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Original Research Article

Abundance and Components of the *Ulva fasciata* Delile 1813 northern coast of Havana City, Cuba

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Abstract

The aim of this work was to determine the abundance of *Ulva fasciata* in a 1re ato11 sector in Havana City, Cuba. The natural populations of the *Ulva fasciata* are characterizedin a rising sector in the Western Caribbean coast, Havana City between Quibú and Jaimanitas rivers.The present study was carried out between March 2018 and January 2019. Significant differences were found in the places, years and months for the biological variable and the hydrographic monitored *U. fasciata* inclined. It was found *U. fasciata* was not distributed in a similar way in the entire examinated sector and the availability of nutrients take part in a decisive way.The components of nitrogen and phosphorus in the seawater and the differences in the extent of variation in them justify the differences in the nutritional state (C, N, and P) of *U. fasciata* and show the opportunistic 1re ato1 of the species. These environmental conditions are unvariable on time, which allows the presence of the species during the whole year.

Keywords: Ammonium, Atomic relation, Enrichment, Macronutrients, Micronutrients, Nitrogen, Phosphore

INTRODUCTION

The *Ulva* genus, lives in fresh, brackwish, and saltwater and a lot of moist subaerial 1re ato1, making it a species with a 1re ato11tan distribution (Hayden and Waaland, 2004). The *Ulva* specimens appear with relative frequency in environements full of nutrients that come from the rivers or places where there are sewers pollutants (Rast and Holland, 1988; Fox et al., 2008).

The availability of nutrients in these places is exploited by these macroalgae for their proliferation and at the same time, to accumulate in their thallus big quantities of macro and micronutrients (Cano et al., 2007, Thomsen et al., 2012). The supply of nitrogen seems to control the 1re ato seasonal rates of growing or the total primary production of the macroalgae in most of the coastal systems. However, in some cases, just the phosphorum or this combinated with the nitrogen, is the one that can limitate the production of the macroalgae in some periods of the year (Valiela et al., 1997). Shi et al., (2015) showed the importance of the contribution of land nutrients in the creation of blooms and green tides. The authors showed that *Ulva*specimensareabundant that creates blooms, it showed a really fast increase in absorption rates of nitrate and phosphate when they were exposed to a high concentration of nutrients, having the possibility to use different kinds of nutrients, includding the 1re ato1 organic nitrogen when the sources of organic nitrogen have been exhausted. It must be added that these components have a variation in their concentration depending on the place and the time of the year.

Because of its abundance and nutritional value, *U. fasciata* specimens should be evaluatedue to their highest potential of use in the Cuba platform, according to the suggested by Díaz Piferrer et al., (1961). The authors estimated that the productivity of the *Ulva* specimens in the surrounding 1re ato Quibú, from the organic rests, giving information about the available biomass and the chemical components that are present in these algae. They have alsoevaluated the extention of these mantles and described their seasonal variations, and the algal groups that are present in there. These

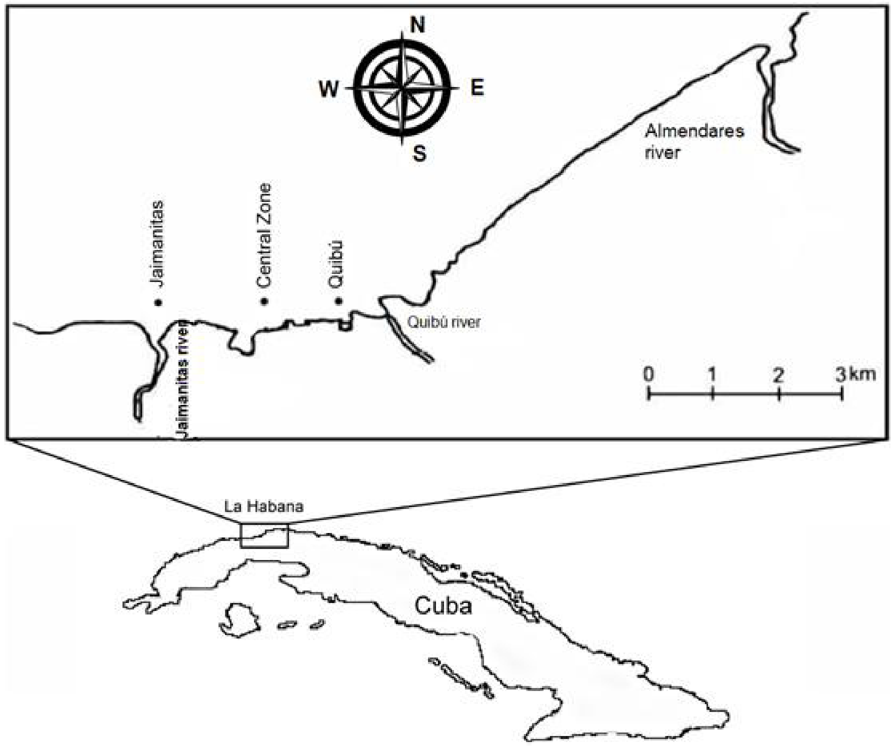

Figure 1. Map of the study area.

results justified the potenciality of *Ulva* for its use in the Havana coastline (Gregorio et al., 2001; Ledesma et al., 2001; Cano et al., 2007).

This genus has raised interest in the last decades because of its use and its usage in techniques of environmental bioremediation (Vidotti and Rollemberg, 2004), and because of the increased value added from the biomass obtained specially through techniques of integrated crop management. In this regard, it is specially important the use of the biomass of *Ulva* in the animal norishment and in the human norishment, due to the good nutritional qualities (Bolton et al., 2009; Taboada et al., 2010; Radulovich et al., 2013).

The north coast of Havana City is exposed to the surfing; however, there are geographic accidents as the cove of the rivers, that in some places, they guarantee places with relative peace or with minor exposure to the surf, which allows the development of the *Ulva* populations (Díaz-Piferrer and López, 1959). The zone from the Quibú River to the Jaimanitas river, is one of the places from the island platform with the most quantity of biomass usable of *Ulva,* it has an impact with the urban and industrial development, which provoques the rise in the domestic residual flux and sewers.

Hereinthe authors determinate that the content of macronutrients (C, N, P, Ca, Mg and K) and the micronutrients (C, N, P, Ca, Mg and K) present in the thallus of the *Ulva fasciata,* and the nutritional components are evaluated (C, N and P) and their atomic relation, as the space-time variations of the nutrients in the sea water.

MATERIALS AND METHODS

Sampling area

Due to the influence of land runoff that comes from the Quibú and Jaimanitas rivers, as well as the effect of the streams, we chose three sample points (Fig. 1). With different characteristics according to the contribution of nutrients (surrounding area to the Quibú, Jaimanitas and Central Zone). The first two, with minor environmental severity, surrounding to the mouths from both of the rivers and a third, in the central zone from the sector of study, with higher environmental severity caused by the fact that the contribution of nutrients preceeds from the rivers is minor, and the exposition to the whippage of the copies of the *U. fasciata,* occasionated because of the surf in that place is a bigger difference from the ones that grow in surrounding zones to the rivers.

The selected biological variation and the process employeed are described by Vásquez and González (1995) to the evaluation of subdital populations and they are recommended to establish the operation process of any species of macroalgae (Alveal, 1995).

We selected seven perpendicular transects (T) to the line of the coast, these were located inside of the three sample zones. Three of them were collocated in the surrounding zone to the Quibú river T1 [23°53'04"; 82°27'54"], T2 [23°53'04"; 82°27'50"] and T3 [23° 53'04"; 82° 27' 48"], separated one from the other by 100 m. Two transects in the Central Zone T4 [23°53'06"; 82°28'22"] and T5 [23°53'06"; 82°28'21"] and the rest in the surrounding zone to the Jaimanitas river T6 [23°05'34"; 82°29'20"] and T7 [23°05'34"; 82°29'21"].

