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Influence of riverine outputs on the physicochemical parameters of water on sandy beaches along the Venezuelan coast

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Abstract: The influence of riverine outputs on the coastal processes near sandy beaches was evaluated in Gulf Triste, Venezuela. The effects in Yaracuy and Aroa rivers on the temporary and spatial variations of the physicochemical parameters, nutrients and total suspended solids in coastal environments of sandy beaches, was investigated from September 2000 to December 2001. The behavior of Yaracuy and Aroa Rivers plumes was assessed using remote sensors. The two rivers differ in their physicochemical parameters. The plume impact area of both rivers in the coastal zone presented variations throughout the periods of survey, the major areas of impact occurred in the last quarters of years 2000 and 2001 (260.14 ± 121.97 and 208.67 ± 171.63 Km^2, 1.64 and 1.32 times the coastal evaluated area, in the respective years). The physicochemical parameters related to riverine outputs showed differences between the sampling sites along the stretch of coastline studied. Furthermore, our findings showed a marked gradient of both riverine and marine influence along the coastline. We conclude that the contributions of the Yaracuy and Aroa rivers affect the physical-chemical parameters, which are expressed in a gradient of salinity variation, from estuarine localities (close to river mouths) up to localities with marine influence (farthest from river mouths).

Keywords: nutrients, river plume, physical-chemical gradient, PCA, Venezuela, coastal zone.

Resumen. Influencia de las descargas de ríos sobre los parámetros físico-químicos del agua en playas arenosas a lo largo de la costa venezolana. La influencia de descargas de ríos sobre los procesos costeros cerca de playas arenosas fue evaluada en Golfo Triste, Venezuela. Se determinó los efectos de los ríos Yaracuy y Aroa sobre las variaciones temporales y espaciales de los parámetros fisicoquímicos, nutrientes y sólidos totales suspendidos en ambientes costeros de playas arenosas, de septiembre de 2000 a diciembre de 2001. El comportamiento de las plumas de los ríos Yaracuy y Aroa fue evaluado usando sensores remotos. Los dos ríos se diferencian en sus parámetros fisicoquímicos. El impacto de la pluma de ambos ríos en la zona costera presentó variaciones a lo largo de los períodos de estudio, las áreas principales de impacto aparecieron en los últimos trimestres de los años 2000 y 2001 (260.14 ± 121.97 y 208.67 ± 171.63 km^2, 1.64 y 1.32 veces el área costera evaluada, en los años respectivos). Los parámetros fisicoquímicos relacionados con descargas fluviales mostraron diferencias entre los sitios de muestreo a lo largo de la extensión de línea de la costa evaluada. Hubo un marcado gradiente desde una influencia fluvial a una marina a lo largo de la zona costera evaluada.

Concluimos que las contribuciones de los ríos Yaracuy y Aroa modulan los parámetros físicos químicos, expresándose en un gradiente de variación de salinidad, desde localidades estuarinas (cercana a las desembocaduras de los ríos) hasta localidades con influencia marina (alejada de las desembocaduras de los ríos).

Palabras claves: nutrientes, pluma de río, gradiente fisicoquímico, PCA, Venezuela, zona costera.

Introduction

The coastal zone can be defined as the interphase between land and the open sea, where 30% of the total oceanic primary productivity occurs (Holligan & Reiners, 1992). This productivity is affected by the inputs of nutrients from continental sources (rivers plumes, runoff), upwelling processes and the atmosphere. It has been estimated that the rivers of the world drain close to 60% of the land area (1.5 x 10^8 km^2) into the oceans, with annual discharges of 26 x 10^9 tons of sediment and close to 38 x 10^3 km^3 of fresh water. (Alongi, 1998).

Because rivers are important modulators of coastal processes, their flow rates and interactions with other factors, such as tides and wave action, have been used to establish a hydrographic classification of coastal systems (Dronker, 1988). Coastal systems whose functional dynamics depend on the increase or reduction of the temporal discharges of rivers and their interaction with tides are called tropical tidal rivers, and the interaction of these rivers with oceanic water masses has been extensively studied for large South American rivers, such as the Amazon River in Brazil, and the Orinoco River in Venezuela (Rhyther *et al.*, 1967; Cochrane, 1969; Edmond *et al.*, 1981; Dronker, 1988; Bonilla *et al.*, 1993; Alongi, 1998; Signorini *et al.*, 1999; Rodríguez & Schneider ,2005; Mann & Lazier, 2006). The influence of river plumes on associated biological communities has been assessed for many coastal ecosystems, particularly in sandy beach environments. The abundance, diversity and species richness of benthic communities has been related to different parameters that can be influenced by the contributions of rivers as well as their distance from river mouths (Herrera, 2007; Herrera & Suárez, 2005; Herrera & Bone, 2011; Lastra *et al.*, 2006; Lercari *et al.*, 2002; Lercari & Defeo, 2003; Lercari & Defeo, 2006; Defeo & Lercari, 2004; Defeo *et al.*, 2009; Ortega *et al.*, 2013; Ortega & Martín, 2013).

