

Evaluation of Water Quality for Bathing Conditions in the Hydrographic Basin of Francisquinha in Porto Nacional

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Abstract— *The search for recreational activities is letting the bathers vulnerable to possible contamination in the bathing places, generated by waste from the sewage, accumulation of waste, pollutants present in the atmosphere, pesticides used in plantations that somehow reach the riverbeds, among several others that end up causing, for the most part, the emergence of bacteria such as total coliforms and Escherichia coli (E. coli). The objective of this article is to evaluate the water quality of the Francisquinha stream in the municipality of Porto Nacional - Tocantins, promoting a bathing conditions study, where microbiological analyzes were performed through the indicators of the total coliform group and Escherichia coli (E. coli) defined by CONAMA Resolution No. 274/00. Through the Colilert technique employed, it was possible to detect simultaneous, specific and confirmatory identifications of these bacteria. The results of the monitoring of the chosen points were compared with the parameters established for bathing purposes, with the conditions being categorized as being proper or inappropriate for bathing.*

Keywords— *Bathing conditions; water quality; total coliform and Escherichia coli (E. coli).*

I. INTRODUCTION

Water is a natural element extremely necessary for human survival. Throughout history, regarding economic and social activities across the globe, water resources have always had a fundamental importance, with the increasing diversification of anthropic activities as a consequence of economic and social development, it implies a greater demand for water in quality and sufficient quantity to meet the need of the users.

Among these functions, we have the following: domestic supply, industrial supply, irrigation, animal use, ecological preservation of fauna and flora, creation of species, generation of electric power, navigation, landscaping, dilution of residue, recreation and leisure.

The use of water for recreation purposes is of great importance for human culture due to the increasing use of these waters by the bathers and may contain health risks if they are contaminated by waste from sewage or garbage that ends up being washed away or dumped directly on the river.

There are also other pollutants found in the atmosphere or in the soil as well as the application of toxic products in agriculture, which when they reach the body of water, they also deposit pathogenic microorganisms and toxic elements. These factors can cause great imbalance to the aquatic environment that consequently generate serious risks to the health of the users.

Primary contact refers to activities such as swimming, surfing, water skiing and diving, in which especially children may have water ingestion or contact with the eyes, ears, membranes, mucous membranes or even skin cuts. Therefore, it is very important to make the evaluation of the quality of the water for bathing purposes in order to know if the place evaluated will meet the requirements for proper bathing conditions.

In 2001, the Luís Eduardo Magalhães Hydroelectric Power Plant was built in the municipality of Lajeado - TO, as the Rio Tocantins contained at that time a great potential for electricity generation. As a result, the river eventually became a lake, causing the water level to rise during the damming, with the submersion of the riparian forest, beaches and buildings located on the banks of the lake.

Therefore, the water quality for recreational activities may have suffered changes, being affected due to possible contamination caused by this event.

CONAMA Resolution 274/00 states that fresh, brackish and saline waters will have the quality levels evaluated by specific parameters and indicators, in order to ensure the bathing conditions (primary contact recreation such as diving, swimming, water skiing and

sport fishing). Therefore, were determined the Most Probable Number (NMP / 100ml of water) of the group of fecal coliforms (thermotolerant) and *Escherichia coli* (*E. Coli*) present in the waters of the Tocantins River basin and the Francisquinha stream, were determined.

The Francisquinha basin, located in the municipality of Porto Nacional-TO, has part of its location adjacent to the Francisquinha sewage treatment plant, and the stream is a good object of studies to evaluate its bathing conditions since because of the presence of sewage in its surroundings, there is a great possibility that the water under evaluation is contaminated by the sewage present there

With this perspective, the purpose of this study was to evaluate the water quality conditions for bathing purposes of the Francisquinha river basin in the Tocantins river. The presence of fecal coliforms (thermotolerant) and *Escherichia coli* were also verified. Physical and microbiological parameters of the water were also analyzed at two monitored points, one next to the Francisquinha ETS, known as Point 1 (P1), and the other

in the exit to Palmas - TO, better known as Point 02 (P2), so that finally, the data of this monitoring will be transmitted on to the public institutions and the community