Hydrochemistry

To determinate the quality of water, we took subsuperficially samples in the column of water (to 0.5 m from the interphase), manually and always in low tide in all the harvest seasons when it was possible. The samples were kept in plastic bags with the capacity of a liter and they were transferred to the laboratory where they were kept on freezing (-20^{0}C) until the next analysis. The hydrochemistry factors, the used methods and the bibliographic sources of reference get related in the following part: chemical oxygen demand (COD): through the oxidation with potassium permanganate in alcaline way; nitrate + nitrite: colorimetry reducing the nitrate to nitrite with cadmium metal and the nitrite made up quantified through the Griss' reaction (IOC-UNESCO, 1993); ammonium (NH_4): colorimetry by the blue infoenol method (IOC-UNESCO, 1993); total inorganic nitrogen (TIN), from the addition of the ammonium concentrations and nitrate plus nitrite, organic nitrogen (ON): by difference between the (TIN) and the total nitrogen; total nitrogen (TN): colorimetry, oxidation to nitrate with potassium persulfate in alcaline way and determinated the nitrate created by the reduction method with cadmium (FAO, 1975; IOC-UNESCO, 1983); inorganic phosphore (PO_4): colorimetry by the formation method from the phosphomlybdic acid complex and reduction with ascorbic acid (IOC-UNESCO, 1983); total phosphore (TP): colorimetry getting rusty the sample with potassium persulphate and subsequent determinarion as inorganic phosphore (FAO, 1975; IOC-UNESCO, 1983); organic carbon (OC): we estimated from the COD, multiplying the value of the same by the coeficient 0.37 (De la Lanza and Rodríguez, 1992). Thes mg L^{-1} of organic carbon tuned to µM L^{-1} from the expression (mgCL^{-1}*1000)/12).

Contents of the macronutrients (C, N, P) and their atomic relation

To evaluate the contents of carbon, nitrogen and phosphate in the thallus and the atomic relations on these components, we collected complet thallus with more than 25 cm of lenght (500 g approximately) to 1 m of depth, on the three different zones.

The analysis of carbon and nitrogen was made with a quarter of each sample aproximately. Each portion was let to dry during 48 h to 60ºC. After this, they were ground and had a homogenization through a Retsch grinder. To to the determinations, we used a Perkin Elmer Elementary Analyser 2 400 Series II CHNS/O. The total content of phosphorus in the thallus was determinated by the described method of Murphy and Riley (1962), after an acid mineralization (H2SO4 and HNO3) in a Büchi 435 digester.

The calculation of the atomic relation was made through the following equation:

$\frac{\text{X content (atom)}}{\text{Y content (atom)}}$ = [X content (mg X g-1 p.s) 10/ X Atomic weight] [Y content (mg X g-1 p.s) 10/ Y atomic weight]-1

X: nutrient 1 Y: nutrient 2 dry weight: ps.

Contents of another macronutrients and micronutrients

The determination of the content of other macro (Ca, Mg, K) and micronutrients (Al, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Zn), took place with the collection of the complete thallus with more than 25 cm of lenght (500 aproximately) to 1 m of depth, in the three zones. They were collected in polyethylene plastic bags and were taken to the lab. We cleaned the material from the epibiosis and from solid waste, we washed with distilled water and we let dry during 48 h to 60ºC. We took a portion of each sample, which was crushed and grounded in a rotatory mortar of scoops of agate; it was finally processed further throught a plastic mesh of 0.6-0.66 µm. After that, the obtained samples with a weight of 4 g were threated with a concentrated mixure of HCl:HNO3:H2O2 in proportion 1:2:3.

The measurements were made through the direct lecture method in a spectrophotometer of atomic absorption Pye Unicam SP-9-800 with flame air-acetylene. The value of potassium (K) took place through flame phonometry (Chapman and Pratt, 1980).

Statistical analysis

All the data was processed with the Microsoft Excel 2017. We obtained the descriptive information correspondant to the average, the standard error and the standard deviation in some cases. The statistic process and the graphics that stemmed from this, was made with the Statistica Versión 7.0.

The normality of the data was proved with the Kolmogorov-Smirnov test and the homogenity of variation through the Bartlett test (Zar, 1996). The variable that did not had the normality were transformed, and even thought being transformed (Taylor method), they didn't had the necessarily premises, the following non parametric tests were used (Siegel, 1974): analysis of variation non parametric of Kruskall-Wallis (to compare more than two averages) with the Nemenyi test with

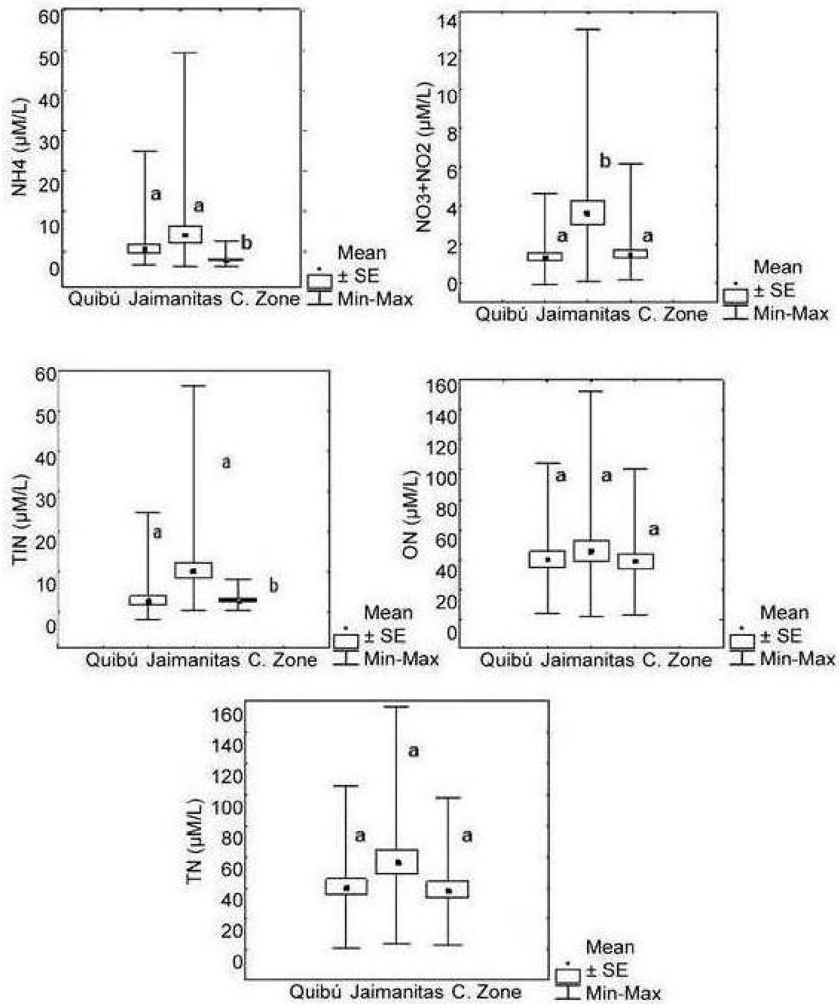

Figure 2. Average values (± standard error: SE; minimum: Min. and maximum: Max.) of the nutrients as nitrogen (nitrate+nitrite: NO3+NO2; ammonium: NH4; Total inorganic nitrogen: TIN; organic nitrogen: ON; total nitrogen: TN) of the water in different zones. The different letters indicate significant differences ($p<0.05$) according to the Nemenyi test.ND= There were no samples.

modification of Dune for unbalanced and linked data (Zar, 1996) and the Mann-Whitney test (to compare two averages).

When the premises were completed for the application of the parametic tests, we made an analysis of the variacion with the comparation of averages tests Student Newman Keuls (SNK) and the t-student test (to compare two averages).

In all the cases we worked with a significant level of 0.05. We used as level of affinity the coefitient of correlation by ranges of Spearman (Zar, 1996). We estimated the variability coefitient (CV %) according to Sokal and Rohlf (1981).

Content of nutrients in the thallus and the atomic radio: Kruskall-Wallis test and Nemenyi test with modification of Dune and the Mann-Whitney test. To connect the variable: nutrients in the thallus, the atomic relation and nutrients in the seawater and the Spearman test was used. We calculated the variation coeficient (CV: %) through the data of the content of nitrogen, phosphorus and carbon in the thallus.

RESULTS

The predominant inorganic nitrogen compound found in the area of study was ammonium, which represents 66 percentage of the total inorganic nitrogen (TIN). The highest level (49.88 µM L^{-1}) was found in the cove of Jaimanitas and it was related to the nutrient load within this river and the discharge of waste waters from a nearby village.

