Scientific Research

Knowledge to Ecological Preferences in a Tropical Epiphytic Algae to Use with Eutrophication Indicators

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ABSTRACT

In Ayapel floodplain periphyton associated to macrophyte roots on the basis of material was collected in fourteen sampling sites in nine moments of compilation. From the analysis of the samples were recorded 550 algal species, of which 56% were diatoms. Furthermore it was valued relative abundances of taxa and the average physicochemical variables to identify the optimal values and tolerance ranges of species. In the case of nitrates optimal value was below 2 mg/L for all algae except for *Actinella* sp. and *Euastrum sinuosum* which optimal values were close to zero with low variability. Regarding all species the algal nitrite concentration showed optimum values below 2 mg/L except *Encyonema minutum* and *E. sinuosum* whose optimum were 0.4 and 0.5 mg/L respectively. About nitrogen as ammonia was repeated the above situation, *i.e.* optimum values below 2 mg/L except for *E. minutum* and *E. sinuosum*. Respect to phosphorus the species with optimum greater than 0.6 mg/L are the diatoms, in contrast, the lowest values were optimal for *E. sinuosum* and *Actinella* sp. From the viewpoint of bioindication high abundance of *Synedra goulardii* indicates high transparency, *Ulnaria ulna and Planothidium lanceolatum* indicate lower concentration of dissolved oxygen and water temperature between 29°C - 30°C, *Actinella* aff. *robusta*, *E. minutum*, *Cylindrospermopsis raciborski*, *Lyngbya* cf. *limnetica*, *Eunotia naegueli*, *Navicula cryptocephala*, *Diadesmis confervaceae*, *Frustulia rhomboides* and *Aulacoseira granulata*. Indicating low electrical conductivity (<100 µS/cm), *Synedra goulardii* indicating neutral waters, *Actinella eunotioides* and *Euastrum sinuosum* indicate low nitrate concentration (<0.2 mg/L), *Eunotia minor* indicating midrange nitrite concentration (0.2 - 0.5 mg/L), *Ulnaria ulna*, *Planothidium lanceolatum* indicating low ammoniacal nitrogen concentration (<0.2 mg/L) and *Actinella eunotioides* indicating low soluble reactive phosphorus concentration (<0.2 mg/L).

1. Introduction

The abundance of species among other factors is determined by their rate of growth, and depends on the environmental conditions. The success of species in reproductive terms will be in relation to optimal values of a set of environmental variables for that species and their range of tolerance [1].

To determine the species responses to the set of variables specific to their environment, we can explore its distribution through direct multivariate analysis, such as the redundancy analysis and canonical correspondence analysis [2]. In this way information is obtained from species responses to multivariate environmental gradients. To identify the ecological preferences of the species with respect to an environmental variable in particular its op-

timum based on its position in this gradient, as well as their tolerance to variations can be estimated. It is important to define accurately the autoecological characteristics of the species for use in bioindication [1].

In Colombia barely begins to explore this research line, which starts from the recent work of Bogotá wetlands [3] who concluded that the assessment of ecosystems through the species of diatoms is the most successful to achieve a discrimination in the limnological state of these bodies of water, in contrast to the saprobien indexes and the diatom generic indexes. This researcher developed a diatoms biotic index to assess the state of Bogota wetlands (IDHB), established that wetlands covered by the study have wide range of conditions from lightly polluted to severely polluted and it showed also that these conditions were sus-

ceptible to changes in time. Correlations between the IDHB and the physical variables and chemical pollution presented values of high significance.

Water eutrophication has become a worldwide environmental problem in recent years, and understanding the mechanisms of water eutrophication will help for prevention and remediation of water eutrophication [4]. Algae is one the most important component studies in eutrophication evaluation, so it is necessary to know its potential indicator in relationship with water conditions. Algae in special diatoms are frequently used as indicators of eutrophication in temperate systems [5], but little is known about their application to impacted South American tropical systems. The idea of this work is to build a record of environmental conditions in which the algae are in an optimum level in tropical natural conditions and in the future, be able to have a large picture of the environmental requirements of the microalgae and identify which algae are the best indicators of environmental conditions in a tropical flood plain.

2. Material and Methods

2.1. Study Area

In Ayapel flood plain system, between May 2006 and January 2009 nine sampling campaigns were carried out, which include three hydrological cycles of the system at different times of the flood pulse. Information has been published on environmental and physicochemical variables [6], taxonomical report [7,8], social appropriation of science [9-11] and dynamic of periphytic algae assemblage associated with macrophytes prevailing in each of the 14 stations of monitoring [12,13].

2.2. Calculated Index

From the distribution matrix to epiphytic algae in different substrates, identified the species that presented more than 1% relative abundance and there were presented in 30% of the evaluated samples. To estimates of optimal values of environmental variables for each species (uk) using weighted averages were calculated an average of the values of the environmental variable for all of the sites where the species was found weighted with their relative abundance, using the following formula [1,14-16].

$$uk = \sum_n yik \cdot xi \Big/ \sum_n yik$$

yik: abundance of k species on the i site.
xi: value of the environmental variable in the i site.