Besides the Orinoco River, there are other tidal rivers in Venezuela with lower flow rates, but of great relative importance for the coastal areas into which they drain. The Yaracuy and Aroa rivers drain a basin with a surface area of approximately 4,720 km². The basin is affected by erosion due to bad agriculture practices and deforestation (Bastidas *et al.*,1999; Bone, 2002). Nevertheless, the effect of river nutrient and sediment load on the water quality associated with sandy beaches located along the Gulf Triste coastline has not been assessed. The aim of this study was to evaluate the effects of the Yaracuy and Aroa rivers on the coastal processes as well as on the temporary and spatial variations of the physicochemical parameters, due to its contributions of nutrients and total suspended solids in coastal environments of sandy beaches.

Materials and Methods

Study site. Gulf Triste is an extensive inlet that is located in the zone western center of Venezuela and is longer in the south-east – northwest direction (Fig. 1). The movement of the Gulf water mass is influenced by the south branch of the current of the Caribbean Sea (Pérez Nieto Ed., 1980). The area studied in this study includes a distance of 30 km in this coastal system, covering from the mouth of the Yaracuy river (10° 34’ 55” N., 68° 14’ 18” W.) up to Tucacas beach (10° 45’ 59” N., 68° 19’ 26” W.). The coastal area evaluated was 158.29 km^2.

River measurements. The concentration of Total Nitrogen (TN) and Total Phosphorus (TP) were evaluated (TN: macro-Kjeldahl method, section 4500-Norg-B, in APHA, AWWA, WEF, 1995; TP: ascorbic acid method, section 4500-P-E, in APHA, AWWA, WEF, 1995) through water sampling at the mouths of both Yaracuy and Aroa rivers, at the end of February, April, July and October 2000 and 2001. We used as data of current values the average of Aroa and Yaracuy river flow rates as (Yaracuy: 1942-1977, Aroa: 1968-1988) which was obtained from the Ministry of the Environment of Venezuela.

The dynamics of the Yaracuy and Aroa rivers plumes were examined using the mean weekly satellite images of the chlorophyll spectrum obtained from SeaWifs, during September, October, November, and December 2000, and January, April, May, June, July, September and October 2001. The maximum area of impact (values over 1.0 mg m-3 of chlorophyll and suspended material) was calculated. The coastal area evaluated was estimated at a scale of 1:459.824, using a Geographical Information

System (GIS) designed by the Venezuelan Geographical Institute Simón Bolívar (2003).

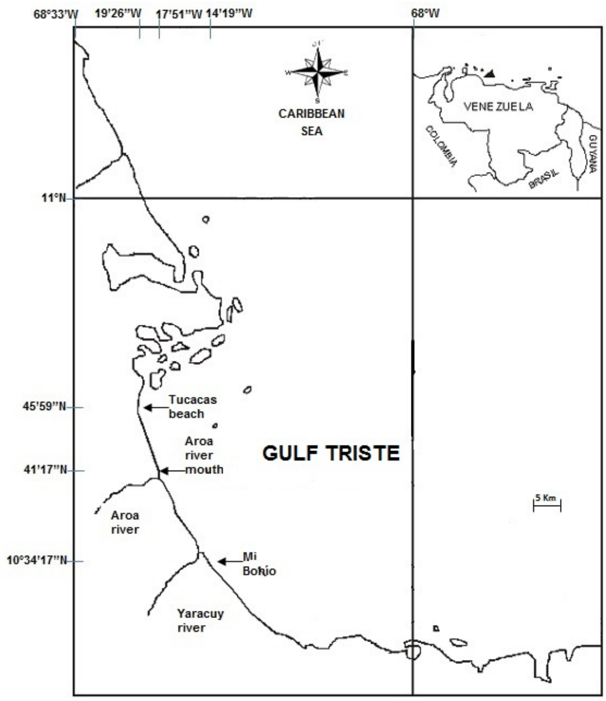

Figure 1. Map of the study area, showing the sites along the coastal side of Gulf Triste.

