

# Water quality in a complex geomorphological lagoon at the Gulf of Mexico, based in recent and compared with information 30 years ago

## Abstract

The physicochemical composition of the tropical coastal water lagoons is result of several factors: sedimentary, fluvial, marine, biological and currently anthropogenic, which vary in space and time. To understand their tendency to change it is necessary to have a sufficient database. Take in account, the present study aimed to estimate the change in physicochemical or water quality in a coastal lagoon of the Gulf of Mexico based on data recorded from the 1970s of the last centuries until 2016-2018; likewise, the analysis was supported with a trophic index to estimate its degree of impact. The results shown the increase in orthophosphates, total phosphorus and chlorophyll "a" content that with the support of Carlson's trophic index defined a coastal lagoon as natural eutrophic in the 1970s and between 2016-18 to cultural hypertrophy, results of peripheral settlements.

**Keywords:** Trophic level, tropical coastal lagoon, Mexico

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## Introduction

The river water arrives coastal systems having a composition depends edaphology watershed, generating a gradient between freshwater and marine through tides which may be local variables and amplitudes. To this must be added the climate and its variability, which results in different concentrations in dissolved chemical compounds in water both spatially and temporally, with intervals that can be considered normal, as long as knowledge it has such variation and not subject to official regulations requiring specific concentrations and do not recognize the environmental change. A stranger to the nature of coastal environments factor is the influence of anthropogenic activities, which go beyond the normal range of physicochemical conditions of water and tend to deleterious conditions not only to aquatic organisms, but for men as well. There are chemical determinations practices that define the physicochemical or water quality; these are: temperature, salinity, pH, dissolved oxygen and their saturation, chemical oxygen demand or COD (measuring the organic load) and so-called nutrients (salts of nitrogen such as ammonia, nitrites, nitrates, total nitrogen that includes organic) and orthophosphates with total phosphorous (which also includes organic).<sup>1</sup>

To determine the physicochemical characteristics of the water of a lagoon and its tendency to increase, it is necessary to have previous information to compare their condition, modification or impact. If it not possible to have the necessary background of a coastal lagoon, at least look information systems or other surrounding lagoons in the country. It is noteworthy that the regulations previously NOM ECOL 001 (Mexican Norm) and now NOM 001-SEMARNAT-2003,<sup>2</sup> is unfortunately developed for wastewater discharges and even treated to induce misinterpretations and serious mistakes.

In a variation of full scale in the chemical parameters, now you have to take into consideration the influence of climate change also affects the coast by rising sea levels and declining contributions from rivers discharging into the area coastal result of its decline and damming for agricultural purposes and urban services in increments of substances harmful to ecosystems. Therefore, it is necessary to make adequate samples to each water body spatial and temporal planning to determine the extent of natural and influence changes as well as

anthropogenic factors affecting water quality and treatment capacity.

In Mexico there are just over 125 coastal systems<sup>3</sup> which are influenced by various anthropogenic activities local and waterways downloads from the origin of its basin until the arrival coastal systems, bringing a wide variety of contaminants collected in its path organic and inorganic materials such as nitrogen and phosphorus, fertilizers, biocides, metals, general trash where plastics include, among others, which have differences in the degradation time and even its stay in pelagic or benthic environment (flora and fauna) and sediments lagoons, estuaries and bays (marine environments) even in the ocean.<sup>4</sup>

Based on the above was chosen to Mandinga lagoon, Ver., In order to determine their conditions and physicochemical changes or quality of water in a in rains (August 2016) and another in drought (March 2018) considering not only two climatic seasons, but also the increase in population; it will assess water quality by natural climatic effects of season and those caused by human activities settled on its periphery with their downloads on the lagoon system. Likewise compare with previous studies since the early 1970s as Vazquez,<sup>5</sup> Contreras,<sup>6</sup> Aguilar,<sup>7</sup> de la Cruz,<sup>8</sup> CONABIO,<sup>9</sup> Contreras,<sup>10</sup> Contreras Espinosa,<sup>11</sup> BarreiroGüemez,<sup>12</sup> Herrera Silveira,<sup>13</sup> among others.

