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Evaluation of the Quality of the Coastal Waters of Playa Dorada (Dominican Republic) and Their Impact on the Development of Tourism and Conservation

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Abstract:
Background: *Sun and beach tourism is one of the main socioeconomic activities in the Dominican Republic. These activities take place on beaches that are part of the coastal-marine systems of the country, where a great variety of vegetation and fauna can be found. In this sense, the aim of this article is twofold: firstly, the hygienic quality of the recreational and tourist water of Playa Dorada is analyzed; and, secondly, the Quality Index of Marine and Coastal Waters (ICAM) of Playa Dorada is determined. The study focused on the mouth of the Muñoz River, which is the main body of water that flows into the beach, one of the biggest beaches for sun and beach tourism in the Dominican Republic.*
Materials and Methods: *Water samples were taken at the mouth of the Muñoz River to determine different ICAM parameters. To calculate the ICAM, the INVEMAR platform (Colombia) was used, adapted with software that applies the formula used to calculate the ICAM. The data was collected using specialized equipment, tabulated in Excel and analyzed in the SPSS program.*
Results: *Presence of these microorganisms has been obtained in the waters that flow into Playa Dorada. The ICAM data show worrying values for NO3-, BOD and PO_4^{3-}. The pH has been inadequate, but an optimal evaluation of the variables OD, SST, CTE and HDD has been obtained.*
Conclusion: *The quality of the water at the mouth of the river Muñoz is optimal for the development of tourism and to guarantee the health of bathers but is detrimental to the development of the flora and fauna of the coastal-marine ecosystem.*

Key Words: *Tourism; Water quality index; Beach; Health.*

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I. Introduction

In the Dominican Republic, tourism is one of the main economic activities. According to data from the World Tourism Organisation (UNWTO), by the year 2020, the Dominican Republic will be growing steadily, receiving 6.4 million tourists and 7.5 billion dollars in tourism in 2019[1]. However, these figures, as has happened with other sectors, have been reduced by the COVID-19 crisis. In 2020, the Dominican Republic received 2.4 million tourists[1]. These figures, although they place it as the fourth destination in the Americas in 2020, after Mexico (24.3 million), the United States (19.4 million) and Canada (3 million), are very poor for the Dominican Republic's relationship with tourism and its importance for the socio-economic development of its local communities.

Puerto Plata, located in the north of the Dominican Republic, is the second sun and beach destination in the country[2]. This geographical area has beaches with All-Inclusive resort hotels, and is the main tourist destination in the Dominican Republic for tourists from North America, with Canada (57%) and the United States (42%) standing out, two of the main groups of demand. arriving in the country[3]. This destination has the main cruise port in the country, receiving 59.2% of all travelers in 2019[4]. It has attractive complementary offers that consolidate it as a complete sun and beach destination, with an average annual hotel occupancy rate of 55.7%, exceeding 80% in the months of January, February and March[3]. In short, and according to information from the Ministry of Economy, Planning and Development (MEPyD), tourism is the main economic activity in the city and province of Puerto Plata, representing 33% of all jobs[5]. Puerto Plata has several beaches, with Playa Dorada being the main one according to hotel occupancy and the number of All-Inclusive resort hotels it houses[5]. This beach is managed by the Association of Owners of Hotels, Condominiums and Commercial Establishments of Playa Dorada. The beach is located in a strategic position, being the closest beach to the city's International Airport. This beach, on the east side, receives the discharge of water from the Muñoz River.

Discharges produced in rivers, coming from anthropogenic activities, result in eutrophication in many estuaries and coastal waters of the world[6]. In this way, the process of economic development can cause significant changes in marine biodiversity[7]. Coastal-marine systems are home to different microorganisms[8] and are vital in the process of regulating the biogeochemical cycles of the earth[9]. Human activities have negatively influenced global coastal-marine systems by affecting the diversity and function of a wide range of key species, including seagrasses, corals and microflora[10]. Coastal pollution can increase the risk of dietary exposure of humans, due to heavy metals and antibiotics[11]. Furthermore, plastic pollution is a major threat to coastal-marine systems globally[12]. Therefore, organic and inorganic pollutants in coastal waters reduce water quality[13]. Organic and inorganic materials flow through rivers, upwelling processes, vertical mixing of water bodies, and anthropogenic sources such as agriculture, aquaculture, industry, fishing activities, fuel use, and ballast water from ships, among others[13].

