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Diatoms of Xochimilco channels (2008)

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ABSTRACT

Diatoms (Bacillariophyta Division) are microscopic algae of great importance in primary production of aquatic ecosystems, due to their great diversity and abundance they contribute significantly to the production of oxygen and biomass, plus they have been widely used as indicators of water quality. Considering the importance of this group, the aim of this study was to establish their diversity and abundance in the Xochimilco channels. We obtained 12 samples collected at six sampling stations for periods of drought (May) and rainy season (September) of 2008, a van Dorn bottle and a trawl net with mesh size of 54 µm were used for the collection of samples. Species richness was low compared to studies conducted in previous years, recorded 23 species. Nine new records were obtained at the study area: Navicula exigua var. sagnata, Fragilaria fasciculata, Cymbella prostate, Pinnularia abaujensis, Navicula exigua var. capitata, Cymbella aspera, Synedra acus, Tabularia barbatula and Gyrosigma acuminatum. The Shannon diversity index of each station was low (<1) in the two sampling periods. The most frequent and abundant species was Cyclotella meneghiniana Kütz found in all the sampling points and with an average abundance of 1807 cel/mL. A cluster analysis showed very marked similarities between all sampling stations and between the two seasons, indicating a high degree of specific homogeneity at Xochimilco channels.

Keywords: Diatoms, diversity, distribution, abundance, channels.

INTRODUCTION

Diatoms (Bacillariophyta Division) are microscopic algae characterized by the presence of a cell wall or frustule composed of silica, which is divided into an upper part (epitheca) and a bottom (hypotheca) (Lozano *et al*. 2010). They are very important because they are mostly autotrophic, because they transform inorganic substances such as water and mineral salts and the energy of sun light into organic substances like sugars, fats and proteins; this is why they are considered as the base of trophic pyramids in aquatic environments (Anonymous 2004, Oliva *et al*. 2008a), in aquaculture activities have been used as food supplements, in addition to providing environmental services, because they produce oxygen and capture carbon dioxide, among other features. Diatoms may be resistant or sensitive to a variety of environmental conditions, as they can live in contaminated water systems with high concentrations of nitrogen and phosphorus (Anonymous 2004), or disappear in such circumstances, serving as biological indicators.

Currently most water bodies in Mexico have some degree of organic matter pollution (eutrophication), among these are the channels of Xochimilco; despite being used for agricultural activities based on chinampas system of high economic importance, it also provides the bases for species of endemic flora and fauna as they have a large number of national and foreign tourists.

In recent years the Xochimilco channels have received the discharge of wastewater from domestic sewage, from various industries, the chinampas fertilized with chemicals and treatment plants of Cerro de la Estrella and San Luis Tlaxialtemalco (Figueroa *et al.* 2008); therefore the structure and function of this system are being seriously affected, which is reflected in the decrease or disappearance of various local species as well as alterations in the phytoplankton community.

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There have been few studies on diatoms at Xochimilco channels, among these are the Flores (1980) who reported 21 species, Reynoso (1986) seven, Aguayo (1993) two, Santos (2004) 39, Figueroa *et al*. (2008) 56 and Blancas *et al*. com per (2012) 36, with large fluctuations in the composition of species and their abundance, affecting the ecosystem production and associated food chains. For this reason the monitoring was made about the changes in the composition, distribution and the spatial and temporal abundance for the diatom species of the channels of Xochimilco, in times of dry (May) and rainy season (September) 2008.

MATERIAL AND METHODS

Xochimilco is located in the southeast of Mexico, between 19 ° 19 'N and 98 ° 56' W, at an altitude of 2240 msnm (Órgano del Gobierno del Distrito Federal 2008). It has an area of 509 square kilometers (335 hectares), which highlights the existence of 25 hectares of chinampas and 140 kilometers of channels. The mainstreams which drain in this area are San Gregorio Atlapulco, San Lucas Xochimanca, Santiago Tepalcatlalpan and San Buenaventura, which arise mostly in the Sierra Chichinautzin and discharge at Xochimilco Channels (CONAGUA 2010)

For this study 12 samples were checked from the collection of algae which belongs to the Phycology and Phytopharmacology Laboratory, collected in different seasons of the Xochimilco channels (Figure 1), during the dry (May) and rainy season (September) 2008, these samples were collected from the surface of the water column.