The tolerance of the species or weighted standard deviation (tk) was calculated according to [15].

$$tk = \sum_{i=1}^{n} yik \cdot \left(xi - uk\right)^2 \Big/ \sum_{i=1}^{n} yik$$

3. Results

The maximum and minimum values for each studied physical chemistry variable (**Table 1**) were determined. A high variability due to the effect of the flood pulse and spatial gradients in Ayapel flood plain system were identified.

555 morphospecies were identified. Diatoms and desmidias were the dominant groups in terms of species richness and abundance. In the first group there were 56 genera and 252 species, of which 13 genera and 103 species are new taxa to Colombia. They correspond to the 50.8% total diatoms identified in this country. On the second group of desmidias, 107 species in 17 genera were found. Several new species to science were found too, which are in the process of description to be published.

Table 2 presents the list of species selected from among the 555 registered in samples, as the most important ecological system.

Figures 1(a)-(m) show the optimal and tolerance of selected species. The species are organized from lowest to highest value of the evaluated parameter, are represented in order to reveal differences in the optimal values of these.

Depending on the level of the flood pulse most of the algae present optimal values under 3 m of the water column and some diatoms (*Eunotia flexuosa*, *Eunotia naegueli*, *Actinella* aff. *robusta*, *Diadesmis confervaceae*, *Planothidium lanceolatum*, *Ulnaria ulna*), *Oedogonium*

Table 1. Environmental variables range.

Variable	Minimum value	Maximum value	Range
Total depth (m)	0.41	6.7	6.29
Secchi transparency (m)	0.08	1.7	1.62
Water temperature (°C)	28.2	35.6	7.4
Dissolved oxygen (mg/L)	0.4	10.6	10.2
pH (pH units)	5.3	7.73	2.43
Electrical conductivity (μS/cm)	12.1	261	248.9
Total suspended solids (mg/L)	1	76	75
Dissolved solids (mg/L)	23	538	515
Nitrate (mg/L)	0	5	5
Nitrite (mg/L)	0	2.1	2.1
Ammoniacal nitrogen (mg/L)	0	0.42	0.42
Soluble reactive phosphorus (mg/L)	0.03	2.8	2.77
Sulfates (mg/L)	0.121	38	37.879
Saturation oxygen (%)	4.73	143	138.27

Table 2. List of species selected as the most important ecological system.

Acronym	Species
	Cyanobacteria
CYRA	*Cylindrospermopsis raciborski* (Woloszynska) Seenayya & Subba Raj
LYSP	*Lyngbya* cf. *limnetica* Lemmermann
OSSP	*Oscillatoria* sp
	Streptophyta
EUSI	*Euastrum sinuosum* Lenormand ex W. Archer
	Chlorophyta
OESP	*Oedogonium* sp
	Bacilariophyta
ACLA	*Actinella* aff. *robusta* Hustedt
ACSP	*Actinella eunotioides* Hustedt
AUGR	*Aulacoseira granulata* (Ehrenberg) Simonsen
AGAN	*Aulacoseira granulata* var *angustissisima* (O. Müller) Simonsen
DICO	*Diadesmis confervaceae* Kützing
ENJE	*Encyonema jemtlandicum* Krammer
ENMI	*Encyonema minutum* (Hilse in Rabernhorst) D. G. Mann
EUFL	*Eunotia flexuosa* (Brebisson) Kützing
EUMI	*Eunotia minor* (Kützing) Grunow in Van Heurck
EUNA	*Eunotia naegueli* Migula
FRCA	*Fragilaria capucina* Desmazieres
FRFA	*Synedra rumpens* var. *familiaris* (Kützing) Hustedt
FRKR	*Frustulia rhomboides* (Ehrenberg) De Toni
GOPA	*Gomphonema parvulum* (Kützing) Kützing
NACR	*Navicula cryptocephala* Kützing
PLLA	*Planothidium lanceolatum* (Brébisson ex Kützing) Lange-Bertalot
SYGO	*Synedra goulardii* Brébisson
ULUL	*Ulnaria ulna* (Nitzsch) P. Compère

sp. and *Lymbia* sp. recorded optimal values at greater depths (**Figure 1(a)**).

The algae are adapted to low transparency levels (**Figure 1(b)**) since all have optimal below 1 m of transparency. According to the water temperature, the optimal values are above 29˚C and in the case of the cyanobateria *Oscillatoria* and *Lymbia* and diatom *Actinella eunotioides* reach optimal value round to 32˚C (**Figure 1(c)**).

All algae have optimal values less than 6 mg·L^{-1} of

dissolved oxygen (**Figure 1 (d)**) and subsaturate oxygen percentages, with values lower than 40% for most of the algae, between 40% and 60% for *Synedra rumpens* var. *familiaris*, *Navicula cryptocephala*, *Actinella eunotioides*, *Aulacoseira granulata* var. *angustissisima* and 80% in the case of *Synedra goulardii* (**Figure 1(e)**).