Levels of total inorganic nitrogen (TIN) and ammonium differed significantly between areas surrounding the river mouth and the central area ($p<0.05$) (Fig. 2). Overall, levels of ammonium exceeded the set value (0.050 μML^{-1}

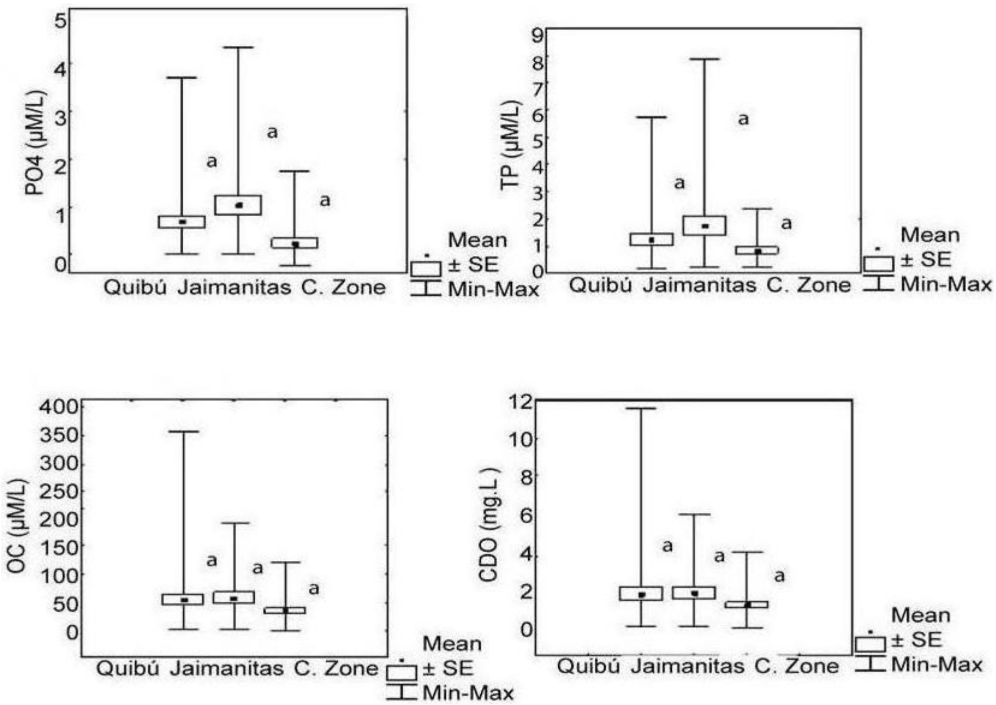

Figure 3. Average values (± standard error: SE; minimum: Min. and maximum: Max.) of the nutrients as phosphore (phosphate: PO4 and total phosphore: TP), organic carbon: OC and chemical demand of oxygen. CDO from the waters in different zones.

Table 1. Coefficient of variation (CV %) of the nutrients in the sea water (nitrate + nitrite, ammonium, total nitrogen, phosphate, total phosphore, organic carbon) and the chemical demand of oxygen (CDO) in *U. fasciata*.

Zone /Indicator	**Quibú**	**Jaimanitas**	**Central zone**
Nitrate + Nitrite	89	88	81
Ammonium	158	138	92
Total Nitrogen	75	71	76
Phosphate	125	113	125
Total phosphore	103	100	85
Organic carbon	106	90	73
CDO	170	87	74

[3, 57 μML^{-1}]) established by Cuban regulation for marine water NC: 22.99(1999), mainly in areas surrounding watercourses which certifies such waterbodies as poor quality aquatories.Levels of nitrates plus nitrites were around 0,01 μML^{-1} and 6,35 μML^{-1}, the highest levels were found nearby Jaimanitas with significant differences compared to the other areas ($p<0.05$).

Levels of total nitrogen concentration, phosphate, total phosphorus, organic nitrogen, organic carbon and chemical oxygen demand (COD) in the three regions analyzed showed no significant differences ($p>0.05$) (Fig. 2,3). The coefficient of variation of ammonium, total phosphorus, organic carbon, and chemical oxygen demand was higher nearby the cove of Quibú and the Jaimanitas river which showed a different dynamic related to the nutrient load compared to the central area (Table 1).

Despite the fact that hydrodynamism in this area allows for the exchange of water loaded with nutrients from rivers and ocean waters, some hydrochemical variables (ammonium, nitrate + nitrite and total inorganic nitrogen) showed significant differences from one area to another, which demonstrates the influence of these rivers on the formation of nutrient gradients within this coastal sector.

The nutrient content of these water bodies showed an important seasonality within each area. Nearby Quibú river, the levels of nitrate + nitrite, ammonium and total inorganic nitrogen showed a significant variation from month to month ($p<0.05$) (Fig. 4). Particularly, ammonium reached its highest levels in March and May 2018 and in August 2019, whereas the highest levels of nitrate + nitrite were recorded in July and September 2018.

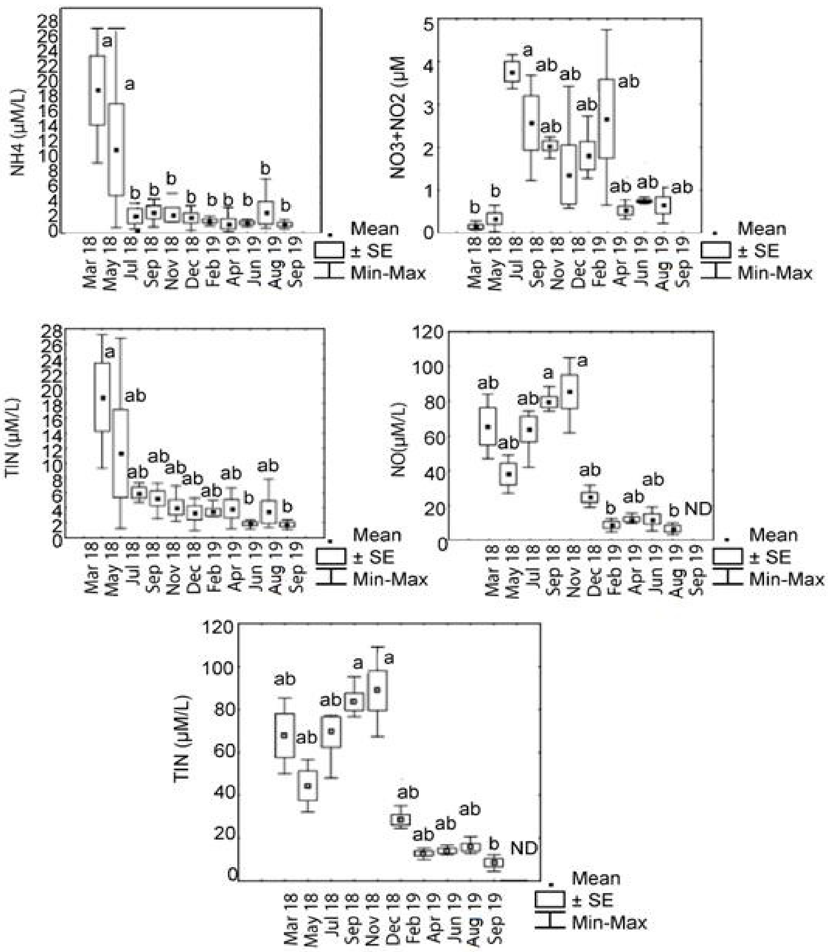

Figure 4. Average values (± standard error: SE; minimum: Min. and maximum: Max.) of the nutrients as nitrogen (nitrate +nitrite: NO3+NO2; ammonium: NH4; total inorganic nitrogen: TIN; organic nitrogen: ON; total nitrogen: TN) in the surrounding zones to the cove of the Quibú river.

Organic nitrogen and total nitrogen remained on a high level over time within this area (Fig. 5), although levels dropped dramatically since December 2018 when significant differences from month to month were shown ($p<0.05$). Such concentrations were higher in November and December 2018, which highly differed from the other months ($p<0.05$).

The highest levels of phosphate and phosphorus were recorded in March, May and September 2018 and showed significant differences compared to the levels of the other months ($p<0.05$) (Fig. 5).

Organic carbon and chemical oxygen demand (COD) presented significant variations in time ($p<0.05$); June 2018 recorded the highest average in both cases (Fig. 5).