The sites that were sampled in both seasons were: Tlilac Lagoon, Vertedero Cerro de la Estrella, San Gregorio Atlapulco, San Luis Tlaxialtemalco, Fernando Celada and Parque Ecologico (Figure 1). The stations Laguna de Tlilac , Fernando Celada and Parque Ecologico correspond to ecotourism areas, San Gregorio Atlapulco, San Luis Tlaxialtemalco are agricultural areas and the Vertedero Cerro de la Estrella is an area where the water from a treatment plant enters.

To collect samples for cells counting a van Dorn bottle was used, the material was deposited into 250 mL vials, to whom was added lugol at 1% final, qualitative analysis was supplemented with drag samples where a phytoplankton net was used with an aperture of 54 μm; these samples were placed in 30 mL vials and were added formalin at 4% final.

For the qualitative study, the review was conducted on subsamples of 0.1 ml of water from each location, based on the Schwöerbel (1975) sweep technique, repetitions were performed until realizing that there weren't new organisms. We used an optical microscope, Zeiss brand, Axiostar model. Quantification was performed twice for each subsample to know the quantity of present organisms, these data was captured in a matrix in the statistical software Excel 2007 charts that were developed to show the frequency and distribution of species by sampling stations and times, it also calculated the Shannon diversity index, using the natural log of pi, according to Begon *et al*. (1987) and a cluster analysis of the species composition per sampling stations and by seasons in the Systat 10.2 software versión was developed.

For each organism observed, photomicrographs were taken with a digital camera Canon Power Shot A2200, which served for identification, using taxonomic keys and descriptions of Ortega (1984); Maidana (1985); Anónimo (2007); Cubas (2008); Figueroa *et al*. (2008); among others.

RESULTS

In this study, a total of 23 species was registred (Table 1, Plate 1) of which nine are new records for the study area: *Navicula exigua* var. *sagnata, Fragilaria fasciculata, Cymbella prostata, Pinnularia abaujensis, Navicula exigua* var. *capitata, Cymbella aspera, Synedra acus, Tabularia barbatula* and *Gyrosigma acuminatum*. It was observed that over 50% of species reported in previous studies, were not observed in this study.

In terms of species richness, it was found that this richness was higher in September than in May, at this time of the year the site with the greatest richness was Laguna de Tlilac with 19, followed by the vertedero Cerro de la Estrella with