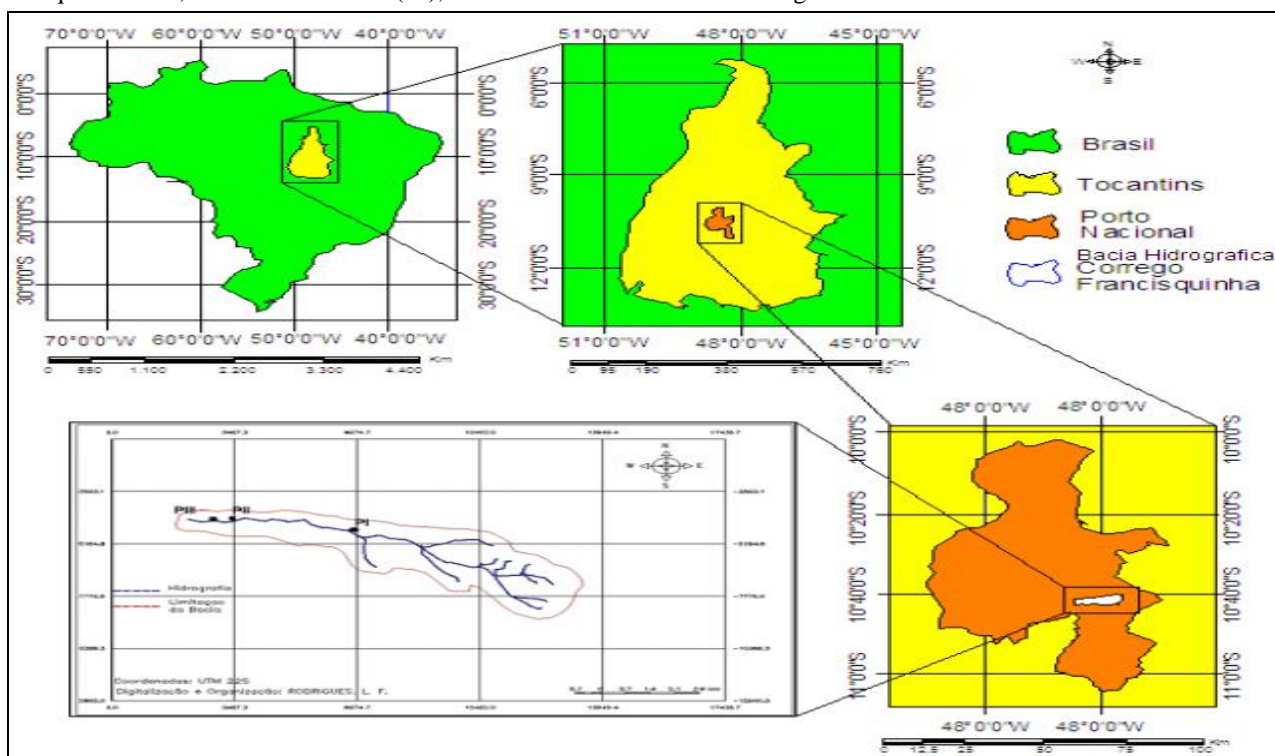
II. MATERIAL AND METHODS

RESEARCH TYPE

The research Project is an experimental one, with a descriptive analysis with surveys performed in loco, with the objective of obtaining a evaluation of the bathing conditions of the Francisquinha stream, establishing the water collecting and analysis places of the study.

LOCATION OF THE STUDY AREA

The Basin of the Francisquinha Stream is located in the State of Tocantins. The municipality of Porto Nacional is located in the geographic center of the State, in the eastern mesoregion, with an average altitude of 212 meters above sea level and a surface area of 4,449.9 km² and it has as coordinates 10°42'29 "latitude and 48°25'02 "west longitude.



TRADUÇÃO DAS PALAVRAS DA FIGURA:

Brasil – Brazil

Tocantins – Tocantins

Porto Nacional – Porto Nacional

Bacia Horográfica Córrego Francisquinha - Hydrographic Basin of the Francisquinha Stream

Fig.1: Map of the location of the Hydrographic Basin of the Francisquinha Stream

Source: Rodrigues (2015)

Location of Point 01 (P1)