Sampling design and environmental variables along the coastal zone. Between September 2000 and December 2001 water physical-chemical characteristics were studied at three sampling sites along the coast (Figure 1). Temperature (°C), salinity (‰), dissolved oxygen concentration (mg L^{-1}), percentage of dissolved oxygen and pH were measured using a multiparametric probe (model Hydrolab DS4). For the analysis of Total Suspended Solids (TSS; Standard Methods, section 209-C and D, in APHA, AWWA, WEF, 1995), TN and TP, we collected water samples in plastic bottles of 1 l.

Statistical analysis. A two-way ANOVA was used to analyze the differences in the physicochemical parameters and nutrients between the Yaracuy and Aroa rivers, with river and quarters as factors, and the differences in the physicochemical parameters between the sites along the coastal zone and the quarters as factors. The gradients of the environmental parameters measured from the water column from the coastal field sites were determined during the dry (January-June) and rainy seasons (July-December), using Principal Components Analysis (PCA; CANOCO program version 4.5; Ter Braak, 1986) with weighted regression smoother between the salinity and the ordination factors by means of Loess methods (Cleveland & Grosse, 1991). Each variable was standardized and normalized. The groups established by the PCA were analyzed using a multivariate analysis of variance (MANOVA, InfoStat version 2014; Dirienzo *et. Al*, 2014).

Results

The influence of the rivers on the receiving waters. The Yaracuy and Aroa rivers differ in their physicochemical parameters: temperature (Annual average Aroa River: 29.71 ± 1.31 °C vs. Yaracuy River: 28.15 ± 1.54 °C; F=8.87, p<0.5), dissolved oxygen concentration (5.27 ± 1.68 vs. 3.62 ± 1.69 mg/l; F=8.01, p<0.05), percentage of dissolved oxygen (76.09 ± 23.43% vs. 48.52 ± 22.80 %, F=11.57, p<0.05), pH (8.61 ± 0.47 vs. 8.19 ± 0.38; F=8.96, p<0.05) and SST (43.67 ± 21.27 vs. 13.28 ± 12.18 mg/l; F=14.79, p<0.05) (Table 1). Nevertheless, there were no significant differences the salinity values between both rivers. The salinity presented an annual average of 0.74 ± 0.84 %o at the Aroa River and 1.26 ± 1.44 %o at the Yaracuy River. Besides the pH (F=6.09, p<0.05), there were no significant differences among months for both rivers in the physicochemical parameters. The Yaracuy River had more volume and total nitrogen and total phosphorus contributions than at Aroa River (Table I).

The plume impact area of both rivers presented variations throughout the survey. The maximum area of impact of Aroa and Yaracuy rivers in the coastal zone of Gulf Triste was diminished in January - March and April - June, 2001 (95.5 ± 9.19 and 2.5 ± 3.54 km^2, 0.60 and 0.02 times the coastal evaluated area, in the respective quarters) (Table II). The plume was largest during the last quarters in 2000 and 2001 (260.14 ± 121.97 and 208.67 ± 171.63 km^2, 1.64 and 1.32 times the coastal evaluated area, during each year, respectively).

The water column in the coastal zone. There were significant differences among sites in temperature (Mi Bohío: 28.67 ± 1.74 °C; Aroa river mouth: 29.32 ± 1.43 °C; Tucacas beach: 30.39 ± 1.64 °C; F=6.70, p<0.05), Salinity (Mi Bohío: 30.96 ± 9.24 %o; Aroa river mouth: 14.89 ± 10.56 %o; Tucacas beach: 33.29 ± 4.68 %o; F=21.73, p< 0.05) and TSS (Mi Bohío: 90.42 ± 21.55 mg/l; Aroa river mouth: 91.96 ± 82.41 mg/l; playa Tucacas: 154.42 ± 59.79 mg/l; F=6.39, p< 0.05) (Table III).

Table I. Annual Means (± standard deviation) of physicochemical parameters, contributions and volume of each river evaluated.