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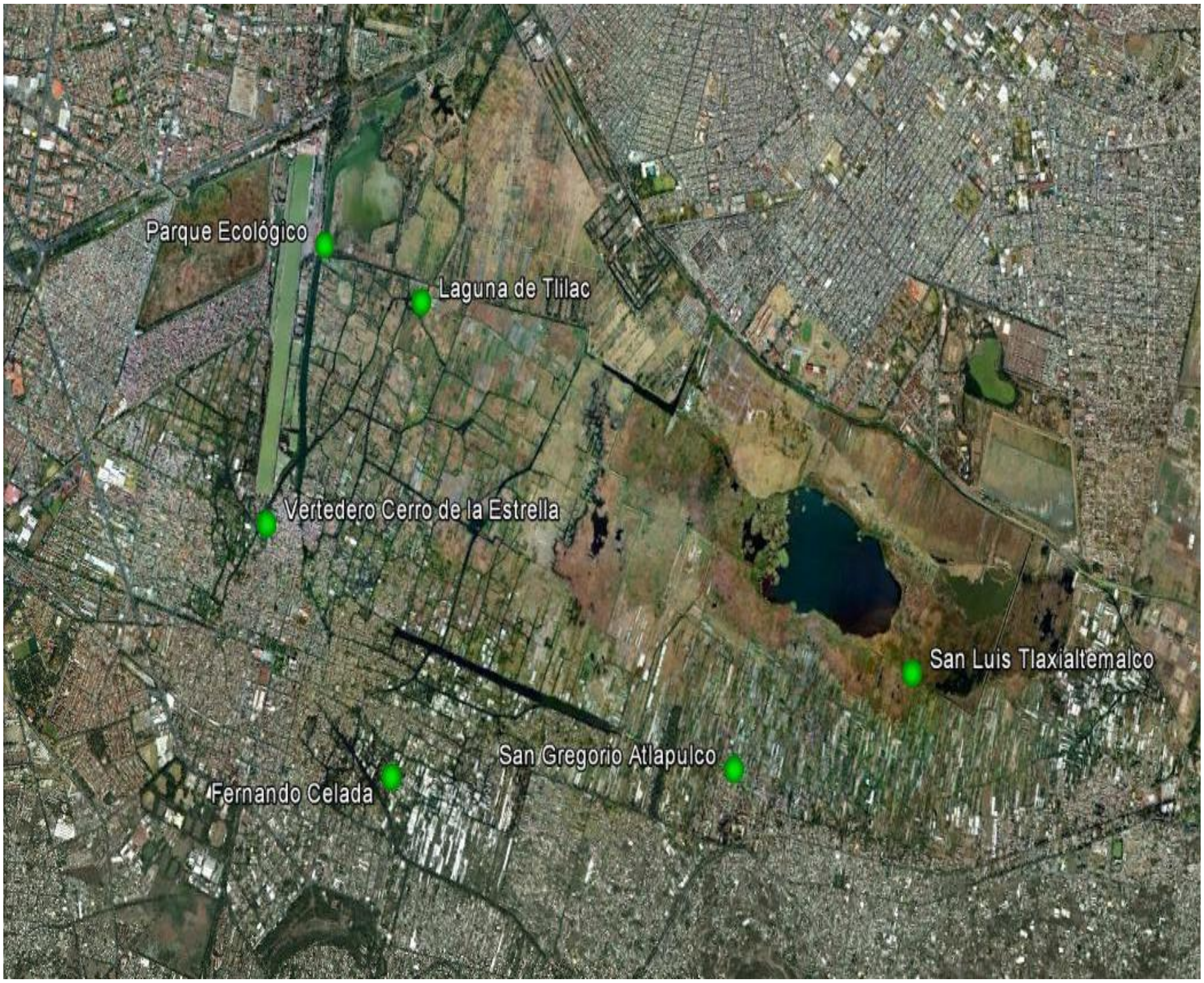

Fig. 1. Study area and sampling stations (Google Earth modified 2012).

17 species, however, the site that had the lowest species richness was San Luis Tlaxialtemalco with just three. In May the sites that had the highest species richness were Vertedero Cerro de la Estrella with 12 and San Gregorio Atlapulco with 10; and the site that had the lowest species richness was the Parque Ecologico with only two species (Fig. 2).

Otherwise, it was observed that the most frequent species were Cyclotella meneghiniana, present in the twelve sampling sites, this means, that in six stations and two seasons (100%), followed by *Cocconeis placentula*, *Navicula exigua* var. *sagnata* and *Fragilaria fasciculata* present in 10 sites (83%) and conversely rare species, which were recorded at a single site were *Cyclotella* sp. *Cocconeis placentula* var. *euglypta, Rhopalodia gibba, Nitzschia amphibia* and *Cymbella affinis* (8.3%) (Figure 3). *Cyclotella meneghiniana* was also the most abundant species with an average of 1807 cel/mL, followed by *Fragilaria fasciculata* with 204 cel/mL and *Aulacoseira granulata* with 109 cel/mL.

