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RESEARCH ARTICLE

Microbiological Water Quality in watershed Caño Grande

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Abstract

Objective: To analyze the microbiological quality of three tributaries of Caño Grande by estimating and comparing the indicator groups of quality according to Colombian regulations. **Method:** Sampling was carried out from September 2022 to January 2023. For each monitoring in September, November and January, 34 samples were taken, and for each monitoring in October and December, 30 samples were taken, following the protocol of the Colombian Technical Standard NTC 813. The determination of the indicator groups was performed using the multiple tube method and plate count. **Findings:** For the microbiological quality analysis, the results were compared with the permissible ranges described in Colombian regulations. 86% of the analyzed samples from Caño Grande, 66% of the catchment points, and 33% of the filters in use were above the permissible ranges for Fecal Coliforms. 100% of the analyzed samples from Caño Grande, 100% of the catchment points, and 83% of the filters in use were above the permissible ranges for Aerobic Mesophiles. 100% of the analyzed samples from Caño Grande, catchment points, and filters were above the permissible ranges for Molds and Yeasts. **Novelty:** The results of this first study recommend continuing monitoring to compare results over time and guide the community in implementing methods to improve resource conditions.

Keywords: Monitoring; Quality; Regulations; Determination; Microbiological

1 Introduction

The Nukak National Natural Reserve is located in the departments of Guaviare and Vaupés, and features a mosaic of Guianan landscapes with rapid environmental transition and high spatial heterogeneity, making it an ideal area for maintaining abiotic and biotic components and providing significant ecosystem services, such as water supply[1,2]. However, one of the municipalities within the reserve, El Retorno, has an inefficient water supply system, making it difficult to provide clean water in rural

areas of the municipality. This has led to the use of nearby untreated water sources, such as the watershed Caño Grande, the most important water source in the municipality, which is influenced by agricultural and deforestation activities[3]. However, the lack of information has not allowed to generate suitable solutions to the magnitude of the problem, therefore it is necessary to demonstrate water microbiological contamination as a first step to establish government regulations that apply to manage the problem of water resource contamination within management plans in the Nature Reserves[4]. Thus, this work focuses on carrying out the first monitoring the microbiological quality of water in three tributaries of the watershed Caño Grande.

2 Methodology

The study was conducted in the municipality of El Retorno, located north of San José del Guaviare, with a land area of 1017 km2, an elevation of 245 meters above sea level, and an average annual temperature of 28°C. The municipality has an approximate population of 22,192 inhabitants. This study was conducted in three tributaries of the watershed Caño Grande in the natural reserves of the Civil Society: Las Violetas, La Siberia, and La Fortuna.

2.1 Field phase

A total of 5 field trips were carried out between September and January of the years 2022 and 2023. For each of the months of September, November, and January, 34 samples were taken at 10 stations in the watershed Caño Grande, 2 catchment points, and 2 ceramic filter points used by the community. For each of the months of October and December, 30 samples were taken at 10 stations in the watershed Caño Grande, following the protocol described in the Colombian Technical Standard NTC 813[5] and the National Institute of Health manual for water analysis[6].

2.2 Laboratory phase

The determination of indicator groups was carried out using the multiple tube method for fecal coliforms and plate counting for aerobic mesophiles and molds and yeasts.

The multiple tube technique was performed by inoculating three sets of tubes in triplicate with decreasing concentrations of 10 ml, 1.0 ml, and 0.1 ml, estimating organisms by the production of acid or gas from cultured bacteria. The results were reported as the most probable number (NMP).

The plate counting technique was used, based on the count of colonies grown on Plate Count agar for aerobic mesophiles after 24 hours of incubation at 37°C and on PDA agar for molds and yeasts after 8 days of incubation at room temperature. The results were reported in colony-forming units per milliliter (UFC/ml).

2.3 Statistical analysis

The results obtained were analyzed using descriptive statistics and compared with the permissible ranges described in the Colombian Technical Standard NTC 813[5] and Resolution 2115 of Colombian regulations[7]. According to the permissible range of Resolution 2115[7], the maximum permissible value for fecal coliforms is 0 NMP/ml, for aerobic mesophiles it is $\leq$ 100 UFC/ml, and for molds and yeasts it is $\leq$ 20 UFC/ml.

3 Results and Discussion

3.1 Fecal Coliform

The results indicate that 86% of the 150 samples analyzed from Caño Grande had an average of 960 NMP/ml (Figures 1, 2 and 3), 66% of the samples from the catchment points had an average of 214 NMP/ml, and 33% of the filters in use had an average of 96 NMP/ml (Figure 4), which were above the permissible ranges (0 NMP/ml) for fecal coliforms.