Electrical conductivity algae are grouped into two levels according to their optimal value (**Figure 1(f)**), most have optimal below 100 µS/cm and *Euastrum sinuosum*, *S. goulardii*, *Planothidium lanceolatum* and *Ulnaria ulna* exhibit optimal values above 100 µS/cm. Total suspended solids (**Figure 1(g)**) show all algae have optimal less than 20 mg·L^{-1}. The optimal values for total dissolved solids are lower than the 100 mg·L^{-1} (**Figure 1(h)**).

With respect to the pH (**Figure 1(i)**), with the exception of *P. lanceolatum* and *Oscillatoria* sp. which feature optimal values less than pH 6, the rest of the algae present optimal circumneutral (pH between 6 and 7). Although *U. ulna* presents a wide tolerance to variations in pH.
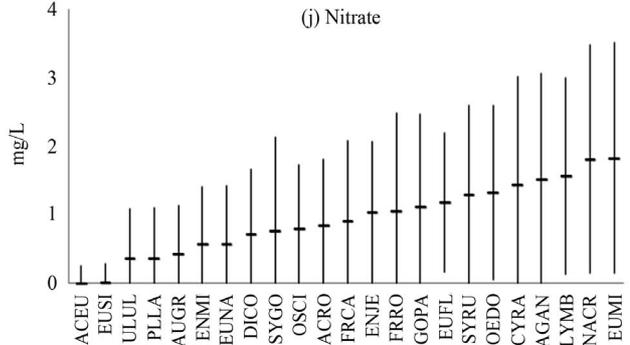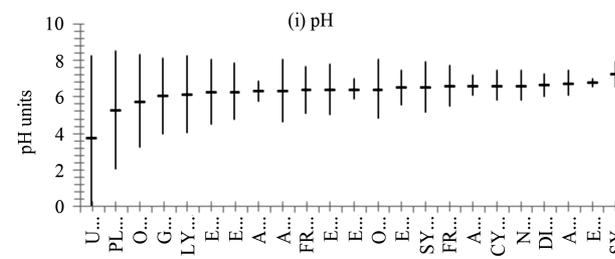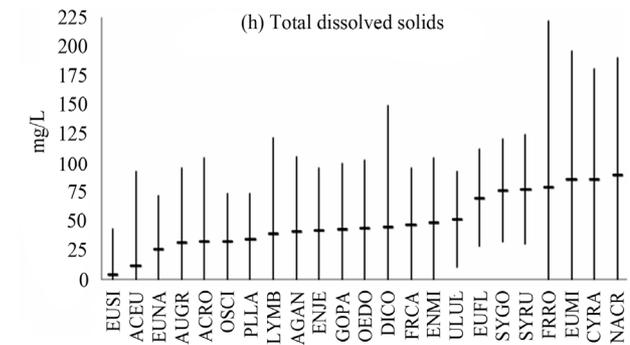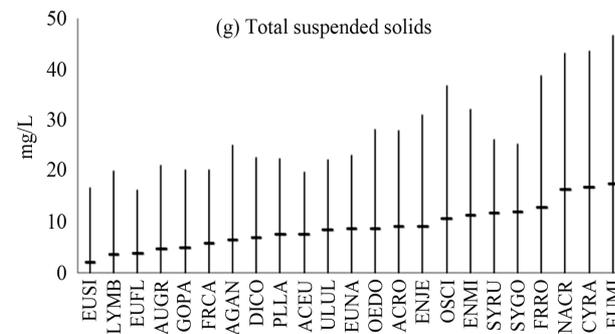
About wih nutrients concentrations, in the case of nitrate its optimal value was below the 2 mg·L^{-1} for all algae, although it must be emphasized that *Actinella* aff. *robusta* and *E. sinuosum* prese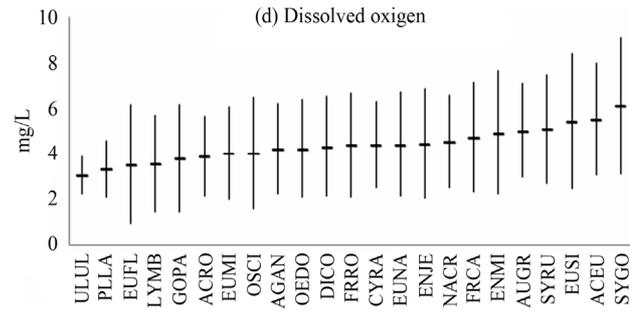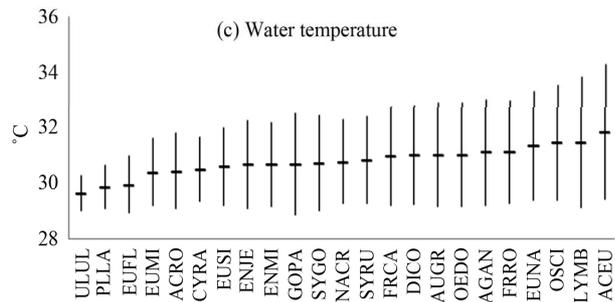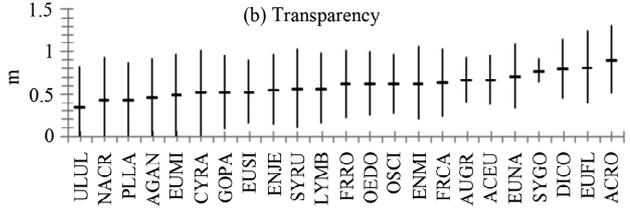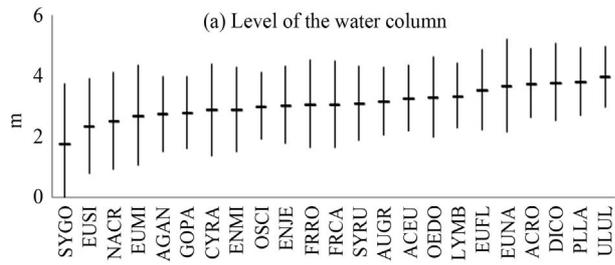nt optimal values close to zero and low variability (**Figure 1(j)**). With respect to the nitrite concentration all algae have optimum values below 2 mg·L^{-1} (**Figure 1(k)**) except *Encyonema minutum* and *E. sinuosum* which have optimal values of 0.4 and 0.5 mg·L^{-1} respectively. In the case of ammoniacal nitrogen, repeats it the previous situation, *i.e.*, optimal values below 2 mg·L^{-1} except *E. minutum* and *E. sinuosum* (**Figure 1(l)**). In the case of the SRP species that were on the right side of the gradient are diatoms which present an optimal value exceeding 0.6 mg·L^{-1}, in contrast, with lower optimal values *Actinella* aff. *robusta* and *E. sinuosum* (**Figure 1(m)**).