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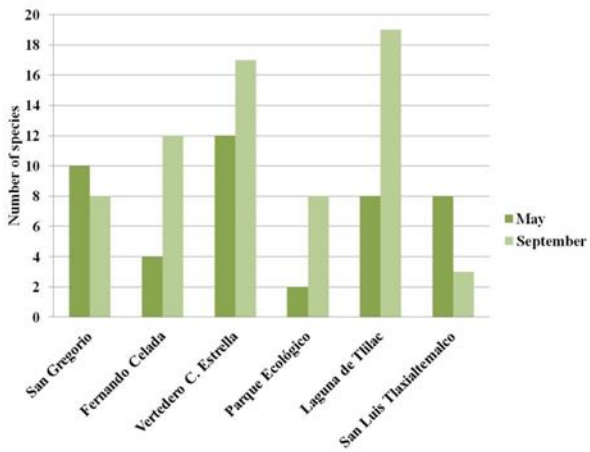

Fig. 2. Species richness at sampling stations in May and September 2008

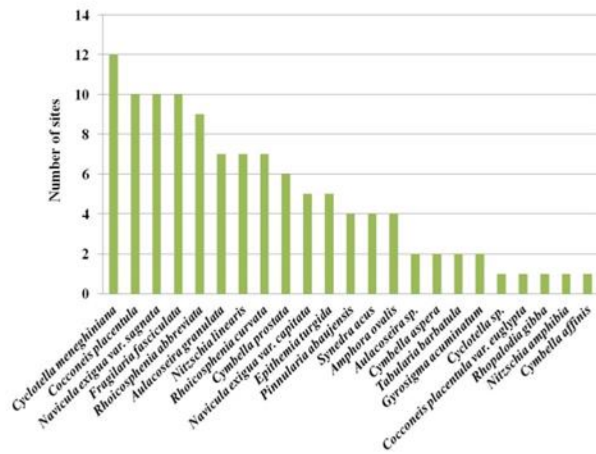

Fig. 3. Frequency of species from Bacillariophyta Division

Fig. 4 shows a group or cluster with records of the different species inside the six sampling stations in both seasons, showing that there is a marked similarity between all sampling stations; calls attention that parquet Ecologico and Fernando Celada stations were grouped together in the rainy and dry seasons, showing no important differences regarding the two seasons. Moreover, it was observed that in the rest of the stations there was no clear distinction between the rainy and dry seasons, by showing no separation of them, in respect to the weather seasons and for being both of this climatic seasons interspersed with each other, this indicates a marked homogeneity between them. The differentiation at Laguna de Tlilac, San Gregorio, Vertedero San Luis Tlaxialtemalco and, for being separated in the rainy and dry seasons, this could be attributed more to small physical changes and chemical water at sampling stations, due to this the care and use given rather than to the seasonal changes.

As species diversity expressed by the Shannon index (Table 2, Fig. 5) showed that in sampling stations both seasons the index was low (<1), this indicates a clear dominance of one species, which in this case was *Cyclotella meneghiniana*, at all sampled stations.

Stations with H values greater than 0.5 were Vertedero Cerro de la Estrella, Fernando Celada,

Parque Ecologico and Laguna de Tlilac at sampling of September, the remaining stations showed lower values. The total Shannon index of September was also higher (0.589) with respect to May (0.374).

DISCUSSION

The diatom species richness was 23 species, similar to that reported by Flores (1980) with 21 species, however its low compared with that reported by Santos (2004) and Figueroa *et al.* (2008), who found 39 and 56 species respectively.

Although species richness was relatively low, nine new species were registered in the study area, which speaks of the need to continue sampling the area, because their knowledge has not been exhausted and the ecosystem is constantly changing.

The most common and abundant species in the majority of the sampled sites was *Cyclotella meneghiniana*, which agrees with that reported by

Blancas *et al. com pers.* (2012 under revision) for the study area in the 2009 and 2010 surveys; where he indicates that temperatures close to 23 ° C and slow flow of water favors their development, coupled with this Tellez and Schillizzi

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(2002), Rivera *et al.* (2003) and Oliva *et al*. (2008b) indicate that the species of *Cyclotella* are cosmopolitan, found in a variety of freshwater environments with different trophic states, this been common in hypertrophic water bodies.