Likewise, organic carbon levels were higher in March and May of the year.

In the bordering zone to the Jaimanitas river, levels of ammonium, total inorganic nitrogen, organic nitrogen, total nitrogen and nitrate + nitrite presents significant variations between months ($p<0.05$) (Fig. 6). The first four compounds recorded its highest levels in December 2018 and showed significant differences compared to the levels of the other months ($p<0.05$) in all cases. The highest concentration of ammonium was recorded in August, 2019.

In waters off the same river, the levels of phosphate and total phosphorus presented significant variations in time (Fig. 7). In the first case, March, May and September 2018 as well as on August 2019 recorded the highest average levels and showed no significant differences compared to the other months ($p<0.05$).Total phosphorus reached its highest average level in September 2018. Chemical oxygen demand presented no significant differences at any time, except for June and August 2019 when the highest levels were reached; likewise, in July 2018, September 2018 and April 2019 the lowest levels were recorded, although with no significant variations.Chemical oxygen demand did not show significant difference at any time ($p>0.05$), except in

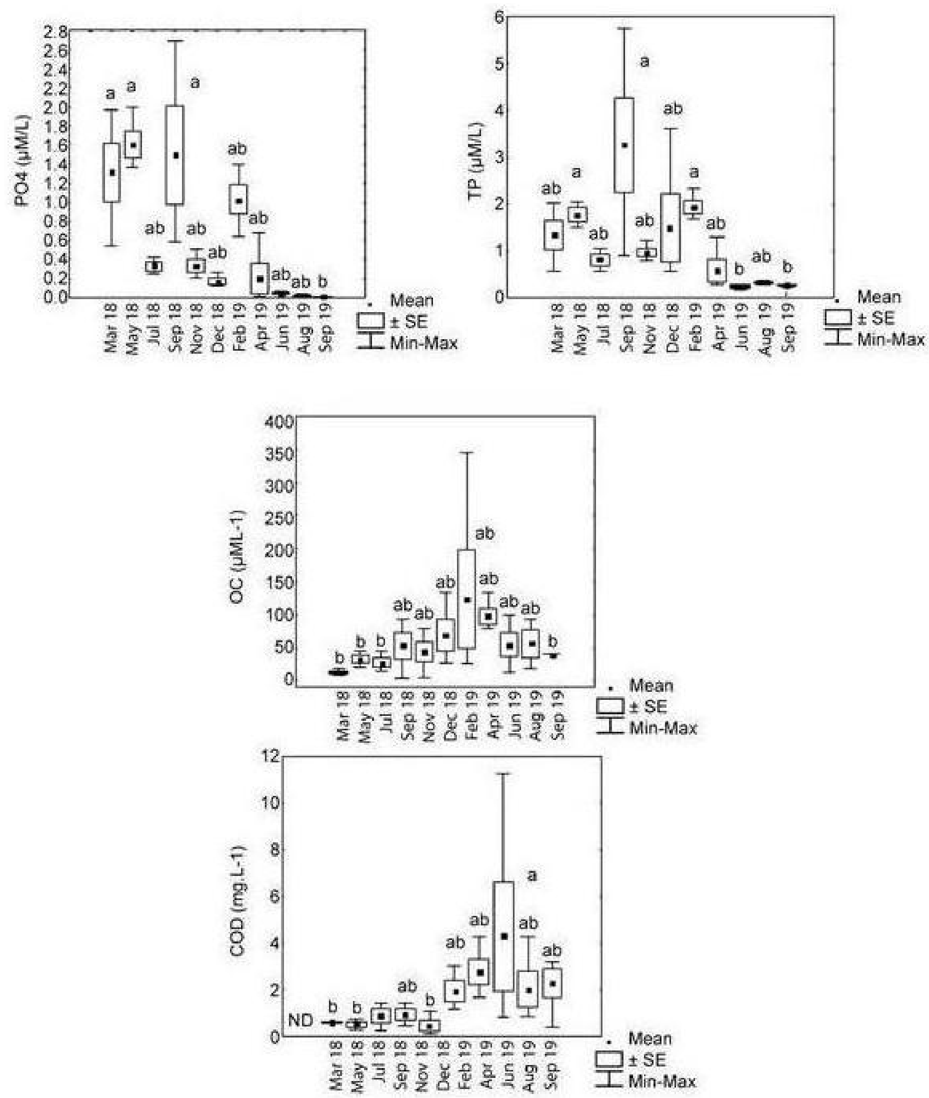

Figure 5. Average values (± standard error: SE; minimum: Min. and maximum: Max.) of the nutrients as phosphore (phosphate: PO4 and total phosphore: TP), organic carbon (OC) and chemical demand of oxygen. QDO in the surrounding waters to the cove of Quibú river.

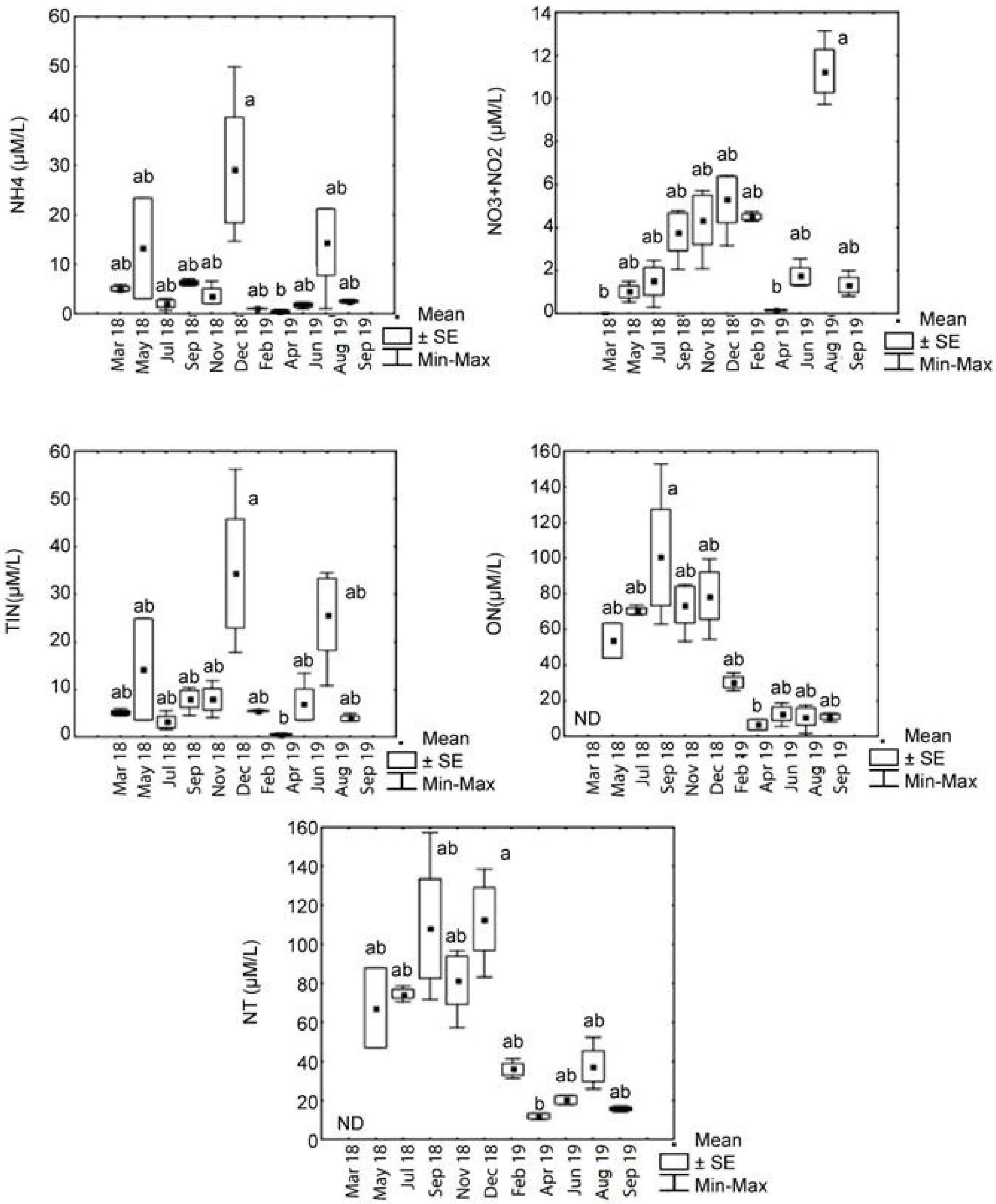

Figure 6. Average values (± standard error: SE; minimum: Min. and maximum: Max.) of the nutrients as nitrogen (nitrate+nitrite: NO3+NO2; ammonium: NH4; Total organic nitrogen: TIN; organic nitrogen: NO; total nitrogen: TN) in the surrounding waters to the cove of the Jaimanitas river.

