

Water quality of the Marimonda and El Salado swamps (Necoclí-Antioquia)

Abstract

This work was carried out in the El Salado and Marimonda swamps, located in the municipality of Necoclí (Antioquia-Colombia) and some physicochemical parameters were analyzed. They were shown to be sporadically representative in the wet and dry periods. The study area included 7 monitoring stations in the Ciénaga Marimonda and 5 in the Ciénaga el Salado. The parameters that were measured were hardness, alkalinity, pH, chlorides, nitrates, sulfates and total coliforms, compared with the minimum quality requirements included in decree 1594 of 1984 for natural waters and resolution 2115 of 2007 for water for use. potable. The result of the application of the ICA for the Marimonda swamps in the dry season reveals better quality indices in all monitoring stations with values between 74.12 and 69.32, While in the wet season a slight deterioration in quality is observed. but keeping the classification on the scale with values ranging between 66.23 and 56.09. For the Ciénaga el Salado in the dry season it was 74.32 and 68.52, while in the rainy season it was 68.22 and 52.32. The results were compared with the standards established by Colombian legislation.

Keywords: contamination, ICA, dry season, health risk

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Introduction

In the world, water pollution represents the greatest health risk for humans, with a countless number of illnesses and poisonings occurring throughout history as a result of exposure to untreated or poorly treated drinking water.¹The main sources of contamination of water bodies are municipal, industrial and agricultural waste (solid and liquid), sludge, garbage, pesticides, effluents from livestock and poultry farms, among others, because all these residues contain polluting substances. which have different migration capacities, different toxicities, and different physical and chemical properties, making some of them represent a greater threat to the population, exerting their adverse effects even at very low concentrations.²

In the municipality of Necoclí, the main causes of environmental and ecosystem deterioration are the anthropic activities that are currently occurring in the region. The impacts generated by these limit the development of ecosystems and their communities, affecting their functioning, the sustainability of the natural base of the coastal zone and the services they support and offer to adjacent populations (Gobernación de Antioquia).

These bodies of water are home to a diversity of species, fauna and flora where nurses of multiple species of environmental and commercial importance develop and represent a potential for the development of the fishing activity on which the vast majority of the surrounding communities depend.³ Inadequate agricultural and livestock practices that are being carried out in this area can become possible sources of heavy metal contamination in fish, due to their high storage capacity of these compounds in their organisms, compared to the concentration present in the medium, this implies that its consumption can become a health problem for the populations that feed on this resource.⁴ Knowing the state of contamination that could exist in an area of the Urabá region (Ciénaga El Salado and La Marimonda), will allow this investigation to provide a reliable diagnosis of the level of water quality, in turn this information will allow the authorities to establish control standards and action strategies in the region.

Materials and methods

Study area

The study area included the Marimonda swamp, whose coordinates are 8°34'0" N and 76°49'0" W and 10°56'51" N and 74°55'16" W for the El Salado swamp. They are located to the north of the urban area of the municipality of Necoclí, about 45 minutes away by road.¹² representative random samplings were carried out in the wet (May 2017) and dry (March 2018) periods, Figure 1.

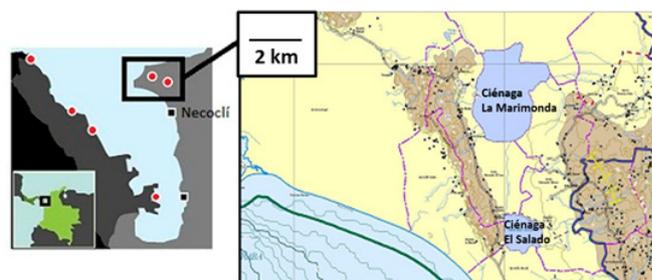


Figure 1 Study area map. Ciénagas El Salado and La Marimonda - Necoclí Antioquia.⁷