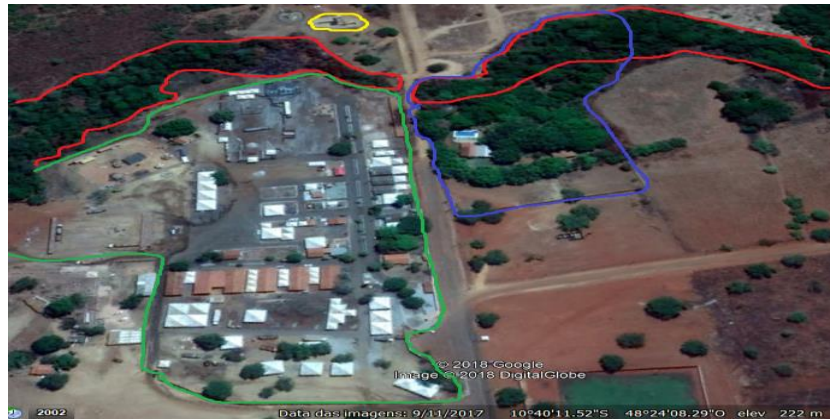
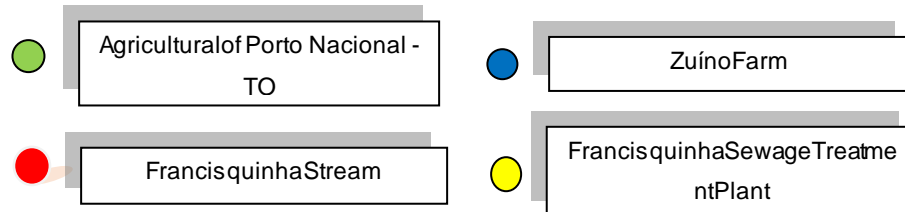


Fig.2: Satellite location of Point 1 and its surroundings

Source: Own elaboration (2018)

Legend:



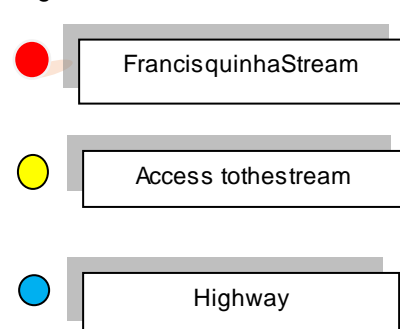
Location of Point 02 (P2)



Fig.3: Satellite location of Point 2 and its surroundings

Source: Own elaboration (2018)

Legend:



MONITORING POINT AND ITS DIAGNOSTICS

With the aid of a GPS - *Global Positioning System*, two collection points were determined, which are in the perimeter of the Francisquinha stream, according to the geographical coordinates represented in Table 01.

Table.1: Point of collection of water samples

POINTS	GEOGRAPHICAL COORDINATES	
	Latitude (ϕ)	Longitude (λ)
P1	S 10° 40,325'	W 48° 24,202'
P2	S 10° 40,093'	W 48° 23,874'

Source: Own elaboration (2018)

According to table 05, the sample was collected in the downstream and upstream areas of the basin, with Point 1 (P1) being located in the Zuíno farm, Guaxupé sector, alongside the agricultural of Porto Nacional - TO, and Point 2 (P2), located off the exit to Palmas - TO, just off the highway. Thus, water collection sites were identified through GPS and photographic records.

STUDIES CONDUCTED

For the study in the river basin of the Francisquinha stream, were performed the Total Coliform and *Escherichia Coli* tests and pH, turbidity and electrical conductivity analyzes, according to the Standard Methods norms (APHA, 2007). The fecal coliform test verifies the presence and number of fecal bacteria in the beach water sample. This bacterium may be a vehicle for the transmission of diseases such as hepatitis or gastrointestinal disorders (INMETRO, 2018).

This indicates that the water in the basin may be contaminated with sewage water for being in an area located next to the sewage treatment plant, causing great risks for children who can ingest the water more easily

Thus, 6 water samples (microbiological and physical-chemical) were analyzed, collected in six consecutive weeks, and in each collection of the two points, the samples were collected and sent to the laboratory on the same day for analysis

The parameters of pH, electrical conductivity and turbidity were made on the site, and for the electrical conductivity parameter was used the conductimeter, for the turbidity one was used the turbidimeter and for the pH one it was used the pH meter equipment, according to the protocols of use of these equipment.

The microbiological and physical-chemical samples were collected in 100 ml bottles, then packed in ice-containing thermal boxes and taken for processing in the laboratory at the IFTO - Instituto Federal de Educação, Ciência e Tecnologia do Tocantins, in Porto Nacional.