Finally, the sulphate optimum concentration for algae was around 2 mg·L^{-1} and only some diatoms most (*Fragilaria capucina*, *Synedra rumpens* var. *familiaris*, *Eunotia flexuosa*) and the cyanobateria *Lyngbia* reach optimal near the 4 mg·L^{-1} (**Figure 1(n)**).

Differential responses among the desmidias and diatoms were not found when selected at the level group, because differences the optimal values correspond to the nature of each species. Algae that showed conditions restricted for distribution can be considered candidates to be used as bioindicator of the ecological quality of water (**Table 3**).

4. Discussion

The ecological preferences of algae periphytic studied, in relation to the water level, predominantly optimal values were closed to the surface of the water, which may be
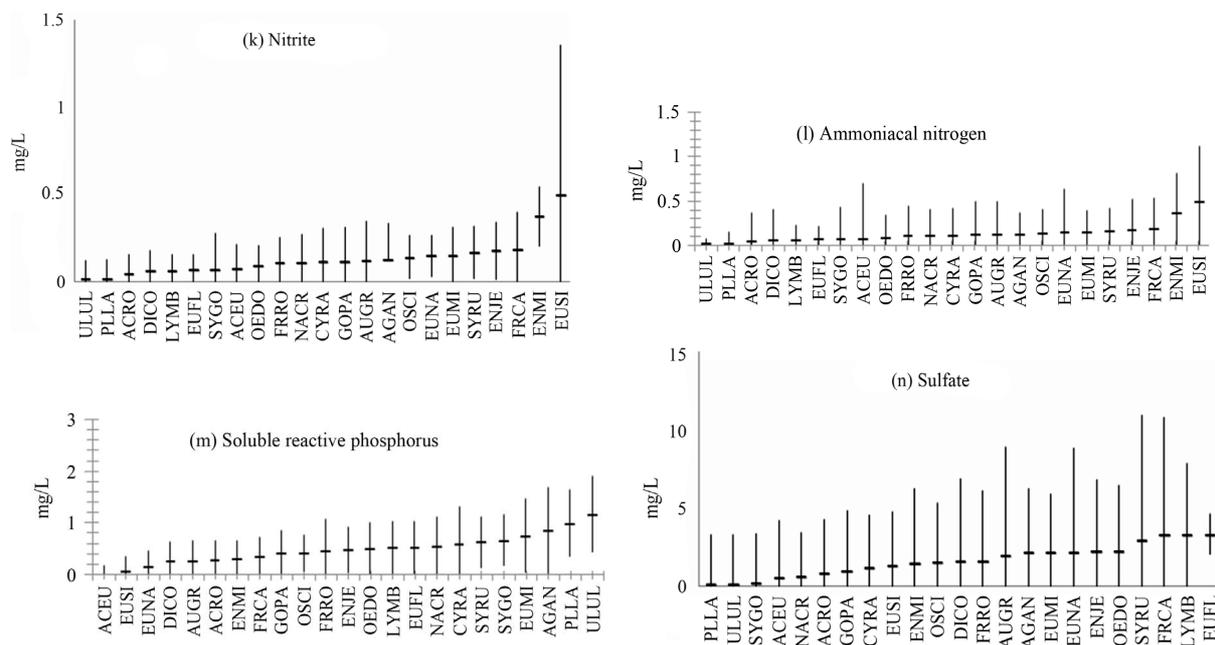
(a) Level of the water column