Physicochemical variables: Samples for physicochemical analyzes were taken using previously washed, dried and preserved 1L plastic containers (Table 1). For the analyzes of total and fecal coliforms, samples were taken in sterilized glass containers of 250 mL capacity with a screw cap.⁵

Table 1 Preservation of samples for analysis of physicochemical variables

Parameter	Preservation	Storage
Alkalinity	Refrigerate	14 days
chlorides	Refrigerate	28 days
Total hardness	HNO ₃ to pH<2 and refrigerate	6 months
Nitrates	H ₂ SO ₄ to pH<2 and refrigerate	48 hours
nitrites	Refrigerate	48 hours
Sulfates	Refrigerate	28 days

Table Continued...

Parameter	Preservation	Storage
COD	H2SO4 to pH<2 and refrigerate	14 days
turbidity	Use Amber Container	24 hours
fecal coliforms	Refrigerate	6 hours
total coliforms	Refrigerate	6 hours
S.T.	Refrigerate	7 days
OSH	Refrigerate	7 days

Samples were analyzed as soon as possible after arrival at the laboratory.

Statistical analysis of results. The f-test was used in the ANOVA table, which determines if there are significant differences between the means. If any, Multiple Range Tests determined which means are significantly different from others. If outliers are present, the Kruskal-Wallis test was chosen, which compares the medians instead of the means. The significance criterion is set at $p < 0.05$. The analysis was carried out using the statistical package Statgraphics Plus 5.1 (free software).

Results and discussion

The analytical results of the investigation are represented as the average of the values obtained in each sampling carried out, both for the wet and dry periods (May 2017 and March 2018 respectively).

Physicochemical variables

In addition to the physicochemical variables used in the calculation of the ICA, the variables temperature, conductivity, dissolved oxygen, total suspended solids (TSS), total hardness, alkalinity, chlorides, sulfates, nitrites and organic matter were additionally evaluated, in order to expand the baseline of environmental contamination of the El Salado and La Marimonda swamps. This allows developing a starting

Table 3 Average concentrations of physicochemical variables (Hardness, Alkalinity, Chlorides and Sulfates) in the sampling stations of the El Salado and La Marimonda-Antioquia swamps. EN: Dry season; E.LL: Rainy season. LC: Limit of Quantification. Different letters indicate a significant difference to the Tukey test (p -value<0.05)

Swamp	Station	Hardness mg CaCO ₃ /L		Alkalinity mg CaCO ₃ /L		Chlorides mg CaCO ₃ /L		Sulfates mg/L	
		IS	E.LL.	IS	E.LL.	IS	E.LL.	IS	E.LL.
The Marimonda	E-1	61.32±1.12 to	52.12±1.53b	51.13±2.32 years	43.68±1.53b	80.43±3.43 a	61.12±6.43b	45.43±4.22 years	39.97±2.12b
	E-2	54.33±2.43 a	46.18±1.87b	45.33±3.22 years	38.72±2.32b	57.83±5.33 a	43.95±6.32b	52.21±2.21 a	45.93±1.21b
	E-3	73.32±5.20 a	62.32±2.43b	47.33±4.22 years	40.43±2.42b	65.54±4.22 a	49.81±2.12b	7.33±2.42 to	50.45±2.32b
	E-4	78.76±4.22 a	66.94±1.64b	49.22±1.21 a	42.04±1.33b	67.43±3.32 to	51.24±1.21b	64.32±1.32 to	56.60±1.22b
	E-5	53.22±7.32 a	45.23±3.22b	45.53±1.42 to	38.89±3.22b	76.33±5.33 a	58.01, 2.42b	56.32±1.32 a	49.56±2.21b
	E-6	48.54±3.64 a	41.25±5.33b	65.33±2.43 a	55.81±3.45b	75.43±3.22 a	57.32±2.54b	58.34±1.42 a	51.33±2.21b
	E-7	76.44±1.42 a	64.97±2.42b	58.43±2.12 years	49.91±2.41b	58.54±4.22 a	44.49±1.32b	53.23±1.76 a	46.84±1.32b
Average		63.70±12.34 to	54.14±10.49b	51.75±7.47 a	44.21±6.38b	68.79±8.88 a	52.28±6.75b	55.31±5.87 a	48.67±5.16b
The salty	E-8	76.43±2.12 years	64.96±3.75b	56.75±1.42 to	48.48±2.53b	89.65±4.22 a	68.13±2.01b	56.44±1.98 to	49.66±2.08b
	E-9	56.33±3.21 years	47.88±6.43b	58.54±2.43 a	50.01±2.21b	98.55±5.32 a	74.89±2.13b	54.55±1.32 to	48.00±1.22b
	E-10	44.32±1.32 to	37.67±7.33b	65.33±1.43 a	55.81±3.22b	101.12±7.32 a	76.85±2.31b	57.44±1.43 a	50.54±1.43b
	E-11	53.32±1.42 a	45.32±1.23b	54.33±3.22 years	46.41±5.33b	134.22±4.22 a	102.00±1.98 b	53.55±1.88 to	47.12±2.42b
	E-12	76.42±1.53 a	64.96±2.21b	59.65±1.32 to	50.95±2.32b	120.21±3.22 a	91.35±2.03b	57.43±1.32 to	50.54±1.32b
Average		61.36±14.44 a	52.15±12.27b	58.92±4.11 a	50.33±3.51b	108.75±18.08 a	82.65±13.74b	55.88±1.76 a	49.17±1.55b
LC		5		twenty		2.34		5.22	