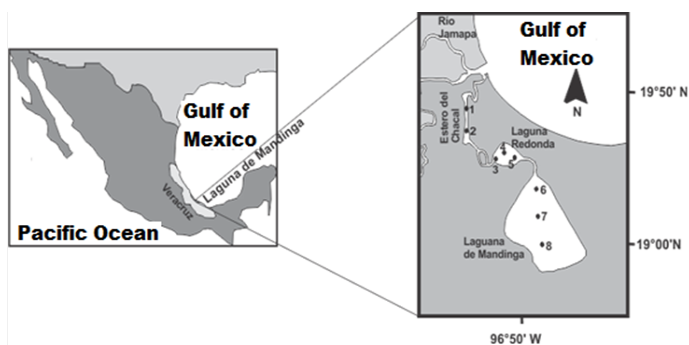
## Study area

Mandinga Lagoon is located between 19°00' and 19°06' north latitude and meridians 96°02' and 96°06' west (Figure 1) long with an area of 3,250ha and climate: AW2 (w) (i ' ) w'.<sup>14</sup> The rainfall is 1500mm per year, the rainfall occurs in the months of June to October and the drought season from November to May. It has a north-south orientation while the nearby coast adopts a northwest-southeast direction, forming the atoll of Antón Lizardo. To the northwest lagoon system, it is separated from the sea by a barrier of sand dunes. It is associated with Jamapa River, which originates with snowmelt from Pico de Orizaba, that runs 150km; also receives several small tributaries and Jamapa River that flows into the Gulf of Mexico.

## Methodology

In August 2016 eight were chosen sites sampling, same that were considered in the collection March 2018 (Figure 1). Sampling

consisted of in situ determination: temperature, salinity, pH, dissolved oxygen and their saturation and turbidity, recorded in the first five to 10 cm of the surface and deep as the depth and through the computer HIDROLAB YSI 556 MPS.



**Figure 1** Location of Mandinga Lagoon, Veracruz, Mexico and sampling sites.

In addition, water samples were collected for determination of chlorophyll “a”, nutrients to conserved refrigerated at 4°C in the laboratory, as recommended by Strickland and Parsons<sup>15</sup> and the APHA.<sup>16</sup> Likewise, techniques, the results were compared with previous information from 1980 to 2013 in order to estimate possible changes in physical chemistry due to peripheral human settlements in the space between the decade of the 80’s and 2013. In addition, the trophic status of the lagoon was calculated through trophic index by Carlson.<sup>17</sup>

## Results and discussion

Temperatures were in August, especially in surface between 29.78 and 31.11°C, interval with a little difference at the bottom between 29.13 to 30.94°C. In April surface interval was between 25.13 to 27.11°C and at the bottom of 24.91 to 25.89°C; marking a time difference that is greater in lower rainfall and dry, respectively. Intervals have been recorded by other authors since the early 80s of last century, considered typical of a Mexican coastal lagoon of the tropical latitude, dependent to the epoch year.

Salinity in August (rainy) interval ranged from 8.61 to 18.11ups result of the location of the sampling site with highs in marine intercommunication, a place where the influence of Jamapa River was recorded in conjunction with input seawater by bottom; with lower salinity sites sampling that was in the middle of the lagoon. In April (dry) increased the variation of salinity more than doubled, with the maximum in marine mouth (31.64-31.78 ups) with lower and homogeneous in the other stations in both surface and deep levels (29-36-27.65ups). 28 years ago, in the months of September-October and May, as Bornn<sup>18</sup> determined a saline range from 4.58 to 29.1 ups in the rainy and dry, respectively. Amador and Cabrera<sup>19</sup> determined a range of salinity from 3.1 to 33 ups, Morales<sup>20</sup> noted that the haline variation ranged from 13.9 to 34.6ups in the dry season, like other authors like Gomez<sup>21</sup> and Castan<sup>22</sup> intervals. This conservative parameter depends on the rains, the dry season, the influence of river discharge and therefore the geomorphology and location of the sampling site.

The dissolved oxygen content in both samples were heterogeneous result of being a factor by non conservative effects of photosynthesis and respiration, not by the epoch, with the lower scarcely contained in at the bottom. As for the percent saturation in the rainy season was estimated at 111.3% to 43.7% with a punctual site where the lowest level site was considered risky for biota; He noted at the

dryness the saturation range between 107.8 to 112.1% with greater uniformity, which denoted higher photosynthetic activity. a single low concentration was recorded at station 2 (Estero el Conchal) with 43.7% saturation in the bottom, critical level for the survival of benthic organisms. Cabrera<sup>19</sup> determined a level range between 1.7 to 9mg/L. like other authors like Gomez<sup>21</sup> and Castan<sup>22</sup> intervals.

The pH range was between 7.4 and 8.8, levels considered normal for such coastal environments. For its Cabrea<sup>19</sup> reported a pH range between 5.9 (acidic condition) to 8.3 (alkaline condition), result of the importance of geomorphology and time of sampling which involves the influence of diurnal variation in phytoplankton activity and respiration of plankton.

As nitrates and nitrites in both samples ranged between undetectable (0-M) up to 1.23uM until 0-14 (micromoles) concentrations considered low; even like determined by Bornn<sup>18</sup> and Contreras<sup>10</sup>; more than 30 years and 20 years ago respectively, which means the maintenance of good environmental status, regarding these nutrients.