The Marine and Coastal Water Quality Index (ICAM) is a tool designed and validated by the José Benito Vives de Andrías Marine and Coastal Research Institute (INVEMAR). This tool analyzes Dissolved Oxygen (DO), Nitrates (NO3-), Total Suspended Solids (TSS), Thermotolerant Coliforms (TTC), pH, Dissolved and Dispersed Hydrocarbons (HDD), Biochemical Oxygen Demand (BOD) and Phosphates (PO_4^{3-}). Through these parameters, and following a mathematical sequence, the conservation status of coastal water is quantified for the purpose of preserving flora and fauna. This tool has been widely used and its results have been published in scientific literature[14-17]. In the Dominican Republic, there is no similar tool and that is why this tool has been selected, which has been used by Colombia and other countries in the Latin American and Caribbean region. Therefore, analyzing the ICAM of a certain place is important to verify if the characteristics of the coastal waters are suitable for the conservation of the flora and fauna located in their vicinity. For instance, some studies with ICAM have shown that the DO of coastal waters has been decreasing in recent years, due to the nutrient inputs generated by anthropogenic activities[18].

The hygienic quality of coastal water has also been analyzed for recreational and tourist use. Some of the most used parameters to measure the hygienic quality of water have been Total Coliforms, Fecal Coliforms, *Escherichia Coli* and Fecal *Enterococcus*. These parameters are indicators of fecal contamination[19,20]. The use of these parameters as indicators of contamination of recreational and tourist waters was recommended by the United States Environmental Protection Agency (USEPA), because they could generate gastroenteritis, respiratory diseases, conjunctivitis and dermatitis in people[19]. Therefore, it is essential to analyze these parameters to know if a coastal area has adequate water for recreational and tourist use.

The goal of this research is twofold: first, to analyze the hygienic quality of recreational and tourist water in Playa Dorada; and, secondly, to determine the Quality Index of Marine and Coastal Waters (ICAM) of Playa Dorada. The study focuses on the mouth of the Muñoz River, which is the main body of water that flows into the beach. The contribution of this research is twofold. First, this study evaluates the hygienic quality of the water in one of the main sun and beach destinations in the Dominican Republic, which will help to draw conclusions for the Government of the Dominican Republic to design policies that can generate greater control of water pollution in the destination of Puerto Plata and, specifically, in Playa Dorada. Secondly, an ICAM is established to determine the water conditions for the preservation of life in marine-coastal systems. It should be noted that this study is aligned with the Strategic Plan of the Ministry of Environment and Natural Resources[21] of the Dominican Republic, which indicates the importance of conducting water quality studies in marine-coastal systems.

II. Materials and Methods

The methodology of this research has been divided into three parts. First, the sampling area is presented. Next, the variables measured in this research are described, as well as the materials and methods used to obtain the data and, finally, the program used for the tabulation and analysis of the data is presented.

Sampling area

The location of this research focuses on the mouth of the Muñoz River, located on the main beach of the city of Puerto Plata: Playa Dorada. This is one of the main tourist beaches in the Dominican Republic[3]. Along the river banks there are several human settlements along the river, which can have a negative impact on the waters that flow into the beach, due to contamination from domestic wastewater, inadequate solid waste disposal and agricultural runoff.

To select the sampling point, the following procedure was followed:

Phase 1: The research team located and selected the main tourist and recreational points of the city of Puerto Plata, using the Google Earth tool.

Phase 2: Three field visits were carried out along the marine-coastal systems of the city, following the locations previously selected in Google Earth. These visits were made during the months of January and February 2019. The purpose of these visits was to locate possible bodies of water that flowed into the beaches.

Phase 3: Three technicians from the Ministry of Environment and Natural Resources of the Dominican Republic, two from the Puerto Plata Aqueduct and Sewer Corporation (CORAAPPLATA) and two from the Playa Dorada Hotel and Condominium Owners Association were interviewed. These interviews helped to understand aspects such as the wastewater treatment used in the city and in the hotel complexes, the behavior of the local population and its link to the coast, and the behavior of tourists in the city.

Phase 4: A new visit was made along the coast, in order to take aerial images with a drone. The aim of this activity was to obtain images of the vulnerable points of the coast where a mouth of a water body could be observed in the sea. Through the images, information was obtained on the accumulation of solid waste in coastal areas, and the real proximity of human and industrial settlements to the coast and to water bodies. This information is relevant to understand some values obtained in water sampling.