Parameter	Aroa	Yaracuy
Temperature (°C)	29.71 ± 1.31	28.15 ± 1.54
Salinity (‰)	0.74 ± 0.84	2.74 ± 6.46
Dissolved oxygen (mg L^{-1})	5.27 ± 1.68	3.62 ± 1.69
Saturation of dissolved oxygen (%)	76.09 ± 23.43	48.52 ± 22.80
pH	8.61 ± 0.47	8.19 ± 0.38
Total N contribution (g s^{-1})	0.82±0.81	3.42±4.4
Total F contribution (g s^{-1})	0.64±1.11	3.52±5.94
TSS contribution (g s^{-1})	126.64 ±31.7	124.83±68.74
Volume (m^3 s^{-1})	3.2±1.04	9.2±3.06

Table II. Maximum impact area of the sediment plume on the Gulf Triste coastal system, estimated from satellite images.

Date	Maximum Area of impact (km^2)
02/09 to 08/09	77
09/09 to 15/09	233
23/09 to 29/09	429
07/10 to 13/10	312
18/11 to 24/11	371
02/12 to 08/12	245
09/12 to 15/12	154
Sept-Dec 2000	**260.14 ±121.97**
01/01 to 06/01	102
15/01 to 21/01	89
Jan-Mar 2001	**95.5 ±9.19**
16/04 to 22/04	0
29/05 to 03/06	5
Apr-Jun 2001	**2.5 ± 3.54**
02/07 to 08/07	2
09/07 to 15/07	0
02/09 to 08/09	253
16/09 to 22/09	378
Jul-Sept 2001	**158.25 ± 188.61**
30/09 to 06/10	396
21/10 to 27/10	171
28/10 to 03/11	59
Oct-Dec 2001	**208.67 ± 171.63**

The physicochemical parameters that presented significant differences between the quarters were: temperature (F=7.71, $p<0.05$), dissolved oxygen concentration (F= 3.31; $p< 0.05$) and percentage of dissolved oxygen (F= 3.03; $p< 0.05$). The lowest average temperature occurred between July - September 2001 in Tucacas beach (26.16 ± 11.78 °C), whereas the highest average temperature occurred in the same period in the Aroa river mouth (30.83 ± 0.35 °C); the lowest average dissolved oxygen concentration occurred in July - September, 2001 in Tucacas beach (3.80 ± 1.97 mg/l), whereas the highest average occurred in the quarter October - December, 2001 in the same locality (6.25 ± 3.79 mg/l); the lowest average percentage of dissolved oxygen occurred in July - September 2001 in Tucacas beach (59.23 ± 30.86 %) whereas the highest average ocurred in January - March, 2001 in Mi Bohío (96.07 ± 10.39 %); the lowest average pH occurred in January - March, 2001 in Tucacas beach (6.38 ± 4.17) whereas the highest average occurred in the same quarter in the Aroa river mouth (8.80 ± 0.40).

Environmental gradients. Principal Components Analysis (Fig. 2) indicated that there was a marked gradient from a riverine to a marine influence along the section of coastline evaluated, from the sampling site Mi Bohío up to Tucacas beach. During the dry season (Figure 2-A) the sampling sites adjacent to the river mouths of the Yaracuy (Mi Bohío) and Aroa rivers showed lower salinities during all months than the farthest sites from the river mouths (beach Tucacas; the first factor explained 39.16 % of the total variance and 59.63 % of the variability in salinity, the second factor explained 21.15 % of the total variance and 22.38 % of the variability in salinity).

A pattern similar to the dry season presented itself in the ordination diagram of the rainy season (Figure 2-B). During this season, the first factor explained 29.94 % of the total variance and 5.07 % of the variability in salinity, the second factor explained 24.10 % of the total variance and 56.26 % of the variability in salinity. There were significant differences between the sites under marine (Tucacas Beach) and riverine (Mi Bohio, Aroa river mouth; MANOVA F= 5.62, $p< 0.05$)

Table III. Quarterly and annual means (± standard deviation) of the physicochemical parameters for the three study sites along the coast.