(b) Transparency

(c) Water temperature

(d) Dissolved oxigen

(e) Saturation oxygen

(f) Electrical conductivity

(g) Total suspended solids

(h) Total dissolved solids

(i) pH

(j) Nitrate
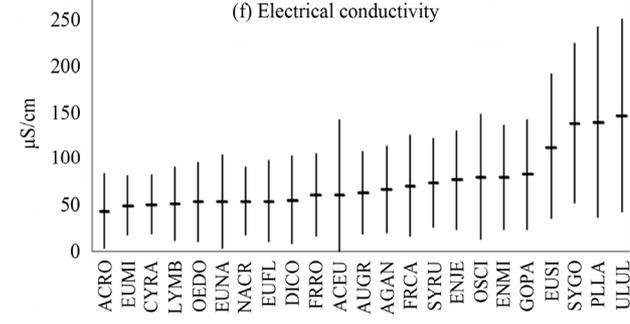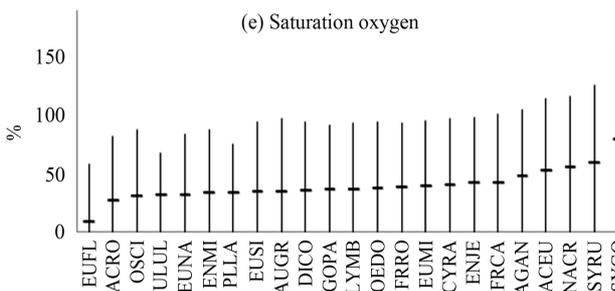
Figure 1. Physicochemical optimal and tolerance of selectionated species.

Table 3. Species indicators of water conditions in Ayapel flood plains system.

Water feature	Taxones
High transparency (0.7 - 0.9 m)	*Synedra goulardii.*
Low water temperature (29˚C - 30˚C)	*Ulnaria ulna, Planothidium lanceolatum.*
Low dissolved oxygen (2.2 - 4)	*Ulnaria ulna, Planothidium lanceolatum.*
Low electrical conductivity (<100 µS/cm)	*Actinella* aff. *robusta, Encyonema minutum, Cylindrospermopsis raciborski, Lyngbya* cf. *limnetica, Oedogonium* sp, *Eunotia naegueli, Navicula cryptocephala, Diadesmis confervaceae, Frustulia rhomboides, Aulacoseira granulata.*
Low total suspended solids (<25 mg/L)	*Euastrum sinuosum, Lyngbya* cf. *limnetica, Eunotia flexuosa, Aulacoseira granulata, Gomphonema parvulum, Fragilaria capucina, Aulacoseira granulata* var *angustissisima, Diadesmis confervaceae, Planothidium lanceolatum, Actinella* aff. *robusta, Ulnaria ulna, Eunotia naegueli, Synedra rumpens* var *familiaris, Synedra goulardii.*
Low total dissolved solids (<50 mg/L)	*Euastrum sinuosum.*
Midrange total dissolved solids (30 - 120 mg/L)	*Eunotia flexuosa, Synedra goulardii, Synedra rumpens* var *familiaris.*
Slightly acid water (pH = 6)	*Actinella eunotioides, Euastrum sinuosum, Eunotia naegueli, Actinella* aff. *robusta, Cylindrospermopsis raciborski, Navicula cryptocephala, Diadesmis confervaceae, Aulacoseira granulata, Eunotia flexuosa.*
Neutral waters (pH = 7)	*Synedra goulardii.*
Low nitrate concentration (<0.2 mg/L)	*Actinella eunotioides, Euastrum sinuosum.*
Low nitrite concentration (<0.2 mg/L)	*Ulnaria ulna, Planothidium lanceolatum, Actinella* aff. *robusta, Diadesmis confervaceae, Lyngbya* cf. *limnetica, Eunotia flexuosa, Synedra goulardii, Actinella eunotioides, Oedogonium* sp.
Midrange nitrite concentration (0.2 - 0.5 mg/L)	*Eunotia minor.*
Low ammoniacal nitrogen concentration (<0.2 mg/L)	*Ulnaria ulna, Planothidium lanceolatum.*
Low soluble reactive phosphorus concentration (<0.2 mg/L)	*Actinella eunotioides.*
Low sulfate concentration (<12 mg/L)	*Cylindrospermopsis raciborski, Lyngbya* cf. *limnetica, Oscillatoria* sp, *Euastrum sinuosum, Oedogonium* sp, *Actinella* aff. *robusta, Actinella eunotioides, Aulacoseira granulata, Aulacoseira granulata* var *angustissisima, Diadesmis confervaceae, Encyonema jemtlandicum, Encyonema minutum, Eunotia flexuosa, Eunotia minor, Eunotia naegueli, Fragilaria capucina, Synedra rumpens* var *familiaris, Frustulia rhomboides, Gomphonema parvulum, Navicula cryptocephala, Planothidium lanceolatum, Synedra goulardii, Ulnaria ulna.*