In art. 2° (CONAMA, 2000), fresh, brackish and saline waters intended for bathing (primary contact recreation) had their condition evaluated in the proper and improper categories, as shown in table 02.

Table.2: Fecal coliform limit, Escherichia coli limit and percentage of time according to their categories

Category	Fecal Coliform Limit (Thermotolerant) (Most Likely Number per 100ml)	<i>Escherichia coli</i> Limit (Most Likely Number per 100ml)	Percentage of time
	Safe Water		
Excellent	250	200	Maximum values in 80% or more of the time
Very Good	500	400	
Satisfactory	1.000	800	
Unsafe Water Category			
Unsafe	>1.000	> 800	Greater than the indicated value in 20% of the time

Source: Own elaboration (2018)

For the fecal coliform test, the CONAMA Resolution (2000) establishes that at least 80% of the analyzed samples present a bacterial count lower than

1000 per 100 ml of sample, for the bathing conditions of the beach to be considered satisfactory (INMETRO, 2018).

According to the CONAMA (2000) Resolution number 274, the water will be considered unsuitable for primary contact when, in the section evaluated, one of the following occurrences is verified:

- a) not meeting the criteria established for the safe water category;
- b) value obtained at the last sampling is greater than 2500 fecal coliforms (thermotolerant) or 2000 *Escherichia coli* or 400 enterococci per 100 milliliters;
- c) high or abnormal incidence in the area of transmissible diseases by water, indicated by the sanitary authorities;
- d) presence of waste or disposal, solid or liquid including sanitary sewage, oils, greases and other substances, which may offer health risks or render the recreation unpleasant;
- e) pH <6.0 or pH > 9.0 (fresh water), except for natural conditions;
- f) flowering of algae or other organisms, until proven to offer no risk to human health;
- g) other factors that temporarily or permanently contraindicate the exercise of primary contact recreation.

The pH test is an indicator of the acidity level of the water. If the water in the stream has a pH level below the range determined by the Resolution, the user may experience some type of skin or eye irritation (INMETRO, 2018).

The resolution number 274 of CONAMA (2000) also states that stretches of beaches and balnearies will be interdicted if the environmental control body of the area, at any of its instances (municipal, state or federal), finds that the poor water quality for primary contact recreation justifies the measure.

METHODOLOGICAL PROCEDURES

Sample collection plan

In order to verify the fecal coliforms (thermotolerant) and *Escherichia coli* of the water of the Zuíno balneario, in the Francisquinha stream, weekly samples were collected at two points, during six consecutive weeks, in the months of December 2018 and January 2019.

Laboratory analysis

The COLILERT technique was used to determine The Most Likely Number (NMP/100ml) of bacteria from the fecal coliform group in 100 ml of water, according to the methodology of the Standard Methods for the Examination of Water and Wastewater - APHA, 2005 / American Public Health Association.

According to the COLILERT method, after collecting the water in a bottle of 100 ml, the reagent was added to the collected sample and taken to the incubator for 24 hours at 35 ± 0.5 °C. After removing the sample

from the incubator, the results were read where the sample had a colorless appearance, the result would be negative for Total Coliforms and *Escherichia coli*, if it presented a yellowish appearance, the result would be positive for Total Coliforms and presented a yellow/fluorescent appearance, the result would be positive for *Escherichia coli*, in terms of presence or absence of bacteria.

In terms of quantification, the reagent was added to the sample, soon after the sample mixture was placed in the Quanti - Tray carton and then placed in the carton in the wipe coating. After this was done, the rubber coating was placed next to the carton and passed in the sealer to allow the mixture to be distributed and the sample distributed throughout the carton, and then placed in the incubator for 24 hours at 35 ± 0.5 °C and at lastly the reading was made comparing with the table of the most probable number, the amount of Total Coliforms. To quantify the *Escherichia coli* bacterium, it was necessary to place a UV lamp in a dark environment to make the reading.

In this context, the laboratory results of the water quality parameters were compared with the criteria of CONAMA Resolution number 274/00, which define the balneario conditions classified in the categories safe or unsafe for recreation of primary contact. Evidence of high fecal coliform values will indicate fecal water contamination, which may pose a risk to the health of the bathers.

