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Study of the balneability in the Francisquinha Stream Basin, in the municipality of Porto Nacional/TO

Water is a natural resource that is indispensable for life of all. However, this resource is not inexhaustible. Its use can have the most diverse purposes, whether for industrial activity, common daily use up to recreation activities. The municipality of Porto Nacional has several tributaries, that can be used in various ways by the local population. One of the forms of use is recreational activity, and in this study the bacteriological analysis of the Francisquinha Stream Basin was performed through the indicators of the group of total coliforms and Escherichia coli (E. coli).). The results of the monitoring were based on the parameters established for balneability purposes defined by the current norm of CONAMA Resolution No. 274/00. In order to obtain the confirmatory results of microbiological presence, the Colilert technique was used in laboratory experiments. The detected levels of E. coli bacteria demonstrate a high concentration rate, thus allowing the classification of waters for balneability as improper waters, according to CONAMA Resolution No. 274/00. Therefore, the intention of recreational activity in the basin under study was framed outside the required standards.

Keywords: Balneability; Recreation Activities; Francisquinha Stream.

Estudo da balneabilidade da Bacia do Ribeirão Francisquinha, no município de Porto Nacional/TO

A água é um recurso natural indispensável à vida de todos. No entanto, esse recurso não é inesgotável. A sua utilização pode ter as mais diversas finalidades, seja para a atividade industrial, uso diário comum até atividades recreativas. O município de Porto Nacional possui diversos afluentes, que podem ser utilizados de diversas formas pela população local. Uma das formas de utilização é a atividade recreativa, e neste estudo a análise bacteriológica da Bacia do Arroio Francisquinha foi realizada através dos indicadores do grupo de coliformes totais e Escherichia coli (E. coli). Os resultados do monitoramento foram com base nos parâmetros estabelecidos para fins de balneabilidade definidos pela norma atual da Resolução CONAMA nº 274/00. Para obter os resultados confirmatórios da presença microbiológica, a técnica de Colilert foi utilizada em experimentos de laboratório. Os níveis detectados da bactéria E. coli demonstram alto índice de concentração, permitindo assim a classificação das águas para balneabilidade como impróprias, conforme Resolução CONAMA nº 274/00. Portanto, a intenção de atividade recreativa na bacia em estudo foi enquadrada fora dos padrões exigidos.

Palavras-chave: Balneabilidade; Atividades recreativas; Ribeirão Francisquinha.

Topic: **Engenharia Ambiental**

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INTRODUCTION

According to Grassi (2001) water is a fundamental element for human survival, it is present in approximately 71% of the Earth's surface, but only about 3% is composed of fresh water, being approximately 0.77% for human consumption. All this extensive body of water is called the hydrosphere. However, water is not an inexhaustible resource and is always subject to infestations in many different forms, just as it is also tending to its end. This resource is used in several activities such as agricultural production, daily routine consumption of the population, in the industrial sector and in several other activities that involve it, which are the most diverse, among them recreation.

The water resources, since it is of fundamental for the most diverse human activities, it´s intrinsically linked to the history of civilizations and of all people. Whether in domestic use; industrial; navigation; agricultural; power generation; food; sanitation; leisure and recreation (FERREIRA et al., 2013). According to Martins (2012) in all over the planet, and in Brazil is not different, it has substantially increased the growth of activities for recreational purposes in aquatic environments, ranging from sports practices that make direct contact with water (swimming, canoeing, surfing) and also activities that do not involve direct contact with the water, as the sport fishing.

The quality of water, presence of microorganisms, pathological agents, algae, bacteria, fungi and various other aspects, whether physical, chemical or biological, which may influence the emergence of diseases that affect the population, must be detected and eradicated completely before use. As Padua (2003) said, these microorganisms develop in the gastrointestinal tract of 'warm-blooded' animals (hemeotherms), bacteria that belong to the group of thermotolerant coliforms. These bacteria may contain pathogens, such as those belonging to the genus *KlebsiellaeEscherichia* coli.

Also according to Pierrat (2016), in addition to fecal contamination, other criteria are also mentioned in the CONAMA resolution as part of the concept of bathing water quality which may be, for example, the presence of algae, occurrence of diseases not so frequent, solid and liquid wastes, pH (low or high) of water. However, these are not systematic quantitative control terms. This shows the agreed importance of sewage contamination reported by authorities.