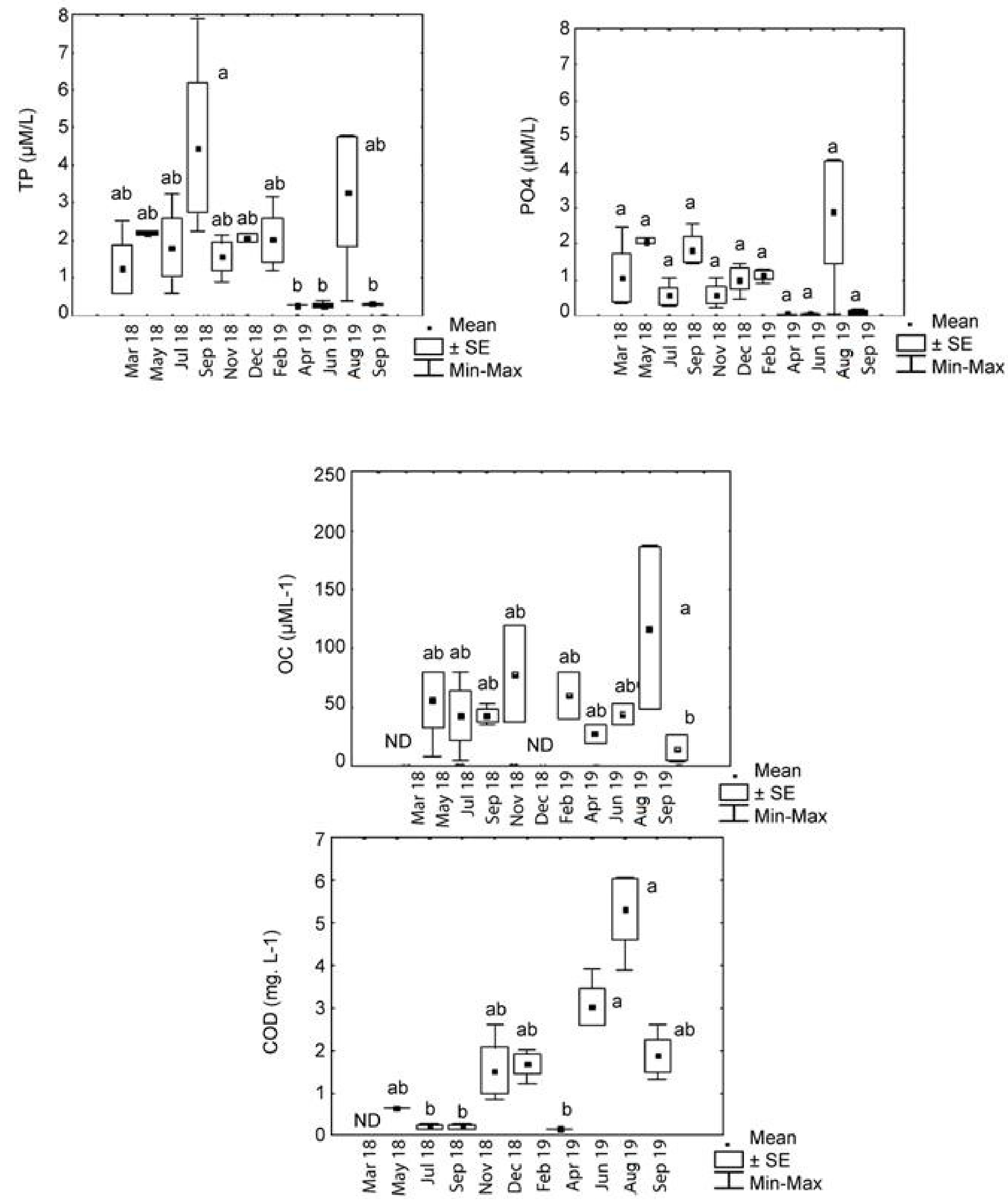

Figure 7. Average values (± standard error: SE; minimum: Min. and maximum: Max.) of the nutrients as phosphore (phosphate: PO4 and total phosphorus: TP), organic carbon: OC and chemical demand of oxygen. CDO in the surrounding waters to the cove from the Jaimanitas river.

June and August 2019 when the highest levels were recorded, as well as in July 2018, September 2018 and April 2019 when the lowest levels were recorded, although without any significant differences ($p<0.05$) (Fig. 7).

The nutrient content showed significant variations from month to month ($p<0.05$) in the central area, except for the amount of total phosphorus ($p>0.05$) (Fig. 8, 9).The highest levels of ammonium were determined in March 2018, February 2019 and June 2019. The highest concentration of nitrate + nitrite was recorded in September 2018, while the highest concentrations of total inorganic nitrogen were recorded in the same months when ammonium reached its highest levels.Organic nitrogen and total nitrogen levels in this Central zone remained high all the time, until December 2018 (Fig. 8), when a lower level was reached, compared to the other months ($p<0.05$). Phosphate levels reached its largest average in May and September 2018 with differences compared to the other months ($p<0.05$).

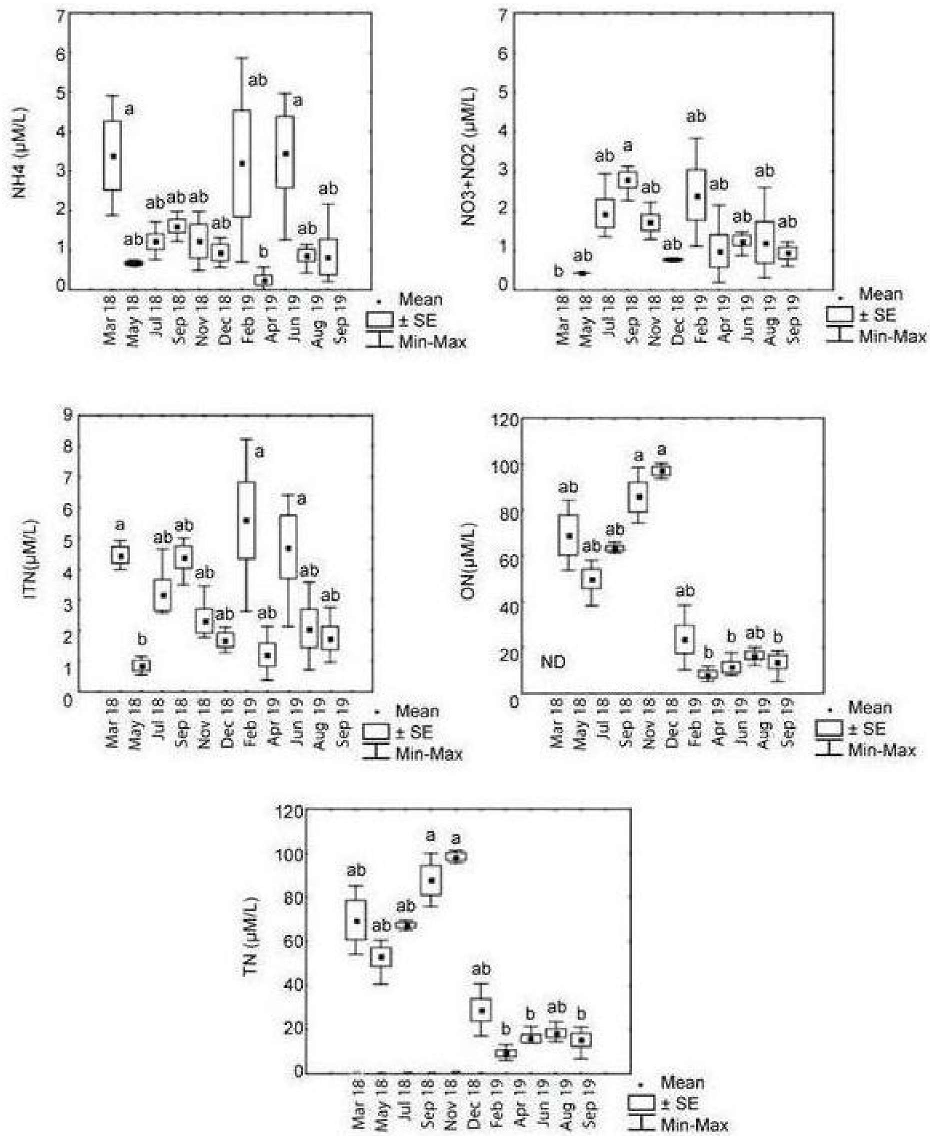

Figure 8. Average values (± standard error: SE; minimum: Min. and maximum: Max.) of the nutrients as nitrogen (nitrate + nitrite: NO3 + NO2; ammonium: NH4; Total inorganic nitrogen: TIN; organic nitrogen: ON; total nitrogen: TN) in the Central zone.