point to evaluate the subsequent impact produced by activities, mostly anthropic, on a natural resource, and on the basis of the environmental diagnosis of the region.

The results obtained in the two periods studied were compared by means of an analysis of variance (ANOVA), with a criterion of significance established at ($p < 0.05$). However, of the physicochemical variables evaluated, only the results of the variables: hardness, alkalinity, pH, chlorides, nitrates, sulfates and total coliforms, were compared with the minimum quality requirements included in decree 1594 of 1984 for natural waters and Resolution 2115 of 2007 for drinking water (Table 2). The other physicochemical variables, despite the fact that they were present in different concentrations, did not have comparison standards.

Table 2 Water quality criteria for different uses, according to Colombian regulations

Variable	Decree 1594, For natural water	Resolution 2115, For drinking water
Hardness	-	300mg/L
Alkalinity	-	200mg/L
chlorides	250mg/L	250mg/L
Nitrates	10mg/L	10mg/L
Sulfates	400mg/L	250mg/L
pH	5-9 Units	-
NMP CT/ 100ml	20000 MPN	0 MPN

For the La Marimonda swamp, the maximum and minimum values of the physicochemical variables were: Hardness (E4 dry season and E6 rainy season), Alkalinity (E6 dry season and E2 rainy season), Chlorides (E1 dry season and E2 rainy season), Sulfates (E4 dry season and E1 rainy season) (Table 3).

For the El Salado swamp, the maximum and minimum values of the physicochemical variables were: Hardness (E8 dry season and E10 rainy season), Alkalinity (E10 dry season and E11 rainy season), Chlorides (E11 dry season and E8 rainy season), Sulfates (E10 dry season and E11 rainy season). In general, there was a significant difference (p-value <0.05) between the values found in the dry season and the rainy season. In addition, none of the values found during the study exceeded the standards established by decree 1594 and resolution 2115, of Colombian legislation (Table 2).

The variables conductivity, pH, dissolved oxygen, % oxygen saturation, turbidity, TSS, ST, NMP of total coliforms, organic matter, COD and nitrates, presented p-values less than 0.05, therefore there is sufficient statistical evidence to conclude that there are significant differences between the levels obtained between the two seasons, with a confidence level of 95.0%. Therefore, the comparison with the quality standards was made based on average values of each season. Table 4 shows only the average values of the variables that had comparison standards.