Diversity according to Shannon index was slightly higher in September (0589) than in May (0374) probably because, as Lange *et al.* (2011) indicates, the most important factors affecting diatoms are light and nutrients, and in this study is considered probably that because of rain, the nutrients are being resuspendedly available to phytoplankton and the water temperature is warmer, this favors the development of diatoms. According to the work of Blancas *et al. com pers*. (2012) in a similar study, conducted in 2009 and 2010, there were no significant differences (> 0.05) in the distribution and abundance of diatoms in different sites sampled in the Xochimilco channels.

According to the Shannon index, apparently the stations Vertedero Cerro de la Estrella, Fernando Celada, Parque Ecologico and Laguna de Tlilac in September are cleaner and have better physical and chemical conditions, since there favors greater species richness and a more equitable distribution within the sampling stations unlike most polluted stations that favor the development of few species tolerant and opportunistic. Despite this, there was a remarcable similarity between the stations in the rainy and dry seasons, i.e. there is no clear differentiation in species composition between these seasons.

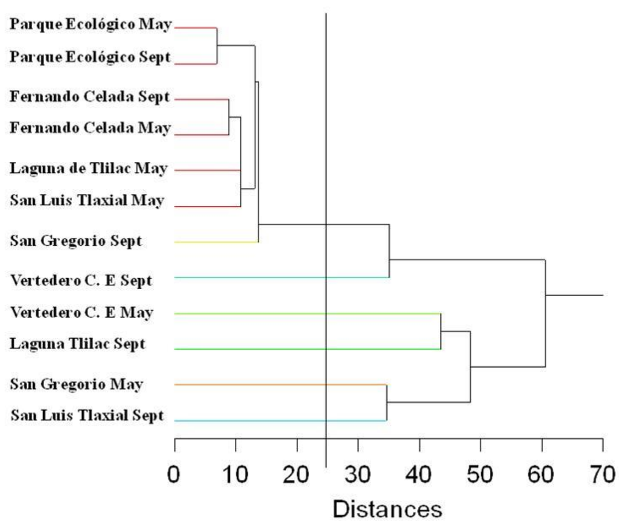

Fig. 4. Cluster analysis of the species composition at various sampling stations.

Table 2. Diversity index (H) of the variety of sampling stations and seasons.

Sampling stations	H	
	May	September
San Gregorio	0.262	0.354
Fernando Celada	0.371	0.755
Vertedero Cerro de la Estrella	0.355	0.883
Parque Ecológico	0.244	0.675
Laguna de Tlilac	0.463	0.604
San Luis Tlaxialtemalco	0.216	0.010
Total	0.374	0.589

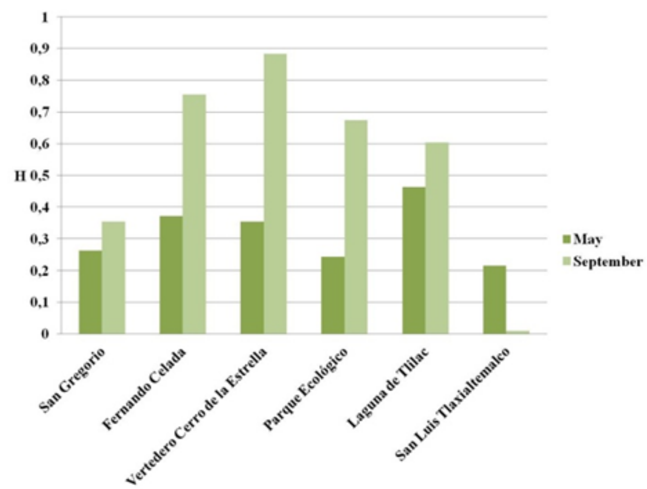

Fig. 5. Sampling stations Shannon index. May and September, 2008.

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Table 1. Richness, frequency and abundance of diatoms species at Xochimilco Channels.