The predominant form ammonia was specifically in April where sampling recorded > 12 uM. few differences in the concentrations of total nitrogen in the two sampled months, highlighting in August and April contents were approximately twice in both sites 7 and 8 (lagoon center) at surface and bottom, compared with the other stations.

The concentrations determined by Bornn<sup>18</sup>, Contreras<sup>10</sup> and Barreiro<sup>12</sup> determined that the nutrients were more abundant in the rainy season, where nitrates ranged between 0.7 and 3.4uM and ammonium, 2 to 8uM; Similar amounts within the given range in 2012-2013. Accordingly, these nitrogen nutrients define the lagoon without problems on water quality.

The range of variation of orthophosphates and total phosphorus (Table 1) (Table 2) showed lower levels in April were considered within normal variation for coastal systems; However, in August sites 7 and 8 (middle of the lagoon) were high that exceeded recorded as normal in coastal lagoons. Comparatively, in 1982 Bornn<sup>18</sup> quantificate lower contents both orthophosphates (1.7-2.8uM) and total phosphorus (2-12uM) and<sup>10</sup> estimated between 0.01 to 5.0uM orthophosphates and 5 to 10uM average total phosphorus; in 2002 Barreiro<sup>12</sup> determined a phosphate content, between 0.2 and 7uM. According to these authors the levels indicated a satisfactory state of ecological health, but the determination between 2012-2013 in the center of the Mandiga Lagoon (7 and 8 sites), exceeded more than doubled on average, probably due to different chemical factors between the water column and sediment,<sup>23</sup> although the contribution of wastewater is not discarded of the human settlements in peripheral villages.

The contents of chlorophyll “a”, were heterogeneous in space and time; in August which amounted to 56.4mg/m<sup>3</sup> at a site 5 (Laguna La Redonda) and even station 3 with 34.1mg/m<sup>3</sup> concentrations that can be slightly elevated compared to the rest of the sampled sites. Amador<sup>19</sup> quantify levels of this pigment between 54.19mg/m<sup>3</sup> and 40.27mg/m<sup>3</sup> in May and August respectively. According Barreiro<sup>12</sup> determined highest concentration of chlorophyll a, (22±2.3 mgm<sup>-3</sup>) recorded in the dry season, which corresponds to the spring; while the lowest content (3.4±1.3 mgm<sup>-3</sup>) occurred during the dry season (April) too.

Based on the Carlson index<sup>17</sup> trophic level of Mandinga Lagoon was heterogeneous in space and time, ranging from eutrophic by phosphorus and eutrophic hypertrophic for chlorophyll content “a”, as

presented in Tables 1, Tables 2 and Tables 3. However those categories, can be uncertain because of the wide variation of the parameters used in this study considered normal and in the case of using these indices, the category would be within natural eutrophication and certain sites sampled cultural eutrophication.

**Table 1** August 2016 sampling parameters of water quality of mandinga lagoon

Site	Prof	Hour	Prof	Temp	Sal	OD	Sat OD	pH	PO <sub>4</sub>	PT	NH <sub>4</sub>	NO <sub>2</sub>	NO <sub>3</sub>	NT	Chlorophyll "a"
			CM	° C	UPS	mg / L	%		uM	uM	uM	uM	uM	uM	mg / m <sup>3</sup>
1	SUP	12:19	183	29.78	14.49	6.75	95.7	8.76	1.29	9.35	7.14	0.07	0.07	22.86	4.70
	BOTT			29.13	16.00	6.25	85.1	8.42	3.87	14.84	9.29	0.14	0.00	25.00	
2	SUP	11:53	152	30.49	14.57	5.22	73.8	8.2	6.13	9.35	8.57	0.29	0.00	25.71	7.64
	BOTT			29.33	11.45	3.16	43.7	7.5	8.06	12.58	9.29	0.36	0.00	27.86	
3	SUP	11:21	152	30.73	10.87	5.79	81.7	8.2	3.55	8.06	7.86	0.21	0.00	24.29	34.1
	BOTT			30.01	12.31	5.78	81.4	8.0	3.87	12.26	8.57	0.50	0.00	27.14	
4	SUP	11:08	152	31.11	10.98	6.09	87.8	8.2	5.81	9.03	6.43	0.14	0.00	21.43	2.9
	BOTT			30.44	11.00	5.63	86.0	7.9	6.13	11.61	10.00	0.43	0.00	25.00	
5	SUP	10:53	152	31.08	10.97	6.01	86.8	8.5	4.19	8.39	7.86	0.21	0.00	24.29	56.4
	BOTT			30.15	9.81	4.65	62.3	8.2	5.48	10.97	8.57	0.29	0.00	27.86	
6	SUP	10:16	335	30.65	10.85	6.46	91.0	7.9	4.84	10.32	8.57	0.36	0.00	26.43	31.7
	BOTT			29.96	11.43	5.67	75.6	7.5	7.74	13.23	9.29	0.57	0.00	28.57	
7	SUP	9:52	213	30.45	10.78	6.18	85.9	7.79	18.71	21.94	7.14	1.07	0.00	50.00	18.2
	BOTT			30.35	11.28	4.64	65.7	7.39	30.00	33.23	7.86	1.14	0.00	53.57	
8	SUP	9:31	189	30.95	8.61	7.89	111.3	7.6	20.97	24.19	12.14	1.14	0.00	50.00	12.3
	BOTT			30.94	11.31	6.08	87.1	7.4	34.84	37.42	12.86	1.29	0.00	52.14	