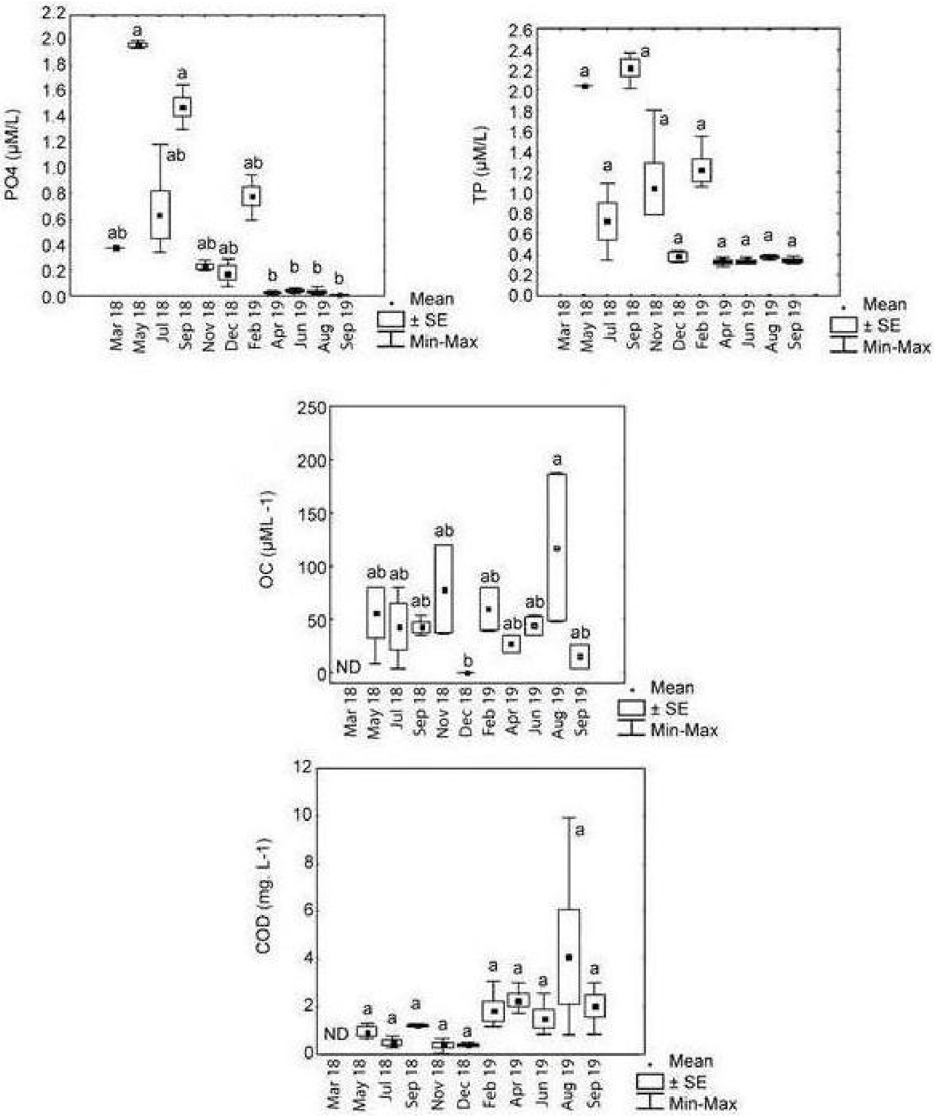

Figure 9. Average values (± standard error: SE; minimum: Min. and maximum: Max.) of the nutrients as phosphore (phosphate: PO4 and total phosphore: TP) organic carbon: OC and chemical demand of oxygen: CDO in the Central zone.

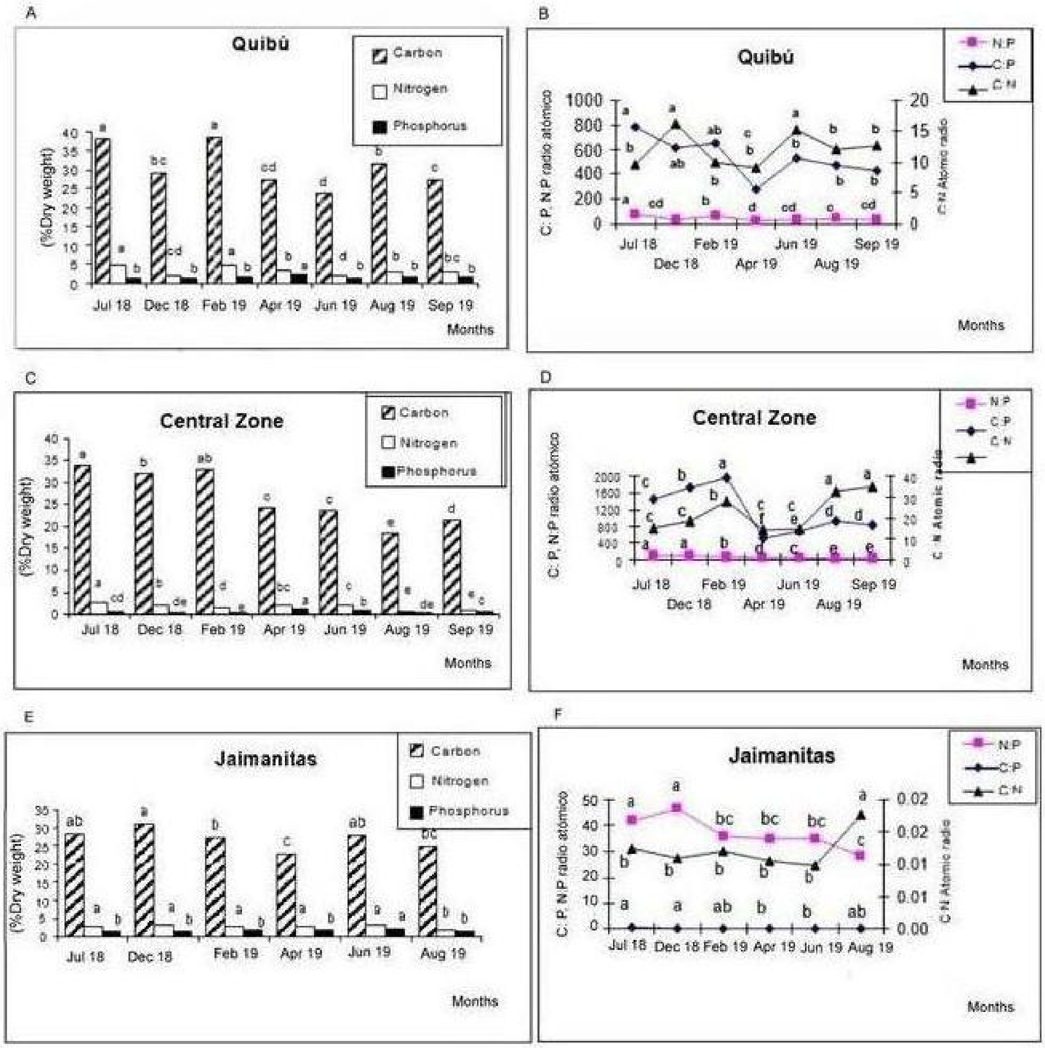

Figure 10. Average value of the content of carbon (%), nitrogen (%) and total phosphore (%) and the atomic relation by months in each zone. A and B: Quibú river; C and D: Central zone and F and E: Jaimanitas river.