Therefore, the water analysis of the Francisquinha stream was guided through sampling collecting, laboratory analysis, correlation with legislation and other parameters pertinent to the evaluation of water for recreational use.

III. RESULTS AND DISCUSSIONS

The monitoring of the microbiological quality of the water under study was performed during the months of December 2018 and January 2019, in the middle of the rainy season. During this period the water presented a dark coloration that comes from the solids carried to the river bed. It is worth to note that the dark coloration of the water alone is not indicative of contamination, as even when the water presents a transparent color it may be contaminated.

During the monitoring period, it was observed that the water presented a polluted aspect, making the bathing conditions in the area to be of a negative factor.

The results obtained in the course of the research were presented and discussed through the indicators of total coliforms and *E. coli*, considering the classification criteria of CONAMA Resolution Number. 274/00, for

safe and unsafe waters for bathing purposes, based on the average of six consecutive samples.

According to table 3, the electrical conductivity presented a variation of 9.81 us/ cm to 17.87 us / cm in point 1 (P1), already in point 2 (P2) the conductivity ranged from 8.55 us/cm at 11.28 us/cm. The turbidity in

those 6 weeks had a variation of 8.98 NTU to 19.4 NTU in the first point (P1), in the second point (P2), there was a variation of 8.88 NTU to 17,6 NTU. All these results were obtained in the monitoring period, also observing a variation in pH from 5.86 to 8.76 in point 1 (P1), already in point 2 (P2) a variation of 5.88 to 8.78.

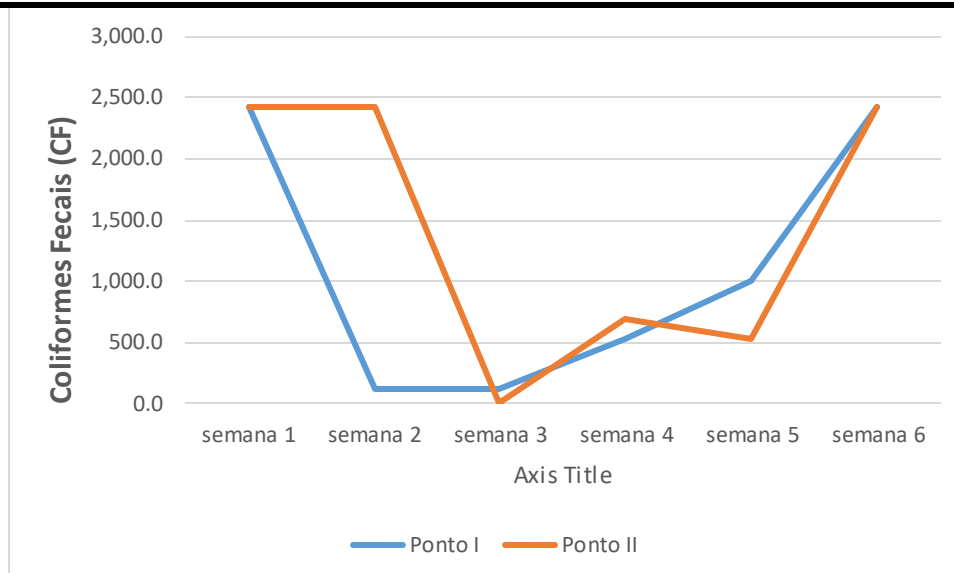
Table 3 - analyzes of the 6 consecutive weeks of the two monitored points

WEEKS	POINT 1		POINT 2	
01	Electric Conductivity	11,95 us/cm	Electric Conductivity	11,28 us/cm
	Turbidity	14,8 NTU	Turbidity	12,2 NTU
	pH	5,86	pH	6,08
02	Electric Conductivity	9,81 us/cm	Electric Conductivity	8,55 us/cm
	Turbidity	8,98 NTU	Turbidity	8,88 NTU
	pH	6,71	pH	6,29
03	Electric Conductivity	10,33 us/cm	Electric Conductivity	8,98 us/cm
	Turbidity	12,7 NTU	Turbidity	11,5 NTU
	pH	5,97	pH	5,88
04	Electric Conductivity	17,87 us/cm	Electric Conductivity	9,63 us/cm
	Turbidity	16,8 NTU	Turbidity	14,9 NTU
	pH	6,57	pH	6,52
05	Electric Conductivity	10,12 us/cm	Electric Conductivity	9,20 us/cm
	Turbidity	13,8 NTU	Turbidity	11,5 NTU
	pH	8,76	pH	8,78
06	Electric Conductivity	11,86 us/cm	Electric Conductivity	9,77 us/cm
	Turbidity	14,41 NTU	Turbidity	12,76 NTU
	pH	6,62	pH	6,64