Phase 5: The information obtained during the visits, photographs and interviews was analyzed, and the area of the mouth of the Muñoz River in Playa Dorada (coordinates 329078, 2186277) was selected.

Research variables, materials and methods

At the sampling point, the UTM coordinates were determined, georeferenced with coordinates (X, Y) in the UTM DATUM WGS84 system, using a Garmin GPS, GPSMAP 64 model, which is a high-sensitivity GPS and GLONASS receiver with a Quadrifilar Helix antenna. In addition, meteorological variables were measured: ambient air temperature, relative humidity, wind speed, and prevailing wind direction. For this, an Extech Model 45170 portable station was used, where the temperature of 0-50^{o}C with a precision of 0.1^{o}C, the wind speed of 0.0 – 30 m/s with a resolution of 0.1 m/s and relative humidity from 10 to 95% with an accuracy of 4%. Indirect methods were used to determine the wind direction.

To calculate the Marine and Coastal Water Quality Index (ICAM), the tool validated by the José Benito Vives de Andrías Marine and Coastal Research Institute (INVEMAR) of Colombia was used. The ICAM is a statistical information tool that allows evaluating changes in the state of marine and coastal water quality, based on criteria or standards that allow quantifying the state of conservation or deterioration of water according to its characteristics and according to its use or destination in a specific place and time[22]. The analysis of the individual variables allows a clear visualization of the quality of the water resource, which is why the aim is to generate a water quality indicator that serves as a basis for interpreting the concentration levels of the physicochemical and microbiological parameters present in the environment[22].

The methodological process validated by INVEMAR is as follows:

Phase 1: Sampling in field trips. They were conducted during 2019, in three different periods of the year: March 8 (drier season), June 12 (rainy season) and September 18 (cyclonic season). In each of the three samplings carried out, a water sample was obtained at the same time: 1:00 PM

Phase 2: Processing of samples in the laboratory. The services of Environmetal Quality Laboratories SRL (EQLAB), with headquarters in Puerto Rico and with a facility in the Dominican Republic, were contracted. This company has more than 20 years of experience in water quality analysis in the Dominican Republic and has environmental accreditation from the Ministry of Environment and Natural Resources of the Dominican Republic, the United States Environmental Protection Agency (USEPA), the United States Food and Drug Administration (USFDA), the International Organization for Standardization of Information, and the National Environmental Laboratory Accreditation Program of the United States (NELAC).

Phase 3: Data entry to the database. Once the reports with the data were received, they were loaded into the INVEMAR system.

Phase 4: Calculation of adjusted curves. The data from each sample was processed in the INVEMAR system.

Phase 5: Calculation of the ICAM. ICAMs were calculated for each of the three samplings. The ICAMs are formulated to estimate water quality for the purpose of preserving flora and fauna in marine and coastal water bodies[23].

Phase 6, 7 and 8: Analysis, reporting, dissemination of results and continuous improvement. The data has been analyzed and the results are presented in this article, with the purpose that the published document can be used by the institutions with competences in the decision making of Playa Dorada, and of tourism and the management of the rivers and marine-coastal systems of the Dominican Republic.

The ICAM includes the analysis of 8 variables. These variables represent, according to their acceptance or rejection values, a water quality or condition based on the reference values of international standards considered suitable for protecting marine-coastal systems[24]. However, if for some reason one of the required variables is missing, the aggregation equation allows supporting the calculation of the ICAM with a minimum of variables, but it should be taken into account that the confidence margin of the result decreases, as well as its objective representativeness[23]. Table no: 1 shows each ICAM parameter, its unit of measurement, the method and instrument or technique used to obtain the data.

Table no 1: ICAM parameter.