related with the fact of these live organisms in the upper part of the photic zone [17] found in this system that the phytoplankton assemblage responded to the temporal variation of flood pulse and during the dry season, the water level reduction, promoted the generation of spatial gradients, this response was mainly reflected by the temporary changes in the biovolume because in terms of composition the most important taxa are temporarily stable.

Two morphologically related species were found (*Synedra goulardii* and *Ulnaria ulna*) which present optimal values opposed to transparency, the level of water, the concentration of oxygen and saturation, so that it can be inferred that taxonomic errors can lead to erroneous environmental interpretations. In addition this specific variability is according to the genera and the evaluated variable differential.

[18] reported to *Synedra goulardii* as inhabitant of oligotrophic environments and indicator of low transparency, what was also evident in this research. Investigators recorded in an Ecuadorian lagoon of flood plain as dominant species in some sampling stations (located in a river that passes near several villages), in which reached up to the 70% of taxa abundance [19].

Ulnaria ulna is considered mesosaprobic [20] and estuarine [18], although this condition does not arise in this study, since evidenced an optimal pattern stenothermic, which can be favored by high temperatures in the area throughout the year.

Planothidium lanceolatum presented the lower pH optimum value, in the literature this species is recorded as of wide variability from the point of view of the pH (acidophilus, neutrophil, alkalophilic), trophic index (oligotrophic, mesotrophic, and eutrophic) and is found in high concentrations of dissolved oxygen [18]. This condition does not arise in Ayapel system, oxygen concentrations are low, undersaturated and these species presented an optimal 3.3 mg/L with less than 40% oxygen saturation, allowing further ecological information on this species. [18] presented to *U. ulna* and *P. lanceolatum* as inhabitants of systems with high ionic charges.

The genus *Actinella* has tropical distribution and in South America has been carried out the largest number of descriptions of the same, with 12 species [21], most of which are found in acidic waters [22]. A few environmental information is known about this genera, so it is highlighted to if two species are found (*Actinella* aff. *robusta* and *Actinella eunotioides*), which are optimal at pH slightly acid, high levels of the column of water, high transparency, warm temperature and subsaturate dissolved oxygen between 30% and 60%, conductivities of less than 60 µS/cm, low concentrations of SST and STD, low content nutrient environments, so it could be these species as indicators to oligotrophic conditions.

A. aff. *robusta* is influenced negatively by the water temperature, conductivity, NH_4, nitrites, dissolved oxygen concentration and positively by the water level and associated with the presence of *Diadesmis confervaceae* ($p < 0.005$). This specie presented less optimal conductivity. *A. eunotioides* presented an optimum value growth in waters little mineralized, oligotrophic and slightly acidic, with a pH equal to 6 and less than 0.2 mg/L nutrient concentrations.

Cylindrospermopsis raciborskii is a species of planktonic type, however frequently found within the periphytic material, so it was considered in the study. In this research *C. raciborskii* presented best conditions in low level of the column of water, low transparency, high water temperature, intermediate concentrations of dissolved oxygen with low saturation (40%), neutral pH, medium solids concentrations and intermediate nutrients level. [23] founded that environmental variables determinants of *C. raciborskii* and *Lyngbya* cf. *limnetica* were the level of water, the transparency, the concentration of nutrients and solids.

Oedogonium sp. showed optimum conductivity lower than 100 µS/cm, like most in diatoms, except *Synedragoulardii*, *Planothidium lanceolatum*, *Ulnaria ulna* and *Euastrum sinuosum* (chlorophycea). *Oedogonium* sp. presented intermediate optimal values for all of the variables evaluated, what may be the result of the association of the information of several species, which have not been identified yet due of the absence of reproductive structures and specialized keys. *Lyngbya* cf. *limnetica* presented a condition similar to *Oedogonium* sp., although it presented some optimal values with trend to the left of the figures (low values) as the concentration of OD, oxygen saturation, electrical conductivity, ammonia and nitrites level.

Oscillatoria sp. evidenced intermediate optimal values, however, there is evidence to low oxygen saturation, high water temperature, slightly acid pH and low concentrations of total dissolved solids.