Table 4 Average concentrations of physicochemical variables (pH, Nitrates, NMP and TC) in the sampling stations of the El Salado and La Marimonda-Antioquia swamps. EN: Dry season; E.LL: Rainy season. LC: Limit of Quantification. Different letters indicate a significant difference to the Tukey test (p-value<0.05)

Swamp	Station	pH		Nitrates mg/L		MPN and CT/100 mL**	
		IS	E.LL.	IS	E.LL.	IS	E.LL.
The Marimonda	E-1	7.02±0.18 to	7.09±0.23b	0.19±0.05 to	0.59±0.09b	6400±2321 to	7894±2322b
	E-2	7.21±0.21 a	6.98±0.30b	0.21±0.02 to	0.56±0.07b	4400±1439 BC	6743±2352b
	E-3	7.21±0.23 a	7.01±0.32b	0.21±0.01 to	0.57±0.05b	26000±2345 to	21883±1452b
	E-4	7.36±0.18 a	7.17±0.14b	0.23±0.01 to	0.62±0.02b	25200±2342 to	14566±1662b
	E-5	7.32±0.21 a	6.87±0.20b	0.16±0.02 to	0.64±0.02b	24300±1343 to	21775±1342b
	E-6	7.12±0.19 a	7.23±0.19b	0.45±0.01 to	0.57±0.01b	23600±2321 to	28094±2736b
	E-7	7.24±0.23 a	7.02±0.30b	0.34±0.01 to	0.63±0.03b	3760±1283 BC	26748±2435b
Average		7.21±0.11 a	7.05±0.12b	0.25±0.10 to	0.59±0.03b	4808.57±1087 to	11386.14±6094 b
The salty	E-8	7.12±0.11 a	7.12±0.12 a	0.18±0.02 to	0.54±0.02b	27900±1762 to	7944±972b
	E-9	7.11±0.12 a	7.33±0.08b	0.18±0.01 to	0.56±0.03b	29675±1873 to	10884±978b
	E-10	7.09±0.12 to	7.12±0.13b	0.17±0.02 to	0.54±0.03b	12423±1234 to	11837±1402b
	E-11	7.04±0.09 to	7.23±0.08b	0.21±0.03 to	0.57±0.01b	7644±1182 to	8983±2192b
	E-12	7.12±0.13 a	7.32±0.07b	0.23±0.03 to	0.58±0.04b	7654±988 to	8474±2781b
Average		7.09±0.03 to	7.22±0.10b	0.19±0.02 to	0.55±0.01b	9059±1062 to	9624±1661b
LC		---		0.031		---	

*Limit of Quantification, **Most probable number of total coliforms in 100 mL.

The pH and Nitrate values found during the study meet the criteria established in decree 1594 and resolution 2115, of Colombian legislation (Table 2), with the exception of total coliforms, which slightly exceeded decree 1594, of the station. E-3, E-4, E-5, and E-6 in the dry season. Likewise, stations E-3, E-5, E-6 and E-7 exceeded the limits according to decree 1594, but in the rainy season in the La Marimonda swamp, for the El Salado swamp the stations that exceeded the 1594 decree they were E-8 and E-9 exhibiting very high standard deviations. The increase in total coliforms and nitrates in the rainy season is due to runoff from livestock stables, streams and pipes that come loaded with waste or feces from warm-blooded animals,

Water quality index (ICA) of la marimonda and el salado swamps

The concentrations of the variables used in the calculation of the ICA (% oxygen saturation, NMP of total coliforms, pH, BOD, Temperature Change, nitrates, turbidity and ST), were transformed into a numerical value that allows defining in words the water quality of the La Marimonda and El Salado swamps and the final result was interpreted according to the ICA-NFS classification scale.⁶ Figure 2 shows the average of the quality indices, for the dry and rainy seasons of each of the monitored stations.