	Quarter (Month/Year)	Temperature (ºC)	Salinity (‰)	Dissolved oxygen (mg L^{-1})	Dissolved oxygen (%)	pH	TSS (mg L^{-1})
Mi Bohio	Sept-dec 00	29.06 ± 0.74	34.08 ± 3.63	4.86 ± 0.44	89.25 ± 7.44	8.27 ± 0.12	94.84 ± 20.55
	Jan-Mar 01	28.29 ± 0.08	28.5 ± 7.74	5.57 ± 0.73	96.07 ± 10.39	8.57 ± 0.35	88.15 ± 18.54
	Apr-Jun 01	28.7 ± 1.35	35.0 ± 0.0	6.20 ± 1.01	85.90 ± 11.81	8.63 ± 0.67	80.06 ± 37.39
	Jul-Sept 01	30.13 ±0.42	33.67 ± 4.93	4.50 ± 0.86	68.30 ± 7.83	8.33 ± 0.12	83.47 ± 21.16
	Oct-Dec 01	27.03 ± 3.48	22.50 ± 19.11	4.06 ± 1.87	69.10 ± 35.95	8.33 ± 0.46	104.13 ± 9.89
	Annual Mean	28.67 ± 1.74	30.96 ± 9.24	5.03 ± 1.18	82.19 ± 18.76	8.42 ± 0.36	90.42 ± 21.55
Aroa river mouth	Sept-dec 00	29.30 ± 1.16	18.21 ± 13.48	5.55 ± 0.71	92.20 ± 4.47	8.31 ± 0.14	133.15 ± 110.17
	Jan-Mar 01	28.42 ± 0.77	10.98 ± 16.47	5.93 ± 0.73	88.07 ± 11.71	8.80 ± 0.40	39.41 ± 7.78
	Apr-Jun 01	29.93 ± 1.65	20.33 ± 4.04	5.95 ± 0.88	83.73 ± 13.20	8.67 ± 0.42	44.74 ± 8.71
	Jul-Sept 01	30.83 ± 0.35	14.35 ± 10.67	4.30 ± 1.40	61.93 ± 15.66	8.33 ± 0.12	129.69 ± 120.09
	Oct-Dec 01	28.13 ± 1.63	9.47 ± 5.31	5.76 ± 1.60	78.93 ± 13.10	8.33 ± 0.50	83.34 ± 52.96
	Annual Mean	29.32 ± 1.43	14.89 ± 10.56	5.50 ± 1.12	81.68 ± 14.80	8.48 ± 0.36	91.96 ± 82.41
Tucacas beach	Sept-dec 00	30.07 ± 1.31	34.72 ± 3.93	5.17 ± 0.66	96.50 ± 12.92	8.32 ± 0.13	174.15 ± 119.36
	Jan-Mar 01	22.25 ± 13.97	34.26 ± 2.40	4.62 ± 2.80	76.26 ± 44.11	6.38 ± 4.17	154.48 ± 36.55
	Apr-Jun 01	26.59 ± 8.52	33.00 ± 4.36	5.67 ± 2.06	85.18 ± 33.34	7.47 ± 2.26	116.49 ± 56.76
	Jul-Sept 01	26.16 ± 11.78	35.33 ± 0.58	3.80 ± 1.97	59.23 ± 30.86	6.84 ± 3.05	128.32 ± 57.50
	Oct-Dec 01	25.37 ± 9.30	28.67 ± 8.50	6.25 ± 3.79	88.19 ± 49.04	6.91 ± 2.65	111.79 ± 36.68
	Annual Mean	30.39 ± 1.64	33.29 ± 4.68	5.91 1.87	93.76 ± 25.27	8.38 ± 0.41	154.42 ± 59.79

influence and between seasons (dry and rainy; MANOVA $F= 2.90$, $p<0.05$).

Discussion

There were differences in the physicochemical parameters and the contributions of nutrients between the Aroa and Yaracuy Rivers. Temperature, dissolved oxygen concentration, percentage of dissolved oxygen, pH and TSS, contributions of TN and TP showed differences in their annual means, but variations within year, with exception of the pH, were similar for both rivers. The plume impact area of both rivers showed variations throughout the survey, where the maximum area of impact was decreased during the dry season and increased in the rainy season.