The origin of pathological agents present in the water can be diverse, from the users of the resorts themselves, to animals that live in the vicinity of these places. These agents can cause gastrointestinal infections after ingestion, they can also cause infection of the airways and nasal cavities (respiratory system), ears, eyes and skin. Daily preventions may not identify these diseases caused from contact with contaminated water, because this type of infection may have a softer effect, according to epidemiological studies and research (VASILIO, 2006).

And balneability, which is the central study of this work, is the ability of a hydrographic basin to receive bathers and users for recreational leisure activities. The Francisquinha Stream will be the place of study. The Francisquinha Stream is in the municipality of Porto Nacional/TO, it is located in the suburban region of the city, next to the agricultural exhibition park of the city, and also has and part of its course the

presence of a sewage treatment plant, which even bears the same name of the stream.

The results were computed and exposed through laboratory tests, after periodic collection of water samples from the stream. What determined the water class and whether it is suitable for use were the amounts of thermotolerant coliform microorganisms, which can cause diseases of various natures to society. The present work aimed to analyze the conditions of the Francisquinha Stream basin, in order to evaluate and know its situation regarding its ability to balneability and recreational activities.

MATERIALS AND METHODS

Type of research

This research has a descriptive and experimental character, where *in loco* surveys were *made,* which the analysis of water quality were made, for balneability, which it was diagnosed through laboratory tests and analysis of coliform data present in water samples collected directly from the stream course.

Area of study

The municipality of Porto Nacional is about 60km from the state capital, Palmas. It has an area of 4449,917 km², altitude of 212m in relation to sea level and with a population of approximately 52,700 inhabitants (IBGE, 2018). The place chosen to carry out the studies of this work is the Francisquinha Stream, which is located in the municipality of Porto Nacional/TO. The collection point is located at 221 meters above sea level and it has as coordinates 10°40'14.19"S of latitude and 48°24'12.71"O west longitude.

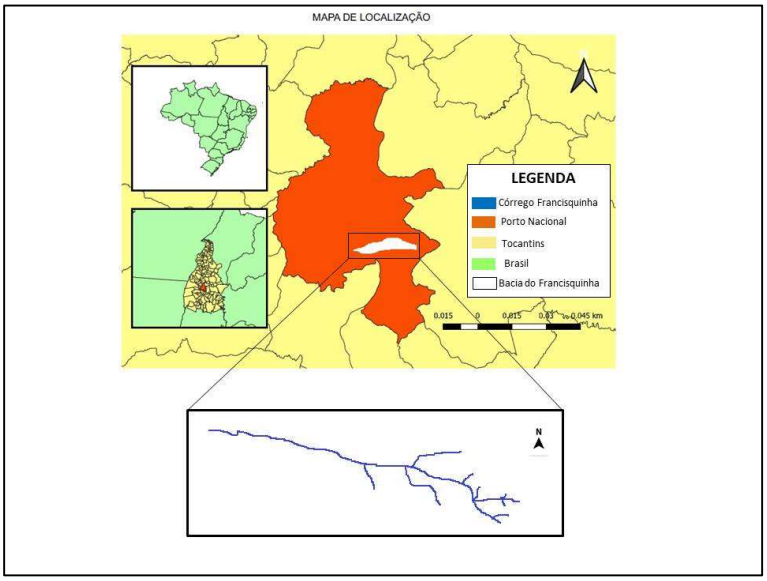

Figure 1: Map of location of the Francisquinha Stream in Porto Nacional/TO.

TRANSLATION OF THE WORDS OF FIGURE:

Mapa de Localização – Location Map
Legenda – Caption
Córrego Francisquinha – Francisquinha Stream
Porto Nacional – Porto Nacional
Tocantins – Tocantins
Brasil – Brazil
Bacia do Francisquinha – Francisquinha Basin

Source: Location Map of the Francisquinha Stream Basin.

Monitoring point

With the aid of the GPS - *Global Positioning System device,* a (01) water sample collection point was chosen, located in the location given by the geographic coordinates presented in chart 1.

Chart 1: Geographical coordinate of the demarcated point.

POINTS	COORDINATES	
	Latitude (ϕ)	Longitude (λ)
P1	10°40'14.19"S	48°24'12.71"O

The samples were collected directly to the downstream of the basin, at the point located on Map 01, with the geographic coordinates of Chart 01. Next to the collection point, which is between zuino's farm and Francisquinha's treatment plant, both are located in the Guaxupé sector.