**Table 2** April 2018 sampling parameters of water quality of mandinga lagoon

Site	Prof	Hour	Prof	Temp	Sal	OD	Sat OD	pH	PO <sub>4</sub>	PT	NH <sub>4</sub>	NO <sub>2</sub>	NO <sub>3</sub>	NT	Chlorophyll "a"
			CM	° C	UPS	mg / L	%		uM	uM	uM	uM	uM	uM	mg / m <sup>3</sup>
1	SUP	10:20	350	25.13	31.64	7.40	108.8	7.26	3.55	11.61	11.43	0.43	0.43	22.86	14.11
	BOTT			24.91	31.78	6.80	101.5	7.47	5.16	12.58	13.57	0.57	2.14	27.14	
2	SUP	11:00	250	25.85	2936	7.52	112.2	7.94	4.19	10.00	11.43	0.21	0.71	25.71	12.93
	BOTT			25.40	27.65	6.88	104.2	7.96	6.13	11.29	12.14	0.29	1.43	27.86	
3	SUP	11:28	185	26.04	28.84	7.31	109.1	8.08	3.23	12.58	11.43	0.36	0.71	13.57	26.46
	BOTT			25.45	27.40	6.90	104.5	8.11	3.55	13.55	12.86	0.57	1.43	15.71	
4	SUP	12:45	160	26.66	28.63	7.03	106.5	8.06	3.55	21.61	11.43	0.07	0.71	18.57	12.34
	BOTT			25.89	28.78	6.90	106.2	8.13	4.19	23.87	12.14	0.21	0.71	22.86	
5	SUP	11:47	225	26.11	28.76	7.17	112.0	8.01	3.87	12.90	12.14	0.21	0.71	24.29	8.23
	BOTT			25.24	28.62	6.83	108.4	8.12	4.52	13.55	12.14	0.29	0.71	27.14	
6	SUP	12:25	350	26.10	28.08	7.41	110.6	8.18	4.52	12.90	11.43	0.36	0.71	54.29	9.40
	BOTT			25.35	28.18	6.83	103.5	8.27	5.16	13.87	12.86	0.36	0.71	58.57	
7	SUP	12:08	180	26.19	28.06	8.00	119.4	8.18	3.55	12.90	9.29	0.14	0.71	47.86	11.76
	BOTT			25.2	27.99	7.40	112.1	8.20	4.84	14.19	10.71	0.71	1.43	52.14	
8	SUP	13:05	180	27.11	28.92	7.02	108.0	8.10	4.19	12.90	11.43	0.21	2.86	50.71	9.40
	BOTT			25.61	29.02	6.90	107.8	8.20	5.16	14.52	12.14	0.36	3.57	55.00	

**Table 3** Criteria application index eutrofización(carlson1977)

Trophic class	TSI	SD(m)	P(mg/m <sup>3</sup> )	CHL a (mg/m <sup>3</sup> )
	0	64	0.75	0.04
Oligotrophic (TSI <30)	10	32	1.5	0.12
	20	16	3	0.34
	30	8	6	0.94
	40	4	12	2.6
Mesotrophic (30<TSI<90)	50	2	24	6.4
	60	1	48	20
	70	0.5	96	56
Eutrophic (60<TSI<90)	80	0.25	192	154
	90	0.12	384	427
Hipereutrophic (90<TSI<100)	100	0.06	768	1183

## Conclusions

It notes that some physicochemical characteristics or water quality of Mandinga Lagoon have remained for several decades oscillating within normal ranges even with higher concentration called natural eutrophication for coastal area spatiotemporal variations. However, content of orthophosphate, total phosphorus and chlorophyll “a” had increased in specific sites in the peripheries to levels eutrophic or hypereutrophic using index Carlson<sup>17</sup> in this case it is possible called cultural eutrophication. This condition may be due to increased population in 1.87% (SEFIPLAN2016).<sup>24</sup>

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## Conflict of interest

The author declares that there is no conflict of interest.

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