The finding about the influence of the Yaracuy and Aroa Rivers plume along the coastal region, as observed from the satellite images, is confirmed by the Principal Components Analysis, since it shows a marked spatial gradient along the Gulf Triste coast (Mi Bohío, Boca de Aroa and Tucacas). There is an effect of riverine and marine environment, where sites located close to river mouths (Aroa, Mi Bohío) show lower salinity than the Tucacas beach, the farthest site from the river mouth. This spatial gradient was demonstrated by the difference in the physical chemical parameters related to riverine outputs among sampling sites. In other coastal zones of Venezuela, the influence of the fluvial contributions in the physicochemical parameters have been evaluated. The influence of riverine outputs on the coastal processes of near sandy beaches was assessed by measuring the physical and chemical characteristics of water and sediment samples at eight sites along the north central Venezuelan coast and from the rivers that flow through this region into the sea (Tuy, Capaya, Curiepe) during two field surveys (Herrera & Bone, 2011). Of the three rivers evaluated, the Tuy River had the highest impact on the coastal zone (789.15 ± 190.63 km^2) in terms of flow rate (246.39 m^3 s^{-1}), nutrients (659.61 ± 503.27 g s^{-1} TN; 52 ± 53.09 g s^{-1} TP) and sedimentary material (9320.84 ± 9728.15 g s^{-1}). The variables measured (salinity, total nitrogen and phosphorus, pH, turbidity, and total organic carbon) showed a spatial gradient along the coast. The Tuy River plume modifies the functioning of the coastal system processes by discharging large amounts of nutrients and sedimentary material into the water column, which are then distributed by marine currents and alongshore transport.

Another example is the Manzanares River in Sucre state (Venezuela), which has a catchment area of 1.652 km^2 and an average annual discharge of 558 x 106 m^3 of water at its mouth in the Gulf of Cariaco which produces a laminated plume generally directed towards the southwest as a consequence of

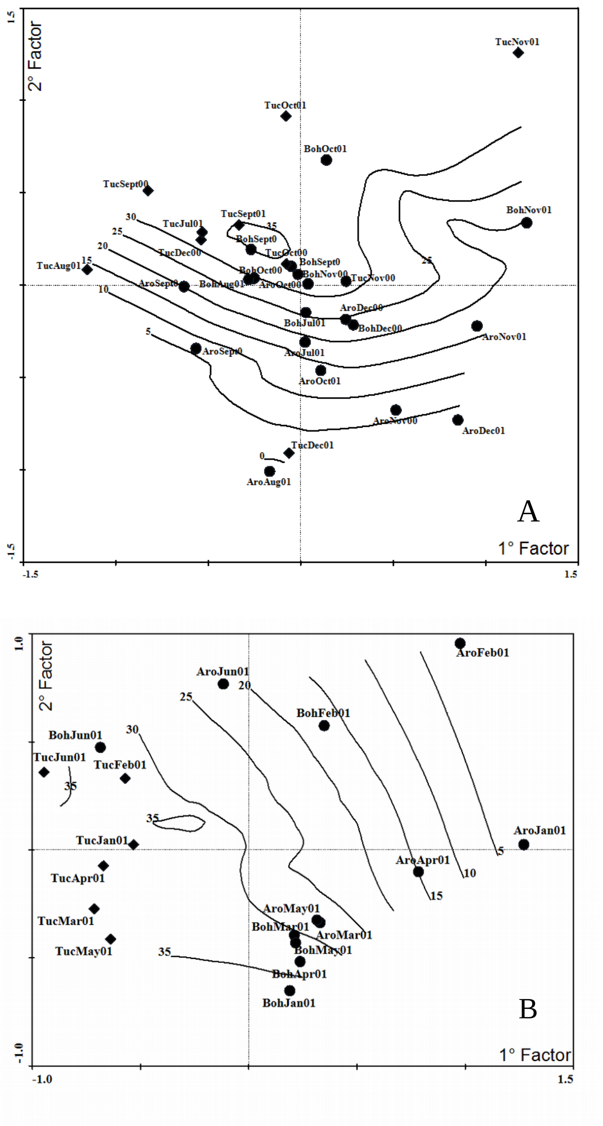

Figure 2. Principal components analysis of the physical-chemical parameters with smoothing curves of salinity for weighted regressions, measured from the water column at each study sites. a) Dry season, b) Rainy Season. Tuc: Tucacas Beach; Ar: Aroa mouth river; Boh: Mi Bohío.

trade winds (Martínez *et al.*, 2001). In the dry season, heterotrophic processes associated with the temporal nature of the river's expenditure dominate both in the riverine and mixing zones, with considerable reductions in the pH and dissolved oxygen, whilst in the marine zone autotrophic processes take over. The amount of suspended material is related to the flow of the river, being greater in the rainy season and lesser in the dry season, and showing a linear relationship with the concentration of nitrates, phosphates and silicates (Martínez *et al*., 2001).