Figure 2:-Location of the Francisquinha Stream and reference points in Porto Nacional-TO.

TRANSLATION OF THE WORDS OF FIGURE:

Localização do Ponto de Coleta das amostras – Location of the Sampling Collection Point
Legenda – Caption
Chácara Zuno – Zuno Farm
Estação de Tratamento Franscisquinha – Franscisquinha Treatment Station
Parque Agropecuário de Porto Nacional – Porto Nacional Agricultural Park
Ponto de Coleta das Amostras – Sample Collection Point

Source: Francisquinha basin study region and collection point - Google Earth (2020).

Procedures to be performed for sample collection

The monitoring and data analysis of this research were carried out in the first semester of 2020, between February and March. The use of GPS is essential once you want the exact location of the sampling site. The sampling patterns followed all the recommendations of the CONAMA Resolution and also of the standard NBR 9897 (planning of sampling of the liquid effluents and receiving bodies).

After choosing the collection point, the samples were collected weekly. Glass containers, properly sterilized, with a capacity of 100ml for storage and disposable gloves to avoid possible external contamination were used to collect the samples. The depth for the collection had to be at least 1m deep. All collections were performed during the morning, at the same time, for six consecutive weeks, according to chart 02.

Chart 2: Dates and times of water collection in the Francisquinha Stream.

DATES/TIMES OF WATER SAMPLE COLLECTION				
WEEKS	**MONTHS**	**DAY OF WEEK**	**DAY OF MONTH**	**TIME**
1ª week	February	Monday	17	
2ª week	February	Monday	24	09h:00min Am
3ª week	March	Monday	02	
4ª week	March	Monday	09	
5ª week	March	Monday	16	
6ª week	March	Monday	23	

Laboratory analysis methods

After weekly collection of the samples, they were immediately sent to the IFTO chemical laboratory, Porto Nacional Campus, for laboratory analysis. The methodology adopted was the Colilert method (APHA, 2005). The Colilert method is a technique based on the principle of identification of microorganisms, and it is estimated a time of 24 hours to determine the Most Probable Number (MPN/100ml) of bacteria from the total coliform group and *Escherichia coli*.

The Colilert method was used to identify the type of bacteria present in water samples. This method was chosen because it is considered fast in the conception of results, and also it adapts to the physical-structural conditions of laboratories and it has an acceptable economic viability. In this method the culture medium (Colilert enzymes) comes in the exact amount of 100ml for water analysis. Each enzyme was added to the 100ml vial with the sample. It had to be stirred until the total dilution of the granules was completed. After this procedure, this solution was incubated at a temperature of 35° in a l for 24 laboratory oven hours.

Produto	Análise	Tempo para obtenção dos resultados
Colilert®	Coliformes totais e *E. coli*	24 horas
Colilert®-18	Coliformes totais e *E. coli*	18 horas
Colisure®	Coliformes totais e *E. coli*	24-48 horas
Enterolert™	Enterococci	24 horas
SimPlate® para HPC	Bactéria heterotrófica	48 horas
Filta-Max™	*Criptosporidium* e *Giárdia*	

Figure 3: Types of Colilert trials.

TRANSLATION OF THE WORDS OF FIGURE:

Produto – Product
Análise – Analysis
Tempo para obtenção dos resultados - Time to obtain results
Horas – Hours
Coliformes totais – Total Coliforms
Bactéria Heterotróficaca – Heterotrophic Bacteria

Fonte: IberLab (2008).

Plastic, sterile and disposable cards (Quanti-TrayTM 2000 plates) were used in this experiment. The reading was performed using an ultraviolet lamp. The MPN (most propable number) which is the conversion of the amount of positive wells into MPN thus giving a margin of confidence of about 95% in the sample result.

According to the criteria established by CONAMA Resolution Nº. 247/2000 and in regulations defined by CETESB, the beaches (natural or artificial) are classified as proper or improper for the recreational purposes of primary contact, considering the density of fecal bacteria that are present in water (CONAMA 2000; CETESB, 2010).