Source: Own elaboration (2018)

At the end of the analysis, all the water samples presented a yellow coloration and fluorescence characteristics, showing a variation in the NMP/most probable number of Escherichia coli concentration, but in the last monitoring, according to figure 4, the numbers have equal values, again indicating a maximum *E. Coli* concentration in the two analyzed points. The concentration of Fecal Coliforms remained constant

throughout the monitoring period, also indicating a maximum concentration. The results obtained at both points over the course of the 6 weeks obtained an average of 1105.03 of *E. coli* at point 1 (P1) and 1413.9 of *E. coli* at point 2 (P2), thus showing that the results obtained in this period of analysis remained above the values recommended by CONAMA Resolution 274/00, which means that the water is unsafe for bathing purposes.



Tradução das palavras da figura

Cloriformes Fecais (CF) – Fecal Cloriforms (FC)

Semana 1, semana 2, semana 3, semana 4, semana 5, semana 6- week 1, week 2, week 3, week 4, week 5, week 6

Título do Eixo – Title of the axis

Ponto 1 – Point 1

Ponto 2- Point 2

Fig.4: Overall result of *E. coli* analyzes for the two points

Source: Own elaboration (2018)

According to Cynthia (2018) in a study performed on the beach of Formigueiro, microbiological analyzes of the total coliforms and *Escherichia coli* were also performed to verify the bathing conditions of the beach. The obtained values were superior to 2,419,6 NMP/100 mL⁻¹, and the agents responsible for these values were animal feces (cattle, chickens, etc.) and human feces from private septic tanks and animal husbandry along the banks of the basin, being able to generate the excessive increase of these bacteria both on the beach of Formigueiro as in the stream Francisquinha, due also to the period of rain that carries the garbage on the banks of the stream increasing the pollution there.

With the Sewage Treatment Plant being operated alongside the Francisquinha basin, this may also be another factor that explains the high concentration of *E. coli* present in the water.

IV. CONCLUSION

The present research was performed with the purpose of evaluating the water quality conditions of the stream for purposes of recreation of primary contact, through indicators of fecal pollution, such as bacteria of the total coliform group and *E. coli*.

The results obtained from the microbiological analyzes of water samples collected in the river basin of the Francisquinha stream in Porto Nacional - TO,

confirmed that the total coliform bacteria were present at the two monitoring points during the study period.

The levels of *E. coli* bacteria highlighted high concentrations that allow the classification of the water in the areas unsafe for bathing purposes, according to Resolution number 274/00 of CONAMA. Therefore, the water of the Francisquinha basin, during the analysis period, based on the bacterial indicator of the *E. coli* group, did not meet the recommended standards for bathing conditions (primary contact recreation).

Measures must be taken by the city hall to perform an appropriate cleaning work in the basin, specifically at the points in question, to meet the standards recommended by CONAMA Resolution number 274/00. They are: a) establishing a water monitoring program as an adequate practice to provide greater sanitary security to swimmers and to encourage the use of the stream throughout the year as an acceptable place for recreation and leisure; b) application of legislation instruments to contain the advance of contamination, such as the criteria determined by Resolution number 274/00 of CONAMA and Environmental Legislation; c) periodic cleaning of the basin and waste margins in order to prevent them from being carried to the water body during the rainy season; d) supervision of local commercial establishments, ie bars and restaurants, requiring the adequate treatment of domestic sanitary effluents; e) implantation of information devices (plates) by the public

power with indication of the condition of the water, thus offering better orientation and sanitary safety to the bathers; f) To have proper supervision in the ETE Franscisquinha for them to be cautious with all the sewage that circulates there next to the stream.

Since the analyzes did not meet the standards recommended by CONAMA Resolution number 274/00, monitoring of water quality should be maintained, being a constant concern of the State and Municipal Secretariats of the Environment, searching partnerships with academic institutions, in order to develop preventive actions through scientific research to provide a clean and uncontaminated environment for tourists and local users, and the competent environmental agencies to take preventive actions to maintain the health of the population.

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