Parameter	Unit of measure for the ICAM	Method	Instrument or technique
Dissolved Oxygen (DO)	mg/l	SM4500-OC	HACH Multiparameter HQ40D
Nitrates (NO3-)	µg/l	H-8039	Spectrophotometer (HACH), model DR6000
Total Suspended Solids (TSS)	mg/l	SM 2540D	Spectrophotometer (HACH), model DR6000
Thermotolerant Coliforms (CTE)	MPN/100ml	SM 9221B	Multiple Tube Technique & Fermentation
pH	Unit	EPA 150.1	HACH Multiparameter HQ40D
Dissolved and Dispersed Hydrocarbons (HDD)	µg/l	EPA-1664A	Gravimetric Extraction with Hexane, Analytical Balance (Sartorious), model TE1200-OCE
Biochemical Oxygen Demand (BOD)	mg/l	SM 5210B	Incubation Dilution
Phosphates (PO_4^{3-})	µg/l	SM 4500-PE	Spectrophotometer DR 2800HACH

Source*: Own elaboration* Note related to the parameter and its acronyms: Dissolved Oxygen (DO); Nitrates (NO3-); Total Suspended Solids (TSS); Thermotolerant Coliforms (TTC); pH; Dissolved and Dispersed Hydrocarbons (HDD); Biochemical Oxygen Demand (BOD); Phosphates (PO_4^{3}-).

The ICAM provides an index that evaluates the level of impact of anthropogenic and environmental activities and their relationship with the development of marine life and biological processes in the marine-coastal system. To evaluate the quality of water for tourist and recreational purposes, and following the methodology of previous studies[25], Total Coliforms, Fecal Coliforms, *Escherichia Coli* and Fecal *Enterococcus* are analyzed. The four variables were analyzed with the multiple tube and incubation technique.

Data analysis tools

The data obtained through the Extech Model 45170 portable station and the instruments or techniques used were tabulated in Microsoft 365 2021, using the Excel version 16.49 program. Subsequently, the tabulation was transferred to the IBM SPSS program (version 24) to carry out the descriptive analyses of the research variables. To calculate the ICAM, the INVEMAR platform was used, adapted with software that applies the formula used to calculate the ICAM. The equation used is shown below[24]:

- ICAM = $[(_{XOD})^{0.16}$ x $(_{XpH})^{0.12}$ x $(XSST)^{0.13}$ $x_{(}XDBO)^{0.13}$ $x_{(}XCTE)^{0.14}$ $x_{(}^{XHDD)0.12}$ $_{x}(^{XNO3-)0.09}$ $x_{(XPO_4^{3-}}])$*0.131/Wi*.
- X_i = quality sub index of variable *i*.
- W_i = weighting factor for each sub index *i* according to its importance within the ICAM, which is weighted between 0 and 1.

The NO3-, HDD and PO_4^{3-} data were obtained in the unit of measurement of mg/l. The values obtained were converted to mg/l and µg/l, before entering the data in the software for the calculation of the ICAM. The data obtained has been compared with the ICAM assessment scale (Table no 2).

Table no 2: ICAM assessment scale.

Quality Scale	Color	Categories	Description
Optimal	Blue	100-90	Excellent water quality
Adequate	Green	90-70	Water with good conditions for aquatic life
Fair	Yellow	70/50	Water that maintains good conditions and few restrictions on use
Inadequate	Orange	50-25	Water with many use restrictions
Terrible	Red	25-0	Water with many restrictions that do not allow for adequate use

Source: Own elaboration, based on Vivas-Aguas and Navarrete-Ramírez[24]

III. Results

Table no 3 shows the data referring to the meteorological variables (temperature, relative humidity, wind speed and predominant wind direction) of the sampling area, collected during the obtaining of the samples. The meteorological conditions for the sampling days remained very stable, with high temperatures, above 27°C and up to 33.3°C in the third sampling. The days were sunny, with few clouds and prevailing relative humidity established between 59-64.4%. The wind speed was normal for the coastal zone, with light to moderate breezes, with speeds of up to 5.5 m/s during the second sampling. On the days preceding sampling 1 and 3, no rain was reported. In the days that preceded sampling day 2, rains were reported in the city of Puerto Plata. It did not rain during any of the three sampling days.

Table no 3: meteorological variables.

Variables	Sampling 1 (March)	Sampling 2 (June)	Sampling 3 (September)
Temperature (°C)	27.3	33.1	33.3
Relative humidity (%)	60.1	59.1	64.4
Wind speed (m/s)	4.7	5.5	2.2
Predominant direction	E-O	E-O	E-O
Precipitation during sampling?	No	No	No
Precipitation during the previous days?	No	Yes	No

Source: Own

In relation to obtaining the data for each of the eight variables, Table no 4 shows the value obtained for each variable in each of the three samplings carried out. The table shows that no data was obtained on CTEs greater than 1.8NMP/100ml, which is the minimum detected by the measurement instrument. These same results were generated with the analysis of Total Coliforms, Fecal Coliforms, *Escherichia Coli* and Fecal *Enterococcus* , obtaining the data of <1.8 NMP/100ml for each of the four variables for the three samplings. No data was detected in sample 2 of the TSS either. For its part, no data were obtained for the HDD, where the analysis of fats and oils was also deepened, and where no detectable values were obtained. The other variables, in their different samples, obtained significant data for the ICAM analysis.