The maximum and minimum values found for ICA-NFS for the El Salado and La Marimonda swamps were at stations E-1 (dry season: 73.35) and E-12 (rainy season: 52.32) respectively. In the La Marimonda swamp, a slight deterioration of the water quality is

observed (decrease in the ICA) as the sampling stations progress, in both seasons of the year, but preserving the classification in the scale. In general, there was a significant difference (p-value <0.05) between the values found in the dry season and the rainy season, with the smallest values being in the rainy season. This decrease is mainly due to the high levels of turbidity that occurred during this season, in addition, lower values were found in the % of oxygen saturation compared to the dry season, which is consistent with the increase in the levels of turbidity. COD for most seasons. A similar behavior was obtained in the El Salado swamp.^{7,8}

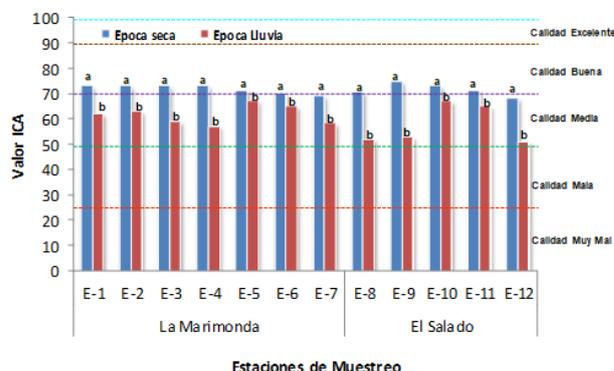


Figure 2 ICA values at the sampling stations of the El Salado and La Marimonda-Antioquia swamps. dry season and rainy season. Different letters indicate a significant difference to the Tukey test (p-value<0.05).

The results reveal a relatively constant mean quality index for the rainy season. However, in the dry season there were better quality indices (Good Quality) in all stations, except in stations E-7 and E-12 with values of 69.32 and 68.33 respectively. A general analysis of all of the ICA values between marshes and between stations shows that the Kruskal-Wallis p-value (P-value = 0.000510919) is less than 0.05, therefore there is a statistically significant difference between the medians between marshes and stations at a confidence level of 95.0%. Figure 3 shows the average ICA values found in the La Marimonda and El Salado swamps. There is a significant difference (p-value <0.05) between the values found in all the stations between different times. No significant difference (p-value >0.05) was found between marshes at the same time of the year. For the La Marimonda and El Salado swamps in the rainy season (E. LL) the quality is medium and for the dry season (ES) it is good quality.

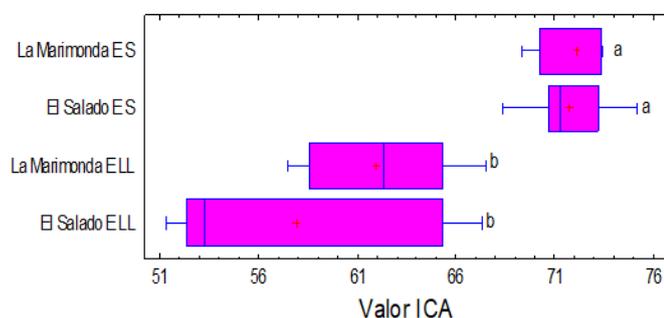


Figure 3 Average ICA values found in the La Marimonda and El Salado swamps. Dry season (ES) and Rainy season (E LL). Different letters indicate a significant difference to the Tukey test (p-value <0.05).

Conclusion

The results of the application of the ICA reveal the current state of the waters of the Ciénaga Marimonda and Salado, showing a similar trend throughout the 12 monitoring stations and a range of medium quality for both, in the rainy season and in good weather. Dry season. However, the lowest quality levels occurred during the wet season, mainly due to the increase in turbidity levels due to the dragging of suspended material generated by the rains.

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Conflict of interest

The authors declare there is no conflict of interest.

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