Species	Number of spots where were found	cel/mL Average
1 *Cyclotella meneghiniana* Kützing	12	1870
2 *Cocconeis placentula* Ehrenberg	10	67
3 *Navicula exigua* var. *sagnata* Hustedt*	10	22
4 *Fragilaria fasciculata* (C. Agardh) Lange-Bertalot*	10	204
5 *Rhoicosphenia abbreviata* (C. Agardh) Lange-Bertalot	9	70
6 *Aulacoseira granulata* (Ehrenberg) Simonsen	7	109
7 *Nitzschia linearis* (C. Agardh) W. Smith	7	37
8 *Cymbella aspera* (Ehrenberg) Cleve*	7	57
9 *Cymbella prostata* (Berkeley) Cleve*	6	23
10 *Navicula exigua* var. *capitata* R.M.Patrick*	5	8
11 *Epithemia túrgida* (Ehrenberg) Kützing	5	23
12 *Pinnularia abaujensis* (Pantocsek) R. Ross*	4	9
13 *Synedra acus* Kützing*	4	5
14 *Amphora ovalis* (Kützing) Kützing	4	11
15 *Aulacoseira* sp. Thwaites	2	1
16 *Rhoicosphenia curvata* (Kützing) Grunow	2	3
17 *Tabularia barbatula* (Kützing) D. M. Williams & Round*	2	2
18*Gyrosigma acuminatum* (Kützing) Rabenhorst*	2	2
19 *Cyclotella* sp. (Kützing) Brébisson	1	3
20 *Cocconeis placentula* var. *euglypta* (Ehrenberg) Cleve	1	25
21 *Rhopalodia gibba* (Ehrenberg) Otto Müller	1	4
22 *Nitzschia amphibia* Grunow	1	9
23 *Cymbella affinis* Kützing	1	4

* New records for the study area

CONCLUSIONS

Species richness was low (23 species), compared with results obtained by other authors for the study area, in other seasons.

Nine new records were obtained for the study area: *Navicula exigua* var. *sagnata*, *Fragilaria fasciculata*, *Cymbella prostata*, *Pinnularia abaujensis*, *Navicula exigua* var. *capitata*, *Cymbella aspera*, *Synedra acus*, *Tabularia barbatula* and *Gyrosigma acuminatum.*