Table no 4: Data of the variables during each sampling.

Variable	Sampling 1	Sampling 2	Sampling 3	Average
Dissolved Oxygen (DO)	7.89mg/l	5.11 mg/l	7.55 mg/l	6.85
Nitrates (NO3-)	3.4 mg/l (3400 µg/l)	4.6 mg/l (4600 µg/l)	0.9 mg/l (900 µg/l)	2.96 (2960 µg/l)
Total Suspended Solids (TSS)	8 mg/l	Not detected	37.3 mg/l	15.1
Thermotolerant Coliforms (CTE)	<1.8 MPN/100ml	<1.8 MPN/100ml	<1.8 MPN/100ml	<1.8 MPN/100ml

pH	9.57 SU	8.94 SU	9.53 SU	9.35
Dissolved and Dispersed Hydrocarbons (HDD)	0 mg/l (Not detected) (0 µg/l)	0 mg/l (Not detected) (0 µg/l)	0 mg/l (Not detected) (0 µg/l)	0 mg/l (0 µg/l)
Biochemical Oxygen Demand (BOD)	354 mg/l	372 mg/l	297 mg/l	341 mg/l
Phosphates (PO_4^{3-})	0.10 mg/l (100 µg/l)	0.10 mg/l (100 µg/l)	0.05 mg/L (50 µg/l)	0.08 mg/l (80 µg/l)

Source: Own

Table no 5 shows the ICAM data for each variable in each of the samples taken. The general indicator of the ICAM for sampling 1 and 2 was terrible, and for sampling 3 inadequate. The variables with poor results are NO3- and BOD for the three samples. The pH and PO_4^{3-} are also terrible in the first sampling. For the second sample, the PO_4^{3-} is also terrible. These variables with such low ICAM values are what cause the general ICAM to be very low. On the other hand, the OD, the TSS, the CTE and the HDD obtain good scores on the scale.

Table no 5: ICAM for each variable and sampling.

Variable	Sampling 1	Sampling 2	Sampling 3	Average ICAM
Dissolved Oxygen (DO)	97.95	64.33	95.31	85.86
Nitrates (NO3-)	1	1	1	1
Total Suspended Solids (TSS)	88.92	100	65.22	84.71
Thermotolerant Coliforms (CTE)	100	100	100	100
pH	16.89	47.37	18.3	27.52
Dissolved and Dispersed Hydrocarbons (HDD)	100	100	100	100
Biochemical Oxygen Demand (BOD)	0.88	0.89	0.86	0.87
Phosphates (PO_4^{3-})	5.25	5.25	100	36.83
General ICAM	15.97	13.14	27.37	18.82

Source: Own

IV. Discussion

The previous results show that the waters of the Muñoz River, which flows into Playa Dorada, are suitable for recreational and tourist purposes, but are terrible for processing marine life and biological processes. This research is, in the opinion of the authors, the first to be carried out in the Dominican Republic in terms of analysis of water quality for tourist-recreational purposes and for the conservation of marine life and biological processes.

Sun and beach tourists spend most of their time in the sand and water of the beach, and microorganisms are a significant component in this environment, acting as a reservoir of vectors and a source of infections for users[26]. To date, the determination of Total Coliforms, Fecal Coliforms and Fecal *Enterococcus* in marine waters for tourist use has been considered as an indicator to assess the hygienic quality of recreational and tourist water[19,24,25]. The presence of *Fecal Enterococcus* is considered an indicator of fecal contamination from human sources[27]. For its part, *Escherichia Coli* is associated with contamination near drains[25] and is a variable that the World Health Organization (WHO) recommends analyzing to ensure the hygienic health of users of tourist and recreational beaches[28].