The criteria for classifying the water quality are: a)Excellent: when presenting a percentage equal to or greater than 80% of a maximum of 250 fecal coliforms (thermotolerant), samples that have been collected

in each of the previous five weeks, and from the same location. Or 200 Escherichia Coli or up to 25 enterococci/100 ml; b) Very Good: when 80% or more of a group of samples obtained, in each of the five weeks and that have been collected from the same place, there are 500 fecal coliforms (thermtolerant), at most 400 E-coli, or 50 enterococci/100 ml; c) Satisfactory: when you have 80% or more of a set of samples, from each of the previous 5 weeks, collected in the same place, there are up to a maximum of 1000 fecal coliforms (thermotolerant) or 800 E-Coli or 100 enterococci/100 ml.

Table 1: Classification of water in relation to bathing according to the current Resolution.

Category	Fecal coliforms (MPN/100ml)*	Escherichia Coli (MPN/100ml)*
Excellent	< 250	< 200
Very Good	< 500	< 400
Satisfactory	< 1000	< 800
Improper	Above 2500	Above 2000

*MPN: Most propable number per 100ml. in 80% or more of a set of samples obtained in each of the previous five weeks. **Source:** CONAMA RESOLUTION No. 274/2000.

Observing with the naked eye it can be observed the following aspects that prove some facts. If the solution shows yellow color, or some fluorescence, it means that the test was positive for Total Coliforms. With bluish coloration, it is positive for Fecal Coliforms. If there was no change in color (without color change) the result would be negative. In the MPN table (table 01), the results will be expressed, where the positive result is equivalent to a bacterium of 100ml of water (ALVES et al., 2002).

As described in CONAMA Resolution (2000) Nº. 274, the waters will be considered improper for primary contact when one of the following occurrences is verified in the evaluated section: a) failure to meet the criteria established for proper waters; b) value obtained in 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 region, in the Region, of water-borne diseases, indicated by the health authorities; d) presence of waste or dumps, solid or liquid, including sanitary sewers, oils, greases and other substances, capable of offering health risks or making recreation unpleasant; e) pH < 6.0 or pH > 9.0 (fresh waters), except for natural conditions; f) flowering of algae or other organisms until it is established that they do not pose a risk to human health; g) other factors that contraindicate, temporarily or permanently, the exercise of primary contact recreation.

RESULTS AND DISCUSSION

For Aureliano (2000), balneability is used as a means of evaluation in which the analysis of the quality of the water that is in contact with people is made. These evaluation data are measured on the basis of samples collected *in loco, which* will undergo laboratory tests. From there it will be completed if the tested water meets the requirements and parameters that are required to be released for recreation.

The increase in the production and emission of solid and liquid waste generated by users and released into the water environment has had a negative effect, thus reducing the quality of bathing. The population should be alerted about the possible risks of attending beaches, baths and spas inappropriate for leisure practices, avoiding exposing bathers to contaminated waters, which can result in negative effects on

data related to public health, tourism and consequently to the local economy (CAMPOS et al., 2015).

According to Smith et al. (1995), bathers who assess water quality only based on their coloration, without following any parameters recommended by the competent agencies, they are at risk. Since only staining, without any technical knowledge or legal means of quality verification, it does not allow the identification of harmful pathogens from animal feces in the vicinity of the watercourse in which they are located.

The analyses and monitoring of water quality in the stream under study were carried out between February and March 2020, a time of year that represents part of the rainy season in the region where the Francisquinha basin is located. In this way, the water may have presented cloudy coloration, due to the solids and substances carried by the rainwater to the stream bed. The collection that showed the greatest presence of *E. Coli* was on 02/17, 02/03 and 03/16, in these days there was a great rainfall index hours before the collection of samples, being the rain one of the possible interventions of the final indexes, considerably increasing the presence of microorganisms.

At the end of all analyses of the water samples, they presented a yellowish color and fluorescent characteristics, implying that there was a variation in the rate of MPN (Most Probable Number) of *E. Coli* concentration. The figure 04 shows, through a graph, that the rate of fecal coliforms in the first week (02/17) has a value of 2419.6 and falling to 403.4 in the second week (02/24). In week 3 (03/02) it obtained the maximum value of 2419.6, while there was another drop in week 4 (03/09) to 333.3. In the fifth and penultimate week (03/16) new maximum of 2416.9 and finally in the week of number 06 (03/23) a drop was recorded to 478.6. The results obtained during the six weeks of studies had an average of 1412.35 *Of E. Coli* in Point 01, thus demonstrating that the results obtained in the period of the survey were above that recommended by CONAMA resolution 274/2000, leading the water to be classified as improper for recreational purpose activity.