These types of coastal dynamics and their products have been studied in other river influenced regions, in particular stratification. Moyer *et. al.* (2015) conducted a first-order assessment of the spatial and temporal variability of Dissolved Organic Carbon (DOC) in the four small sub-tropical rivers that drain into Tampa Bay, Florida, USA. No significant differences were observed in DOC concentrations with respect to river catchment, season, or year of sampling. Average daily fluxes of DOC into Tampa Bay rather than seasonal fluxes were highly variable and strongly influenced by discharge. Riverine DOC flux in the four river catchments ranged from 8.40 to 846.47 mmol day-1, with a bay-wide average of 166.21 ± 285.58 108 mmol day-1. Overall, the small sub-tropical rivers of Tampa Bay had DOC concentrations that were typical of other sub-tropical rivers and tidal tributaries within the region. Yin & Harrinson (2007) studied water quality parameters such as nutrients, phytoplankton biomass and dissolved oxygen, based on 11 years of water quality data in Victoria Harbor and examined how the Pearl River estuary discharge in summer and year round sewage discharge influenced these parameters in Hong Kong waters. The nutrient concentrations in Victoria Harbor are influenced by seasonal riverine inputs and the input of sewage effluent. There were strong spatial and seasonal gradients in salinity and water quality across the estuary, oceanic waters, particularly during the wet season. The stratification, which was mainly determined by salinity, followed a similar spatial and temporal pattern. The bottom salinity was lower in Victoria Harbor than on either side of it, due to the surface water of lower salinities mixing with the bottom water. Therefore, physical processes such as horizontal advection and vertical mixing (due to turbulent tidal flow and winds) determinates the formation of large algal blooms and low bottom oxygen waters in Victoria Harbor.

Although we not evaluated the biotic factors and its relation with the coastal processes studied in Gulf Triste, a variety of community descriptors on sandy beaches have been linked to environmental parameters such as beach morphodynamics and the contribution of rivers. Lercari & Defeo (2006) evaluated the influence of a salinity gradient produced by the Río de La Plata estuary, on species richness and abundance of benthic macrofauna communities at 16 beaches in Uruguay. These authors established that species richness increased with salinity, the width of the surf zone and Dean's parameter (index describing the state of a beach), and decreased with the salinity interval and the slope of the beach when they included these as prediction variables in the regression model (as well as grain size, the selection coefficient, penetrability and the organic material content of the sediment). Lercari & Defeo (2015), in a 2-year study to assess the seasonal dynamics of environmental and macrofaunal descriptors in sandy beaches of the Uruguayan coast defined by the estuary of the Rio de la Plata, found that beaches located towards freshwater conditions showed a major environmental dynamism, which generated high variability in species richness and abundance mainly driven by a higher intra-annual salinity variability in estuarine than in oceanic beaches. Decreasing abiotic and biotic variability towards oceanic conditions keep communities more stable. Fish and crustacean communities answer differently to fluvial contributions. Selleslagh & Amara (2008) established that temporal variations in fish and crustacean communities on sandy beaches on the French coast bordering the English Channel, responded significantly to factors such as temperature, tides, salinity, oxygen, turbidity and phytoplanktonic biomass. Species such as *Crangon crangon, Sprattus sprattus, Carcinus maenas, Syngnathus acus and Portumnus latipes* seem more abundant during periods of high salinity. Turbidity affected negatively the density of *Ammodytes tobianus* whereas oxygen has a positive effect on *C. crangon* and *Pomatoschistus microps*. Herrera & Bone (2015), in a survey in sandy beaches in the coastal central zone of Venezuela, concluded that environmental factors related to contributions of rivers as salinity, TN and TP concentrations and the season (rainy, dry), modulated the temporary and spatial changes of the fishes and crustaceans communities associated with these sandy beaches. In rainy season, the variation in the fishes and crustaceans communities were spatially related by change in turbity, pH and salinity, whereas in the dry season the TN and TP influenced the spatial changes of the fishes and crustaceans communities.

Finally, this investigation provided evidence that the contributions of the Yaracuy and Aroa rivers (Aroa river volume: 3.2 ± 1.04 m^3 s^{-1} ; Yaracuy River: 3.2 ± 1.04 m^3 s^{-1}) modulate the physical-chemical parameters in the coastal zone in Gulf Triste, expressed in a gradient of variation of salinity, from estuarine localities (Aora River mouth: 14.89 ± 10.56 ‰) up to localities with marine influence (Tucacas Beach: 33.29 ± 4.68 ‰). Researches in sandy beaches have found evidence that the contributions from rivers modulate both spatial and temporal variations of the biological communities in these ecosystems.

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