo river): biotic indices and multivariate analysis. Aquatic Ecosystem Health & Management. 2: 301-309.

Gómez N. and Licursi M. 2001. The Pampean Diatom Index (IDP) for assessment of rivers and streams in Argentina. Aquatic Ecology, 5: 173-181.

Lane CR and Brown MT. 2007. Diatoms as indicators of isolated herbaceous wetland condition in Florida USA. Ecological Indicators 7: 521–540.

Licursi M and Gómez N. 2002. Benthic diatoms and some environmental conditions in three lowland streams. Annales Limnology 38 (2): 109–118.

Licursi M y Gómez N. 2003. Aplicación de índices bióticos en la evaluación de la calidad de agua en sistemas lóticos de la llanura pampeana Argentina a partir del empleo de diatomeas. Biología Acuática, 21: 31-49.

Licursi M, Sierra MV y Gómez N. 2006. Diatom assemblages from a turbid coastal plain estuary: Rio de la Plata (South America). Journal of Marine Systems, 62: 35-45.

López-Fuerte FO y Altamirano-Cerecedo MC. 2011a. Diatomeas bentónicas de los oasis de Baja California Sur. Universidad Autónoma de Baja California Sur. Informe final SNIB-CONABIO, proyecto No. HJ032. México, D.F.

López-Fuerte FO y Altamirano-Cerecedo, MC. 2011b. Diatomeas bentónicas de los oasis de Baja California Sur. Universidad Autónoma de Baja California Sur. Informe final SNIB-CONABIO, proyecto No. HJ032. México, D.F

López Fuerte FO y Siqueiros Beltrones DA. 2011. Diatomeas como indicadores de la calidad ecológica de los oasis de Baja California Sur, México. CONABIO. Biodiversitas 99:8-11.

Mac Donagh, Paredes del Puerto JM, Altieri P y Cano MG. 2016. Aplicación de índices bióticos basados en diatomeas epífitas sobre *Schoenoplectus californicus* (C.A. MEY.) SOJÁK, en lagunas pampeanas de Argentina. Biología Acuática. 31: 63-74.

Mathuriau C, Israde I, Herrejón S and Mass M. 2010. Evaluación de la calidad del agua: bioindicadores, capítulo 5.7. En. Cram S, I Israde, M Mendoza, I Sommer, L Galicia (eds). Atlas de la cuenca de lago Cuitzeo: análisis de su geografía y entorno socioambiental, México. Instituto de Geografía/UNAM-Universidad Michoacana de San Nicolás de Hidalgo. pp. 210-213.



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Mirande V y Tracanna BC. 2005. Fitoplancton de un río del noroeste argentino contaminado por efluentes azucareros y cloacales. Bol. Soc. Argent. Bot. 40 (3-4): 169 - 182.

Norma Oficial Mexicana NOM-001-SEMARNAT-1996 Que establece los límites máximos permisibles de contaminantes en las descargas de aguas residuales en aguas y bienes nacionales. Publicada en el Diario Oficial de la Federación el 6 de enero de 1997. http://dof.gob.mx/nota_detalle.php?codigo=4863829&fecha=06/01/1997.

Novelo E. 2003. Bibliografía sobre aguas continentales de México (1974-2002). In Contribuciones ficológicas de México, D. Robledo Ramírez, J. L. Godínez Ortega y Y. Freile-Pelegrín (eds.). Sociedad Ficológica de México, A. C., Mérida. p. 63-88.

Novelo E, y Tavera R. 2011. Un panorama gráfico de las algas de agua dulce de México. Hidrobiológica 21:333-341.

Novelo E, Tavera R y Ibarra C. 2007. Bacillariophyceae from karstic wetlands in Mexico. J. Cramer, Stuttgart. 136 p.

Oliva, MG, Ramírez JG, Garduño G, Cañetas J y Ortega M. 2005. Caracterización diatomológica en tres cuerpos de agua de los humedales de Jilotepec-Ixtlahuaca, Estado de México. Hidrobiológica 15:1-26.

Olivia MG, Godínez OJL y Zuñiga RCA. 2014. Biodiversidad del fitoplancton de aguas continentales en México. Revista Mexicana de Biodiversidad, Supl. 85: S54-S61. DOI: 10.7550/rmb.32706.

Potapova M, y Charles DF. 2007. Diatom metrics for monitoring eutrophication in rivers of the United States. Ecological Indicators 7: 48–70.

Reavie ED, Jicha TM, Angradi TR, Hill BH. 2010. Algal assemblages for large river monitoring: comparison among biovolume, absolute, and relative abundance metrics. Ecological Indicators 10, 167–177.

Rodrigues LM and Lobo EA. 2000. Análise da estrutura de comunidades de diatomáceas epilíticas no arroio Sampaio, município de Mato Leita~o, RS, Brasil. Caderno de pesquisas, Série Botânica Santa Cruz do Sul 12 (2): 5–27.

Round FE. 1991. Diatoms in river water-monitoring studies. Journal Applied Phycology. 3: 129–145.

Salomoni SE, Rocha O, Callegaro VL, Lobo EA. 2006. Epilithic diatoms as indicators of water quality in the Gravataí river, Rio Grande do Sul, Brazil. Hydrobiologia 559: 233–246.DOI 10.1007/s10750-005-9012-3.

Tall L, Cloutier L y Cattaneo A. 2006. Grazerdiatom size relationships in an epiphytic community. Limnology and Oceanography, 51 (2): 1211-1216.

Siqueiros BDA. 2002. Diatomeas bentónicas de la península de Baja California; diversidad y potencial ecológico. cicimar/ipn/uabcs, México.

Velázquez BM, Israde-Alcántara I, Mendoza-Cantú M. 2006. Uso de diatomeas para la evaluación de la calidad del agua del Río Turbio afluente del Río Lerma, México. 12.

Velásquez M. 2007. Uso de diatomeas para la evaluación del agua del río Turbio, afluente del río Lerma, México. Tesis de Maestría en Geociencias y Planificación del Territorio, Instituto de Investigaciones Metalúrgicas, Universidad Michoacana de San Nicolás de Hidalgo.



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