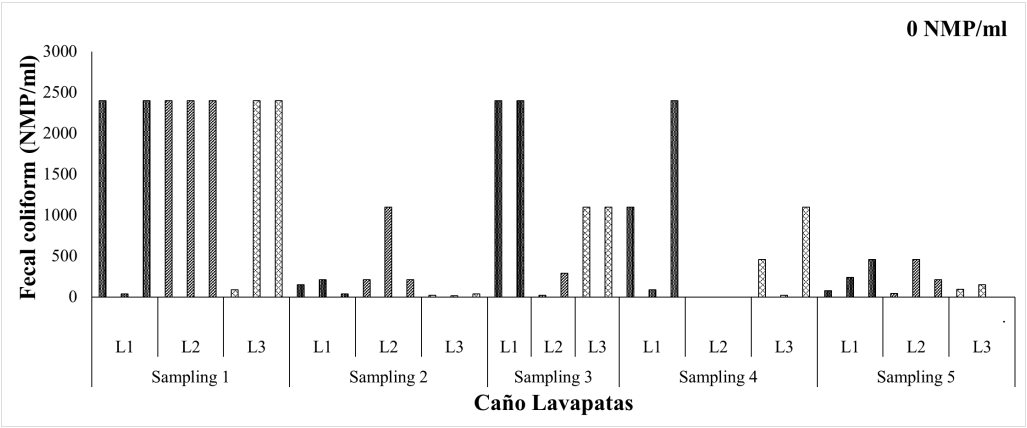

Fig 1. Fecal Coliform estimation forCaño Lavapatas in different samplings, according to the station (L1, L2, L3)

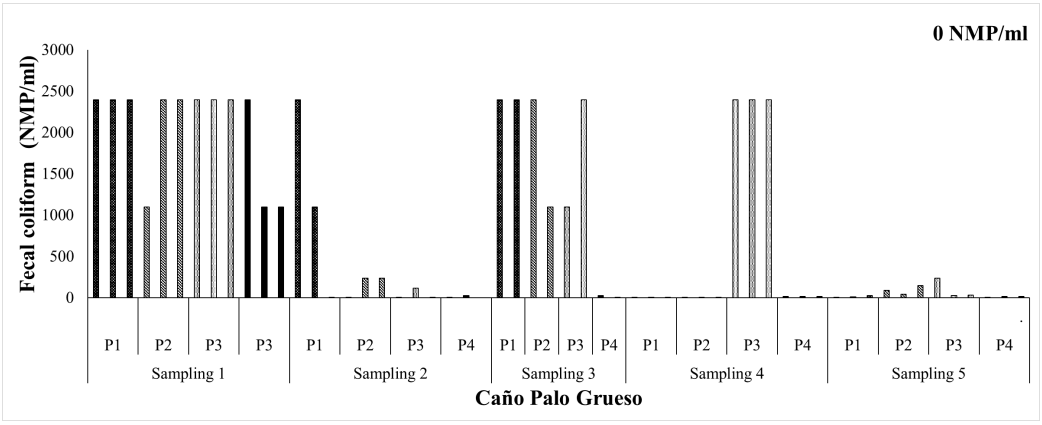

Fig 2. Fecal Coliform estimation forCaño Palo Grueso in different samplings, according to the station (P1, P2, P3, P4)

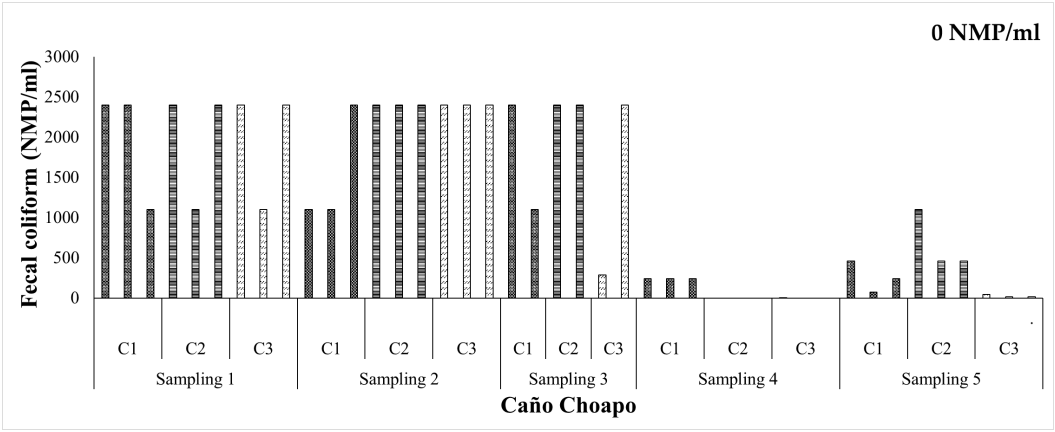

Fig 3. Fecal Coliform estimation forCaño Choapo in different samplings, according to the station (C1, C2, C3)