In this investigation, no presence of these microorganisms has been obtained in the waters that flow into Playa Dorada. This is striking for two reasons: first, considering the number of human settlements on the banks of the Muñoz River and, second, because the presence of human settlements on the banks of rivers has been a problem for beach pollution in other geographical areas of the Latin American and Caribbean region, due to uncontrolled discharges. Therefore, it can be affirmed that the hygienic quality of the water for recreational and tourist use in Playa Dorada is optimal. The data obtained indicate that, according to the classification made by the Ministry of the Environment and Natural Resources of the Dominican Republic for coastal waters[29], Playa Dorada is included in Class E. Class E beaches are suitable for carrying out recreational and tourist activities in contact with water[29].

In relation to the results of the Marine Environmental Information System (SIAM), and more specifically of the ICAM, an optimal assessment of the variables OD, SST, CTE and HDD has been obtained. DO is necessary for the respiration of microorganisms and is essential to sustain aquatic life and determine the survival of species and biological production processes[30]. TSS can be harmful to habitats and cause anaerobic conditions on beaches, due to the decomposition of solids that run through the body of water[24]. High TSS values reduce the entry of sunlight into the water and generate clogging problems[30]. CTEs are used to assess the sanitary quality of water[30], since their presence is related to the transmission of pathogens[30]. For their part, HDDs prevent gaseous exchange with the atmosphere, causing greater toxicity and reducing the entry of sunlight into the body of water, which makes life difficult for marine-coastal populations[30].

The values obtained for the variables NO3-, BOD and PO_4^{3-} were dismal. High levels of NO3- indicate anthropogenic contributions such as groundwater contamination[24], since nitrate is the end product of waste stabilization[24]. In the case of this research, they can appear from the wastewater and fertilizers that reach the river. The dismal BOD may be due to domestic tributaries along the human settlements along the river[24] and its current state causes serious damage to the marine-coastal flora and fauna of Playa Dorada. The PO_4^{3-} are necessary for marine-coastal life, but an excess causes the development of algae and the eutrophication of the waters. In the case of Playa Dorada, it may be due to sewage or residual water that enters the river throughout the basin[30].

On the other hand, the pH has been inadequate. An adequate degree of pH in the water helps to prevent the effects of contamination on marine-coastal communities[24]. The neutral range must oscillate between 4-9[24], although, in the present study, it exceeds the value of 9 in the first and third sampling. Although the pH values are not highly negative, the anthropogenic and environmental activities carried out along the Muñoz river basin should be controlled, such as gravel extraction in some areas of the upper basin of the river or the drainage ways used by human settlements.

V. Conclusions

The quality of the existing waters at the mouth of the Muñoz River offer a terrible quality for the variables NO3-, BOD and PO_4^{3-}; inadequate pH quality; and adequate quality for the OD, TSS, CTE and HDD variables. The data obtained for these variables generate a very poor ICAM, which hinders the development of marine life in the marine-coastal systems located near the mouth of the Muñoz River at Playa Dorada. Therefore, the quality of the water is optimal for the development of tourism and to guarantee the health of bathers, but it is detrimental to the development of the life of the flora and fauna of the coastal-marine ecosystem.

The results of this study are useful for the Government of the Dominican Republic, especially for the Ministry of Tourism and the Local Government of Puerto Plata. In this sense, the Ministry of Tourism can promote a clean destination, offering beaches and complementary activities in an environment with good hygienic water quality in Playa Dorada, its main sun and beach destination. It is recommended that the local government of Puerto Plata develop policies and strategies to ensure greater control of solid waste and residues that are dumped into the Muñoz River from the different settlements along the river basin. On the other hand, the Ministry of the Environment and Natural Resources must regulate anthropogenic activities that take place in some parts of the river basin, such as gravel and sand extraction. These processes pollute the river and generate unsustainable environmental impacts on both the river's flora and fauna and the coastal-marine system. Also, given the data obtained in the Playa Dorada ICAM, it is recommended that the Ministry of the Environment and Natural Resources develop monitoring and follow-up activities, as well as bioassays and evaluation of the physicochemical and toxic parameters that could appear at the mouth of the river.

Like all research work, this study has some limitations. In this sense, it should be noted that the research is planned from a single sampling point. Although it is the main body of water that flows into Playa Dorada, it would have been relevant to do more sampling at other points on the beach. As a future line of research, it would be interesting to introduce new samples in more areas of the beach. Also, it is recommended to apply the methodology carried out in this study in other coastal and tourist regions of the country.

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