The diatoms were dominated by pennate form and were selected only two central, *Aulacoseira granulata* and *A. granulate* var. *angustissisima*. Both taxa are much related, so the optimal values are very similar. They present an optimal water level of 3 m, a water temperature of 31°C, oxygen concentrations between 4 and 5 mg/L, saturations below 50%, slightly acidic pH, electrical conductivity of 60 µS/cm, with low concentrations of SST and STD, concentrations of 0.15 mg/L of nitrites and ammonia nitrogen. Among the differences of the optimal values for these two species, the transparency was identified; already *A. granulata* exhibits one optimum value greater than *A. granulate* var. *angustissisima* and the concentration of nitrates, which the previous trend is reversed. Both species are considered as α mesosaprobic

and *ß* mesosaprobic indicators and environments ranging from oligotrophic to eutrophic environments with low luminosity [18]. *A. granulata* var. *angustissisima* was related to ammoniacal nitrogen and *A. granulata* was related to *Cylindrospermopsis raciborskii*.

Euastrum sinuosum required high nitrogen concentration, especially as ammonia and nitrite, while it presents an optimum value to low concentrations of FSR. This species presented extremely optimal values of the variables frequently, what can impinge on his ability as a bioindicator, since it may be more sensitive to environmental variations. *E sinuosum* were optimal in surface water, with low transparency, intermediate oxygen concentration, pH circunneutral, high conductivity (50 to 200 μS/cm) and low concentration of SST and STD. This species increases its abundance in high waters [24] and inhabits swamp systems with hotter than 29°C in mesotrophic environments [25].

Gomphonema parvulum is considered very tolerant to organic pollution in Europe, however, studies in Brazil revealed that indicator of water moderately polluted (*ß* mesosaprobic) [20]. In Colombia it has been reported in the Tarapoto lake, Resaca lake, Yahuarcaca III lake (Amazon), Medellin river, Peñol dam (Antioquia); Bogotá river (Cundinamarca); Páramo of Santurbán (Norte de Santander); Paticos swamp (Córdoba), Tota river (Boyacá); Guarino swamp (Magdalena). In the system of flood plains of Ayapel the optimal values for *G. parvulum* was intermediates for all variables studied, results that are consistent with the values obtained in Brazil.

Navicula cryptocephala presented low optimal values for the water level (2.8 m), transparency (0.42 m), electrical conductivity (50 μS/cm), nitrite (0.1 mg/L), ammoniacal nitrogen (0.1 mg/L), sulphates (0.7 mg/L); intermediate values for the temperature of the water (30.8°C), the concentration of OD (4.5 mg/L) with a saturation of the 60%, circumneutral pH, PSR concentration (0.5 mg/L), and high optimal values than other algae for SST (18 mg/L), TDS (90 mg/L) and nitrates (1.8 mg/L). Literature records pH circunneutral, to withstand desiccation, eurithermic, *α-ß* mesosaprobic [18].

Of the genus *Eunotia* three species were selected: *Eunotia minor*, *Eunotia flexuosa* and *Eunotia naegueli* which are considered as periphytic and acidophilic in the literature [22]. Samples of this genera presented greater abundance with 45 species and was widely identified in spatial gradient of the system according to the slightly acidic pH conditions presented.

Eunotia minor presented optimal in shallow waters of low transparency, temperature of 30.5°C, oxygen concentration and intermediate saturation, pH of 6.3, conductivity of 50 μS/cm, intermediate optimal value of nitrite, nitrate and PSR, high solids concentrations with respect to other algae (15 SST mg/L) and 90 mg/L of STD and

the higher value of nitrates (1.75 mg/L). *E minor* moves away from the values of the other two species of the genus and reaches higher abundances.

Eunotia flexuosa is recorded in the literature as indicator of oligotrophic environments, acidic pH to neutral and may indicate presence of iron [18]. This research found that their optimal values indicate a column of deep water, greater transparency with respect to other algae (Zsd 0.8 m), temperature of the water around 30°C, intermediate concentrations of OD with low saturation percentage (10%), pH 6.8, low conductivities (less than 50 μS/cm), low concentrations of TSS, STD with an optimum value of 73 mg/L, with regard to nutrients presents intermediate optimal values of nitrates (1.1 mg/L) and PSR (0.55 mg/L), low concentrations of nitrite (0.08 mg/L) and ammoniacal nitrogen (0.06 mg/L) and the highest concentrations of sulphates (3.6 mg/L).

Eunotia naegueli prefers low deep environments with transparency lower, eurithermic, intermediate values of oxygen saturation percentage, slightly acidic pH, low conductivity, concentrations of SST and STD, nitrates, nitrites and PSR and intermediate levels of ammoniacal nitrogen and sulphates. Founded in acidic and oligotrophic environments [18].

Frustulia rhomboides has been registered as an inhabitant of waters of pH circunneutral, oligotrophic to dystrophic [18]. The information obtained in this research allows to slightly expand in the environmental conditions of distribution of the species. Presented optimal in waters with an intermediate level (3 m) column values, with low transparency (0.58 m), water temperature 31°C, intermediate concentrations of oxygen (4.3 mg/L, 40% saturation), slightly acid pH (6.4), low conductivity (60 μS/cm), solids concentrations with respect to other algae (SST 13 mg/L and STD 77 mg/L), intermediate nitrate concentrations (1 mg/L), nitrites (0.12 mg/L), ammoniacal nitrogen (0.12 mg/L), PSR (0.47 mg/L) and sulfates (1.8 mg/L).