In contrast, total phosphorus and chemical oxygen demand did not present any significant variation over time ($p>0.05$) (Fig. 9). Organic carbon reached its highest levels in August 2019, which was highly different from the levels of the other months ($p<0.05$).

Macronutrients (C, N, P) and their atomic relation

The content of macronutrients in the thallus depends on their concentration according to the zone and the months ($p<0.05$) (Fig. 10 A, C and E). The carbon concentration was higher than the one of nitrogen and the phosphore. The level of this component varied from 21. 63% (central zone/ July 2018) and 38.65% (Quibú/ June 2018 and February 2019) and showed in general the higher values in the copies of the Quibú river (27.37% - 38.02%). In June 2018, there were no significative differences among Quibú and the central zone (21.63% - 34.05%) ($p>0.05$).

The total content of nitrogen in the thallus varied from 0.72% and 4.49%. The copies that growed in the surrounding zones to the rivers, presented as the carbon, the higher levels, even thought in specific months there were no significant differences between those close zones to the river and the central zone ($p>0.05$), not exceeding this component in this last case of 2.6%.

The concentration of phosphore in the thallus was also benefited in the closer zones to the river, these places showed a big difference with the central zone during all the time ($p<0.05$). In the Quibú, the algae variated their content between 0.5 % and 2.56% and in the Jaimanitas river 1.42 % - 2.15 %, while in the central zone it did not reached the 1.22 %.

The micronutrients were found in *U. fasciata* (Tab. 2).

Table 2. Average value (mg.kg^{-1} dry weight) ± SE (standard deviation) of the micronutrients (Al, Cu, Fe, Mn, Zn, Cd, Co, Cr, Ni, Pb) and the macronutrients (Mg, K, Ca) in *U. fasciata* in different zones and months: March 2018 (1) - September 2019 (2).

Element	Al	Cu	Fe	Mn	Zn	Cd	Co	Cr	Ni	Pb	Mg
Average Quibú Zone											
1	353.34	17.85	709.5	3.52	25.57	3.38	5.88	4.50	3.03	0.94	6242.1
2	112.5	23.42	1033.5	6.4	91.12	1.1	9.65	1.73	1.13	9	29296.8
Average	**232.92**	**20.63**	**871.5**	**4.96**	**58.34**	**2.24**	**7.64**	**3.02**	**2.02**	**4.95**	**17769.45**
Jaimanitas Zone											
1	445.90	18.69	792.4	3.25	31.77	4.0	6.58	4.17	0.92	0.85	7559.4
2	154.23	7.36	431.5	2.81	20.80	3.52	4.06	4.71	0.66	0.40	5114.04
Average	**300.06**	**13.03**	**611.95**	**3.03**	**26.28**	**3.76**	**5.32**	**4.44**	**0.64**	**0.62**	**6336.7**
Central Zone											
1	630.6	31.40	1343	2.43	70.08	3.04	9.53	4.25	4.20	0.49	13853.4
2	707.73	14.75	852.5	2.81	83.03	2.32	ND	4.23	0.59	7	10171.8
Average	**669.17**	**23.07**	**1079.75**	**2.62**	**77.05**	**2.68**		**4.24**	**2.40**	**3.74**	**12012.6**
General M ± SE	**356,53** ± **250.74**	**16,92** ± **9.09**	**774,17** ± **362.04**	**3,44** ± **1.35**	**47,72** ± **32.76**	**3.01** ± **1.00**	**6.79** ± **2.33**	**3.48** ± **1.57**	**1.62** ± **1.41**	**2.73** ± **3.65**	**11709.43** ± **8274.60**
Maximum	707.73	31.40	1033.5	6.4	91.12	3.76	9.65	4.71	4.20	9	29296.8
Minimum	250.74	9.09	362,04	1.35	32.76	1.1	4.06	0.75	0.59	0.40	8274,6

Table 3. Hierarchical order of the macro and micronutrients found in the *U. fasciata* by zone and for all the area of study.

Quibú river
C>N>P>Mg>Ca>K>Fe>Al>Zn>Cu>Co>Mn>Pb>Cr>Cd>N
Central zone
C>N>P>Mg>Ca>K>Fe>Al>Zn>Co>Cu>Cd>Mn>Ni>Cr>Pb
Jaimanitas river
C>N>P>Mg>Ca>K>Fe>Al>Zn>Cu>Co>Cr>Cd>Mn>Ni>Pb
Across the study sector
C>N>P>Mg>Ca>K>Fe>Al>Zn>Cu>Co>Cr>Mn>Cd>Pb>N

Table 4. Results from the test of the Spearman's range (r^s). Significative correlations in comparing all the variable of the nutrients in the thallus, their atomic relation and the nutrients in the sea water. Significative (0.5-0.6)
*Very significative (0.6-1) **.

Thallus Nutrients		**Nutrients present in seawater and CDO**	
Variables	r^s	**Variables**	r^s
C-N	0.61**	TIN-NO3	0.59*
N-P	0.69 **	TIN-NH 4	0.72**
C-N:P	0.64**	TN-ON	0.97**
P-C:P	-0.80**	ON-PO4	0.67**
N-C:P	-0.68**	TN-TP	0.66**
P-C:N	-0.72**	TP-PO4	0.83**
C:N-C:P	0.82**	CDO-OC	0.95**
		OC-NO	0.52*

The calcium (Ca), reached an average value of 9202.2 mg.kg-1 to ± 7279.4 mg.kg-1. It is common ground that this species accumulated considerable values of iron (Fe), an element in the synthesis of chlorophylls and the transport of electrons in photosynthesis, with an average of 774.2 mg.kg-1 to ± 362.0 mg.kg-1. The average amount of *U. fasciata* components throughout the study sector had the following hierarchical order: C>N>P>Mg>Ca>K>Fe>Al>Zn>Cu>Co>Cr>Mn>Cd>Pb>Ni (Tab. 3).

The coeficient of variation was different for each nutrient, the variavility in the levels of phosphore was higher (CV=46%), followed by the nitrogen (CV = 43 %) and the carbon (CV = 19%) (Tab. 1).

The atomic relation of this macronutrients, had also a significant variation between the zones and the months ofthe year ($p<0.05$) (Fig. 10 B D F). The Central zone showed the medium values that were the highest in the relations (C:P: 518.4-1981.71 and N:P: 24.37-95.05), after the Quibú river (C:P: 283-788.51 and N:P: 31.2-81.56) and the Jaimanitas river (C:P 0.34-0.53 y N:P 34.82-46.57). The relation C:N in the three zones was relatively low (Central zone: 14.28-35.28; Quibú: 9.60-16.22 and Jaimanitas: 0.01-0.018).

Among the analized variable in the thallus, the following gave direct correlation (Tab. 4), C-N $r_s = 0.61$*; N-P $r_s = 0.69$*; C-N:P $r_s = 0.64$*; C-N:C-P $r_s = 0.87$* and among the ones that gave significant invers correlations, we found: P-C:P $r_s = -0,80$*; N-C:N $r_s = -0,68$*; P-C:N $r_s = -0.73$*). There was direct significant correlation among all the variable of the water TIN-NO_3 $r_s = 0.59$*; TIN-NH4 $r_s = 0.72$*; TN-NO $r_s = 0.97$*; NO-PO_4 $r_s = 0.60$*; TN-PO_4 $r_s = 0.67$*; TN-TP $r_s = 0.66$*; TP-PO_4 $r_s = 0.83$*; OC-COD $r_s = 0.95$*; ON-TP $r_s = 0.60$*; with exception on the relation OC-ON ($r_s = -0.52$*). Among the contents of C, N and P in the thallus and the nutrients of the water, there was no significant correlation.

DISCUSSION

The natural mantles of the *U. fasciata* are subject to fluctuations of nutrients in the coast sector between the Quibú and Jaimanitas rivers. The contribution of freshwater carrying nitrogen and phosphore that come from both of the rivers makes it possible the proliferation of *U. fasciata* in this area. Especially the nitrogen is important to the development of the macroalgae (Morganet al., 2003; Fox et al., 2008). The species of the *Ulva* genus, stand out because of their ability to use different inorganic sources (nitrate, nitrite and ammonium) and organic (urea) of nitrogen (Bracken and Stachowicz, 2006) and they have fisiologic mecanisms that allow them to aquire, use and keep in different ways this component, in environments that are subjected to big space and temporal variations in the concentrations of these components (Hanisak, 1990; Lartigue and Sherman, 2002).