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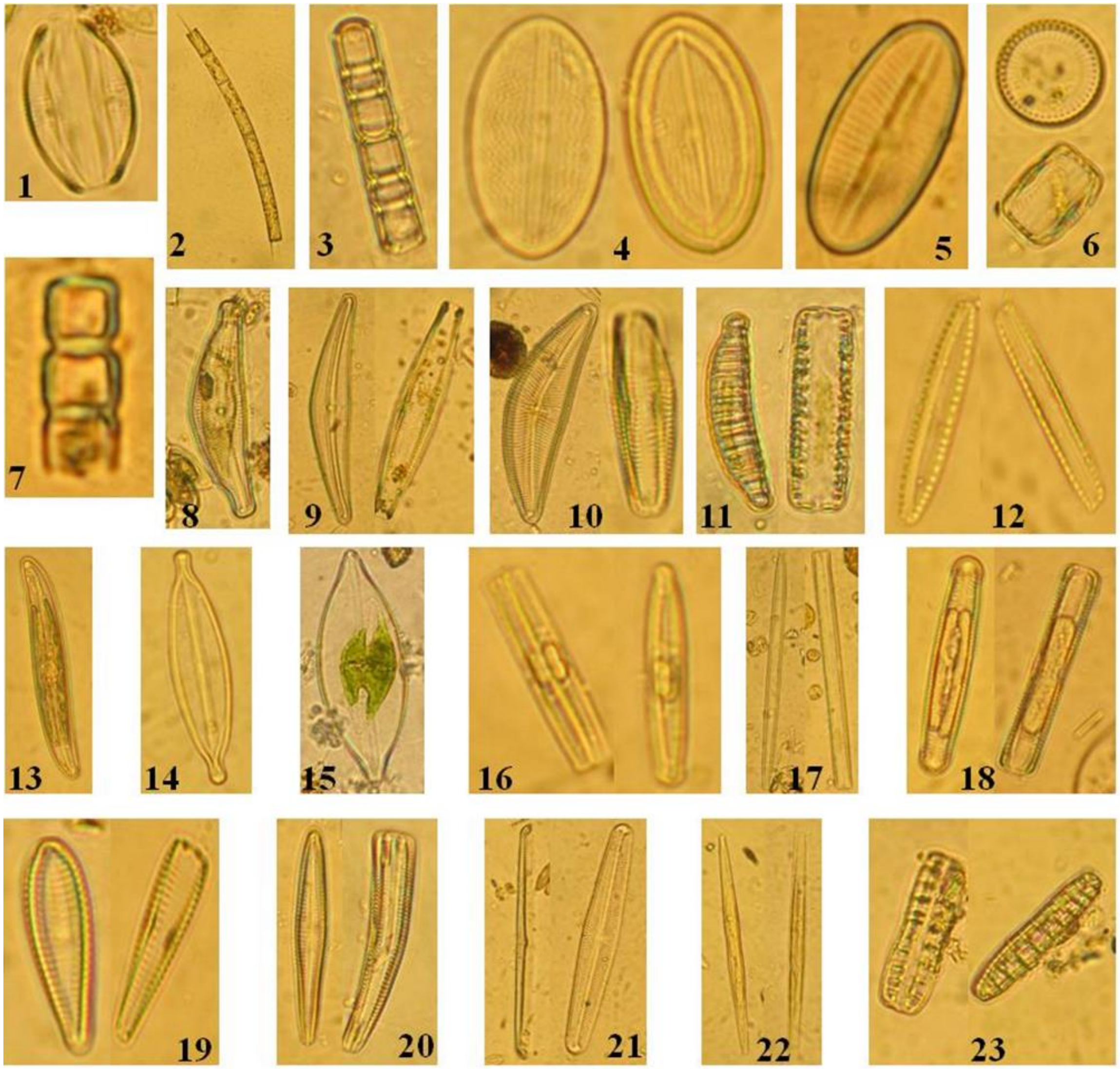

Lámina 1. Figuras 1. *Amphora ovalis, 2. Aulacoseira granulata, 3. Aulacoseira* sp.*, 4. Cocconeis placentula, 5. Cocconeis placentula* var. *euglypta, 6. Cyclotella meneghiniana, 7. Cyclotella* sp.*, 8. Cymbella affinis, 9. Cymbella aspera, 10. Cymbella prostata, 11. Epithemia turgida, 12. Fragilaria fasciculata, 13. Gyrosigma acuminatum, 14. Navicula exigua* var. *capitata, 15. Navicula exigua* var. *sagnata, 16. Nitzschia amphibia, 17. Nitzschia linearis, 18. Pinnularia abaujensis, 19. Rhoicosphenia abbreviata, 20. Rhoicosphenia curvata, 21. Rhopalodia gibba, 22. Synedra acus, 23. Tabularia barbatula.*

In Mexico are few ficofloristic studies that illustrate the species, so it is considered that this work is a useful tool for species recognition.

The most common and abundant species in all stations and seasons was *Cyclotella meneghiniana*.

The highest species richness was presented in September (rainy season), with 19 species and May

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(dry season), there were 12 species, but according to the cluster analysis showed no significant differences in respect of the two seasons, these differences were likely to the use given by the locals to the sampled sites, affecting water quality and not the seasonal changes.

The diversity, according to the Shannon index was slightly higher in September (0589) than in May (0374) in the stations Vertedero Cerro de la Estrella, Fernando Celada, Parque Ecologico and Laguna de Tlilac, carrying these, favorable conditions for the development of diatoms.

Virtually all sampled sites share several species, because the characteristics of the water within the channels are more or less homogeneous and are classified as eutrophic.

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