Diadesmis confervaceae is considered to have a tropical taxa origin that was easily adapted to subtropical conditions of South America and the mild climate of North America, Asia and Europe [26,27]. These latest researchers carried out a comparison of the distribution of the species in different countries, and indicate that it is more frequent in lotic environments. It has been reported as estuarine, *ß* mesosaprobic, pH-neutral, supports desiccation, inhabits soft water and it can tolerate pollution [18]. This research found that it presented optimal values in shallow waters in greater depth (3.8 m), with intermediate transparency (0.8 m), water temperature 31°C, intermediate concentrations of oxygen (4.3 mg/L, 38% saturation), pH circunneutral (6,7), low conductivity (60 μS/cm), solids concentrations (SST 7 mg/L and STD 48 mg/L), concentration intermediate in nitrate (0.7 mg/L),

and low values of nitrites (0.06 mg/L), ammoniacal nitrogen (0.07 mg/L), PSR (0.34 mg/L) and sulfates (1.8 mg/L).

Encyonema jemtlandicum was described for Colombia by [28] in Tumaradó swamp, Chocó. This is the first record for depression Momposina flood plains. Nearly all the swamps that we sampled the swamp Ayapel and known little ecological information about the species. This research found that their optimal values indicate a water column of intermediate depth (3 m), with low transparency (Zsd 0.58 m), water temperature around 30.8°C, intermediate concentrations of OD with low saturation of the same (4.3 mg/L and 41%), pH of 6.4, low conductivities (less than 80 µS/cm), low concentrations of SST (10 mg/L), STD (40 mg/L), nutrient concentrations show intermediate values of nitrates (1 mg/L), nitrites (0.18 mg/L), ammoniacal nitrogen (0.18 mg/L), PSR (0.5 mg/L) and sulphate (2 mg/L).

Encyonema minutum is considered as α-mesosaprobic, circunneutral, euritrophic, pH circunneutral, indicator of low transparency [18]. This research found that the optimal depth value corresponds to intermediate waters of deep (2.8 m), with low transparency (0.6 m), 30.8°C water temperature, intermediate concentrations oxygen (5 mg/L, 40% saturation), pH circunneutral (6.4), low conductivity (80 µS/cm), low solids concentrations (SST 11 mg/L and STD 50 mg/L), intermediate in nitrate concentrations (0.6 mg/L), nitrites (0.18 mg/L), ammoniacal nitrogen (0.17 mg/L), PSR (0.7 mg/L) and sulfates (1.8 mg/L).

For the genus *Fragilaria* has been selected two species, *Fragilaria capucina* and *Fragilaria familiaris*, this last specie is the first report that is made in Colombia. These two species share optimal values for some variables evaluated, such as the intermediate level of the swamp (3 m), a transparency reduced (0.6 m), 31°C water temperature, 5 mg/L of dissolved oxygen with a saturation between 40 and 60 percent, pH of 6.6, conductivity 60 µS/cm, concentration of nitrites 0.18 mg/L, ammoniacal nitrogen 0.18 mg/L and less than 3 mg/L of sulfates. *Fragilaria familiaris* with respect to *Fragilaria capucina* presented more optimal value for the concentration of SST (12 and 5 mg/L, respectively), STD (50 and 75 mg/L, respectively), PSR (0.4 and 0.63 mg/L, respectively).

The wide ranges of the physical and chemical variables under the periphytic algae are development due to the large area of the water mirror of flood plains of Ayapel, which reaches a high fluctuation in fact of the flood pulse effect. Presented physical and chemical differences between some swamps that make up the system, condition that is evident in the North-South gradient in which has been found a decrease in the electrical conductivity values and the East-West gradient in which

there has been an increase in transparency.

High variation of physical and chemical conditions does not mean that periphytic algae are eurioic since it requires the evaluation of fluctuation in relation with his abundance on the values of each variable. Differences were found between the optimal values for algae and differences in the ranges of variation of each physicochemical variable where the organism occurs. The ability to use algae as bioindicators is associated with their level of tolerance of environmental conditions in which, stenoic algae play a preponderant role.

Data evaluated from research in seven swamps and seven streams in 330 periphyton samples in Ayapel system, presented a wide environmental range, allowing algae species to be considered dominant as bioindicators of water quality and species representative of the assembly, although it is necessary to continue the research for further taxonomic and ecological information of them.

In general, there is very little ecological information existing about these species and is required to continue with this type of research to further debug the distribution of algae in the world and identify the optimal environmental conditions for their development. This claim work is basic to consolidate the application of indices which evaluate the biological quality of water by microalgae.

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