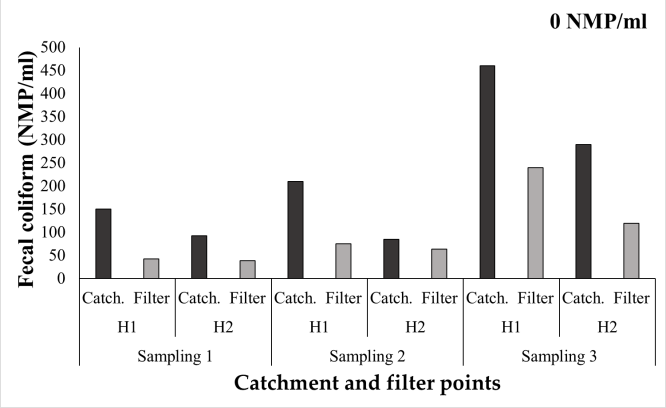

Fig 4. Fecal Coliform estimation in the catchment and filter points of the homes (H1, H2)

Based on the permissible ranges of water quality levels for human consumption, it is evident that the available water resources in the Las Violetas, La Siberia, and La Fortuna reserves are contaminated by microbiological agents. According to the Corporation for Sustainable Development of the Northern and Eastern Amazon, CDA [8], the watershed Caño Grande is contaminated with organic matter due to the discharge of untreated wastewater, indicating possible contamination by microbial agents, which agrees with the values obtained for the coliform group (Figures 1, 2 and 3).

This contamination may be due to the infiltration of organic matter from livestock activities and agricultural runoff present in the study area. Organic matter consists of thousands of particles that event as a growth medium for pathogenic groups and can alter the color, odor, and taste of water [9].

In the influence zones of the monitored tributaries, grazing activities and grass production were also observed, processes that could affect water quality through erosion and sediment transport to surface waters [10].

The filters showed a 50% efficacy in removing fecal coliforms compared to the catchment point [Figure 4]. However, considering that 33% is considered a high percentage with respect to the total analyzed samples contemplated in Colombian regulations, other methods should be considered to optimize the removal of this group. According to Huaman [11], the pores in ceramic filters are very small and do not completely retain this type of bacteria.

3.2 Aerobic Mesophiles

The 100% of the 150 samples analyzed from Caño Grande had an average of 3346 UFC/ml (Figure 5), 100% of the catchment points had an average of 4500 UFC/ml, and 83% of the samples from the filters in use had an average of 2900 UFC/ml (Figure 6), which were above the permissible ranges ($\leq$ 100 UFC/ml) for aerobic mesophiles.

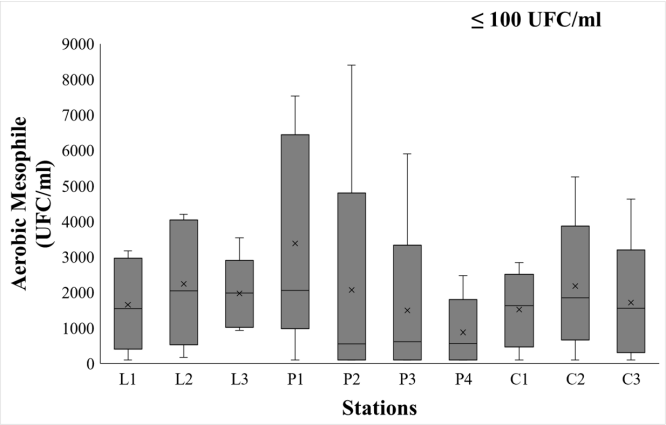

Fig 5. Aerobic Mesophile estimation according to the stations

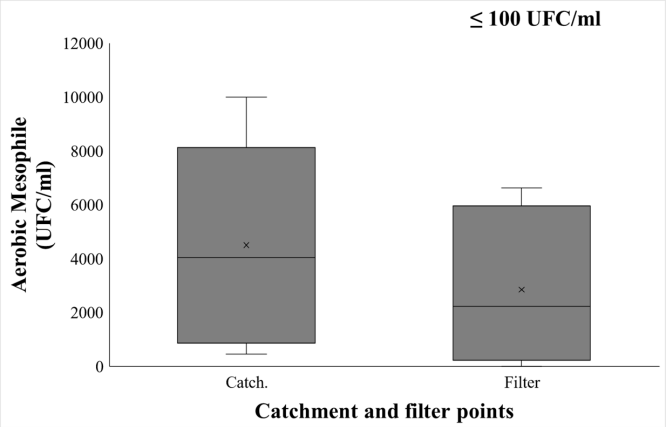

Fig 6. Aerobic Mesophile estimation in the catchment and filter points

The presence of this indicator group (Figure 5) is related to deficiencies in good manufacturing and hygiene practices in productive and domestic activities, such as the disposal of waste with a high load of contaminating matter [12].