The asimilation of ammonium by the algae gets benefits even more when the nutrients are suministred by impluse, that when they are suministred continuously (Cohen y Neori, 1991). This can explain the proliferation of the *U. fasciata* in the coast sector between the Quibú and Jaimanitas rivers, partly because of the availability of the different forms of the nitrogen and the phosphates and their variability in the places close to both rivers.Aquatic plants always have the same proportion of nutrients, regardless of their architecture, structure, evolution and life cycle.

The aquatic plants always have the same proportion ofnutrients, independent of their architecture, structure, evolutions and life cicle. The dominant rol in the availability of components with the C, N and P in the control of growing and the abundance of phytoplanktons, macroalgae and phanerogams, has been established without ambiguity (Duarte, 1992).

The fact that in the *U. fasciata* the carbon was found in a higher concentration to the one of the nitrogen and the phosphore in the thallus and its variability was lower, this confirms that these contents are effective indicators to determinate the nutritional status of the macroalgae (Hanisak, 1990; Fong et al., 1994) and that the carbon is quantitatively the most important element (De Boer, 1981; De Casabianca and Posada, 1998).

A similar gradation in the variability of these components (P>N>C) in *U. faciata* was found in other species of macroalgae and groups of plants (Duarte, 1992; De Casabianca and Posada, 1998). In this Chlorophyta, we can verify that the content of total nitrogen in the thallus got quadrupled and duplicated in the zones that are closer to the Quibú and Jaimanitas rivers, respectively.

The C, N and P and the atomic ratio average determinated by Atkinson and Smith (1983) for marine benthyc macrophytes is 700:35:1. It is considered that this ratio relects the nutritional status from the vegetable and at least the fitoplancton depends on its rates of relative growing. Taking in consideration the last part, we proved that in the *U. fasciata,* the value of this ratio between the components C:P and N:P in its thallus, revealed a high variability between the zones and a deficit of phosphore more sharpened in the central zone in determinated moths of the year (C:P: 518.4-1981.71 and N:P: 24.37-95.05). In the surrounding zone to the Quibú river, the availability of P was also limited but in a minor extent (N:P 31.2-81.56 y C:P: 283-788.51) in specific moments, but it was not the same in the surrounding zone to the Jaimanitas river (N:P 34.82-46.57 y C:P 0.34-0.53). This could be asociated to the highest availability and accumulation of nutrients in the close waters to the rivers, that in the case of P, it is absorbed with greed by the vegetable each time that it is available, which means that even that it always exists, there is an inbalance with the N.However, in comparation to P, the N was found in considerable quantities in *U. fasciata* in the three zones, corroborating throught the medium values obtained in the relation C: N (Central zone: 14.28-35.28; Quibú: 9.60-16.22 and Jaimanitas: 0.01-0.018) that they were always low, especially on these rivers.

Similar results were found by De Casabianca and Posada (1998) in the thallus of the *U. rigida* in the Thau Lake, France, according to the levels of C (21%-32.7%), N (0.99%- 3.5%) and P (0.027%-0.27%). They showed the deficit of phosphore in the lake throught the relation N:P (maximum 25) but not so sharpened as in the study sector.

Throught the direct significative found correlations, between all the nutrients in the water, particulary the total nitrogen and the total phosphore and between these and the nitrogen and the organic carbon, amonium and the phosphate, they corroborated the dependence of the level of nutrients dissolved in the water with the organic discharge coming from the rivers and determined the eutrophic nature of these waters, with predominance of the amonium over the other kinds of organic nitrogen.The differences found in the concentration of the components of organic nitrogen in the seawater, as the contrasts in the extent of variation of each nutrient between the close zones to the rivers and the central zone, justified the differences in the concentration of nutrients in the thallus of the *U. fasciata* and the ones from the surrounding waters.

In the *U. fasciata* we could prove, a remarkable correspondance between the atomic relation of nitrogen and phosphore and the seasonal pulses of enrichment, as the same other species that happens in other macrophyte no rhizophus in the reef lagoons as *B. triquetrum* (Areces, 1995).

In the thallus of the *U. fasciata* they also accumulate in abundance other macronutrients that are essential for the development of these sea vegetables and relevant to men, as it is the calcium, magnesium and the potassium.

Other micronutrients as the iron, brass and zinc are also in the *U. fasciata,* and these are essential to the vegetable and are frequently refered as trace elements. They put a limit in the algal growing if their concentration is low, but they are toxic for the cells in high concentrarions (Sunda, 2012). The excessive accumulation of iron and brass on these vegetables can induce the oxidative stress in the thallus (Bresgen and Eckl 2015)

In general, the hierarchical order in which the macro and micronutrients grown, was very similar to the obtained information for *Bryothamnion triquetrum* (Areces, 1995) and *Ulva fenestrata* (Kozhenkova et al., 2006).

In this study we observed determined changed in the order of some elements according to the zone, which can be associated to the differenced contribution of this contaminants in each zone, from the rivers and other point sources (Pérez et al., 1996; Mendoza et al., 1999).

Following the magnitude of these components, the hierarchical order in the values, coincides with the atomic relation proposed by Bruland, (1991) for the elements trace bioactive that compose the plancton.

In the matter of the proportion between the Zn and the Mn, we did not observe alteration as refered by Areces, (1995) to *B. triquetrum* and a significative group of evaluated species by other authors in the tropical areas or subtropicals (83.3% for the Gulf of Mannar, Bay of Bengal Ganesan et al., (1991); 66.7% in coasts of Qatar Kureisshy (1991); 41.7% in the Western coastof Cuba (Ramírez *et al.,,* 1988) which represented a high content of Mn.

In *U. fasciata*, the content of Ca, Fe, Cu, Mg, Mn, Zn and Cr found in this study, are in acceptable levels for the human consume according to FAO/OMS/ONU (1995).

In general, the levels of Cd in the *U. fasciata* were very close to the established limits by Prosi (1981) and in some areas, it exceeds the norm and the limit referred that points that the concentratrion of Cd in the sea algae must be between 1 and 2 mg kg^{-1}.However, the level of Pb found in this Chlorophyta had the taken regulations as references, except in two areas (Quibú y Jaimanitas) in September 2019 which was over the norm of the European Economic Community (5 mg kg^{-1}). In the surrounding zone to Quibú and other zones of the Havana coast, Hernández et al., (2008) had recentry evaluated the levels of metallic pollutants (Cd and Pb) that are present in the *U. fasciata* and they showed that they were lower than the one found in this study, proving that their values were under the permissible limits. In the algae, the heavy metals as the minerals are absorbed in fonction of the age of the vegetable, the season of collection, the concentration and the way of the metal in the sea field. These elements are absorbed as in an active way, as in passive by the charges of the polyssacharides in the cell wall and the extracellular matrix. The lead (Pb), strontium (Sr), zinc (Zn), and the cadmium (Cd) are taken activelly against a deconcentrarion gradient. The availability light and nitrogen affects the absorption of the Cd (Miau et al., 2005). The old algae hold higher concentration of metals; other factors also influence in the absorption of the same, as the depth, the temperature, the salinity, the epoc and the presence of other pollutants (Lobban and Harrison, 1994).

Because of the characteristics of the macroalgae of reflecting the levels of metallic pollution in the field, the species that are more common of macrophites are used for over the last 30 years as indicators of this pollution. Particullary, the members of the *Ulva* genus, are used for this purposes, because they grow in coast areas urbanized where the quantity of organic aloctine materia is high.

The superficial area of the thallus of these green algae, their ecologic plasticity and the ability to grow in polluted enviroments makes it possible for them to be used to evaluate the components of the organic and inorganic nature (Ratkevicius et al., 2003; Kozhenkova et al., 2006).

CONCLUSIONS

The components of nitrogen and the phosphore in the seawater and the differences in the extent of variation on them, they justify the differences in the nutritional state (C, N, P) of *U. fasciata* and shows the opportunist nature of the species. These environmental conditions are not so variable in the time. This fact guarantees the presence of their population, each year, in this zone.

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