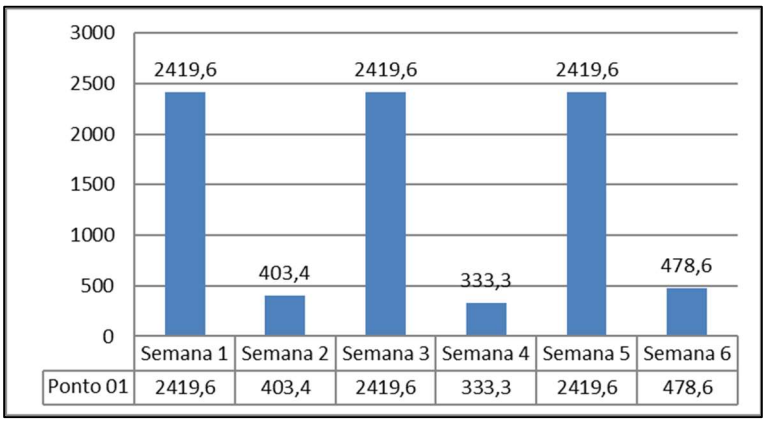

Figure 4: Overall result, in graph, of E. coli analyses

TRANSLATION OF THE WORDS OF FIGURE

Semana 1 – Week 1
Semana 2– Week 2
Semana 3– Week 3
Semana 4– Week 4
Semana 5– Week 5
Semana 6– Week 6
Ponto 1 - Point 1

As stated by Queiroz (2000), the primary contact recreation activities with water resources directly

intervenes in several changes and transformations to the aquatic body, while it leads to economic benefits, it favors a commitment to the quality of the water that will be used.

Below the watercourse of the Francisquinha stream, it is located a Sewage Treatment Plant. This station may be directly linked to the *E. Coli* indexes found in the samples taken from the stream. Along the whole course of the stream there may be other means and beings that can contribute to its contamination directly or indirectly, such as animal feces that inhabit the shores of the basin, dumping of waste by riverside dwellers and residents of the neighborhoods and that surround the stretch and also the irregular disposal of garbage on the banks of the stream, which contributes both to environmental pollution and to the emergence of bacteria and micro-organisms in water.

CONCLUSIONS

The purpose of this scientific research was the analysis of the water quality of the Francisquinha Stream, for the purposes of primary contact recreational activities, the results were achieved through indicators of fecal pollution and the presence of thermotolerant *organisms, E. Coli* and Total Coliforms.

Based on the results obtained, through laboratory tests, of the samples collected in the Francisquinha Stream basin in the municipality of Porto Nacional - TO, it is possible to prove the presence of Total Coliforms, which were present in the water that flowed through the collection point that was adopted in this scientific research, during the study period.

The results show that *E. Coli* levels are at high concentration levels in at least 3 weeks of testing, which allows the classification of water as to its balneability capacity considered as improper, based on what is estabilshed by CONAMA Resolution 274/00. Therefore, based on the indicators of bacteria of the *E. Coli* group, the results did not meet, in the analysis period of this research, the standards required for recreational activity of primary contact (balneability).

For the correction of these problems that affect the Francisquinha basin, the authorities must work together with the population of Porto Nacional for the preservation of this water resource that is of great value to the municipality. These improvements should meet all CONAMA recommendations and their specific articles for the type of activity adopted in this watercourse. Other measures that can be implemented are: - The periodic cleaning of the bed and surroundings of the stream made by trained professionals in the area of activity, especially in rainy periods; - The control and strict supervision of the STP (Sewage Treatment Plant) that lies on the banks of the stream; - Awareness campaigns so that the residents of the surrounding area are educated for non-pollution and preservation of the basin; - Implantation of visual devices for the awareness of bathers/frequenters of the stream; - The sanctioning of municipal laws, following the recommendations of CONAMA Resolution 274/2000 which may alert, warn and even punish those who break the limits of the natural environment and violates current environmental laws, these laws apply to the common population as well as to companies and entities that disrespect them.

In order to fully preserve this basin, the State and Municipal Health Departments must act in harmony for this natural resource, in partnership with educational institutions, aiming to develop preservation plans

based on scientific research to give the population an environment free of infestations, clean and healthy for the development of the most diverse activities , and the responsible bodies take appropriate measures to make this happen in such a way that nature and the population benefit equally.

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