The filters indicated a 17% efficacy in removing mesophilic aerobes compared to the catchment point [Figure 6]. According to Huaman [11], since the filters do not completely remove the bacteria, the application of some type of bactericide or disinfectant is required to maintain a degree of hygiene in the filter against this indicator group.

3.3 Molds and Yeasts

The 100% of the samples analyzed from Caño Grande had an average of 1851 UFC/ml (Figure 7), the catchment points had an average of 2200 UFC/ml, and the filters had an average of 1600 UFC/ml (Figure 8), which were above the permissible ranges ($\leq$ 20 UFC/ml) for molds and yeasts.

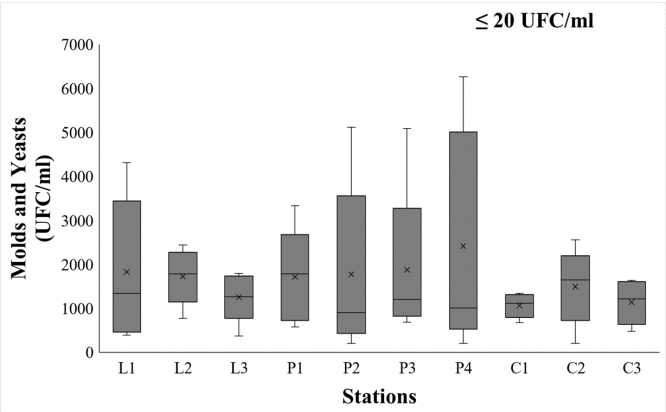

Fig 7. Molds and Yeasts estimation according to the stations

Although the determination of molds and yeasts is not mandatory within Colombian regulations, they are important because they help identify deficiencies associated with treatment processes and/or good hygiene practices in productive and domestic activities carried out by the community [13]. Considering the results (Figures 7 and 8), it can be inferred that it is necessary to design a management plan that makes activities sustainable in the areas and suggest better conditions in the catchment points and replacement of filters or implementation of other water treatment methods that optimize the characteristics of the water resource.

The high estimation of this indicator group (Figure 7) could be due to the fact that although the growth rate of molds and yeasts are lower than the growth rates of bacteria, the production of fungi is often much highe than the corresponding

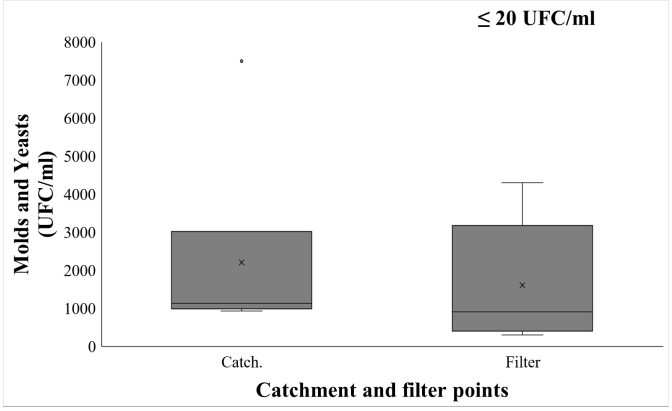

Fig 8. Molds and Yeasts estimation in the catchment and filter points

production of bacteria when both groups are examined simultaneously. This is because this indicator group grows exponentially in the presence of decomposing leaf litter, a componentpresent in the effluents[14].

The filters showed 0% efficacy in retaining molds and yeasts compared to the catchment point [Figure 8]. According to Bustamente et al[15], this occurs due to the lack of a colloidal silver, which is especially effective against this indicator group by inhibiting the enzymes involved in their respiratory process.

4 Conclusion

The first microbiological monitoring carried out in the tributaries of Caño Grande, catchment points, and filters did not meet the established standards (Resolution 2115 of 2007) for the protection and control of the water quality for human consumption since the indicator groups showed higher values; fecal coliforms (0 NMP/ml), aerobic mesophiles (≥100 UFC/ml), and molds and yeasts (≥20 UFC/ml). This could be due to inadequate waste disposal and/or infiltration of organic matter from livestock activities observed at the sampling points, deficiencies associated with treatment processes or good hygiene practices in productive and domestic activities carried out by the community, and not considering the specifications of use or useful life of the filters implemented as a method for water treatment.

Direct consumption of water from the samples analyzed in this initial study can be harmful to human health, as an average of 960 NMP/ml for fecal coliforms, 3346 UFC/ml for aerobic mesophiles, and 1851 UFC/ml for molds and yeasts were recorded. It is recommended to continue with monitoring to compare results over time and guide the community in designing a management plan that makes activities sustainable in the areas and protects the water resource, and in implementing methods that improve the conditions of the resource.

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