La Brava creek: Water quality evaluation

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Abstract. The water quality of the “La Brava” creek, in Ocaña Norte de Santander, was analyzed using physicochemical and biological parameters to determine quality indices. Three sampling sections were established throughout the study area, taking samples in duplicate every four months for each point during a year; characterization of each sample was done following the protocols of standard methods. The information obtained was analyzed through water quality and contamination indices, determining that the water quality of the micro-basin is moderate, and its level of contamination is low; remaining in good homogeneous condition along the entire area. The utilization of a systems of indices allows for a good approach to assess the conditions of the basin, establishing that, currently, anthropic activities have minimal effect on the water resource in the study area. It is important to highlight that, although the level of contamination is low, it is necessary to generate strategies that guarantee the continuous quality and water supply in the area.

1. Introduction
Water is an essential resource for life and development of biological systems. Due to changes in ecosystems and population growth, contaminating agents are generated daily, altering water quality and degrading the quality of life of the communities supplied with affected water [1]. It is important to evaluate water sources quality, for which it is useful to employ physical, chemical and biological parameters. The quantification and analysis of these parameters can be interpreted through water quality indices (WQI) [2-4].

The analysis of water quality is based on the comparison of different indicators according to the requirements of use; However, when it comes to managing an aquifer in a sustainable manner, it is important to consider the water quality variation and, if necessary, take measures to mend this trend [5]. The monitoring of physicochemical parameters allows a measure of the instantaneous quality of the water, while the biological analysis allows the detection of contamination over time [6].

Indices and indicators are pragmatic tools for monitoring water conditions, since physicochemical and biological parameters such as pH, turbidity, color, presence of Escherichia coli and macroinvertebrates can be used in conjunction through what is known as water quality indices. According to Samboni, et al. [7] the formal employment of WQI as quantitative tool started with the work of Horton in 1965, introducing 10 variables to determine the contamination in water; however, these were formally accepted as of the next decade.
Through the water resources information system (WRIS), the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM) defined 6 parameters for Colombia to standardize water quality, which are applicable for all basins and contexts. These are: biochemical oxygen demand (BOD), biodegradable organic load assimilation potential, dissolved oxygen deficit, variation of suspended sediment concentration, variation of sediment load in suspension and the evolution of electrical conductivity in groundwater [8].

This research aims to incentivize and promote the study of basins that are currently unwatched, despite being the primary water source that guarantees sustainability and maintenance of nearby population. In order to generate strategies that guarantee quality and access to water, it is necessary to understand the actual status of this resource in our country and specifically that of the micro basins, since they are the ones that supplying the main rivers of Colombia. It is from this perspective that technology and innovation should be implemented in practices that are environmentally friendly, without sacrificing economic development.

2. Methodology

“La Brava” creek starts between “Curitos” and “Venadillo” villages, and the district of Pueblo Nuevo, forming part of the hydrographic system of Ocaña, Norte de Santander, Colombia. The hydrographic basin, “La Brava” creek, has a mountainous component that extends from its source in the oriental mountain range to the entrance of the independent aqueduct Adamiuain, being part of the rural area and leading to the “Tejo river”. The creek can be accessed through the “Santa Clara” neighborhood (Ocaña) or the district of “Pueblo Nuevo”. Sampling sections were located in the Adamiuain flora and fauna reserve in the municipality of Ocaña Norte de Santander, Colombia (Figure 1); the starting point has geographic coordinates 08° 14'3.69225" LN and 73° 23'52'54527" LW and the final point 08° 14'5.77198" LN 73° 23'27.10685" LW. Sampling was carried out in four consecutive periods (quarters) during the year 2018, taking duplicate samples from each point for a total of 24 samples; sample preservation was done in-situ, according to the sample preservation techniques, specified in the standard methods for the examination of water and wastewater 21th edition (2005) [9]. In order to establish the sampling sections, it was necessary to carry out an inspection through the micro-basin, from the upper part of the village of “Venadillo”, passing through the middle part of the district of “Pueblo Nuevo” and finishing its route in the lower part of Santa Clara neighborhood flowing into the “Tejo” river, shown in Figure 1.

![Figure 1. Geographic location of “La Brava” creek and sampling sections (marked in red).](image-url)
3. Results and discussion
Table 1 shows that the nephelometric turbidity unit (NTU) fluctuated between 0.0 NTU and 1.5 NTU, this being a very low value, according to Zuñiga, et al. “Turbidity has also been associated with the potential microbiological risk in water, especially in wet or rainy periods” [10], which infers that these low values of turbidity are related to the absence of coliforms as it was found in the three sections of the micro basin. The color values ranged, universal product code (UPC), between 12 UPC and 39 UPC, this variation could be produced by the variations in rainy or dry season during the year of study; these values are low and can be related to the also low concentration of iron and colloidal magnesium in the samples of study.

Regarding conductivity, data obtained fluctuated between 182 μS/cm and 203 μS/cm, which did not indicate significant variation among the four periods of analysis. Table 2 shows that during the sampling period, pH reached an average value of 8.1 in the high zone (section 1), of 8.2 in the middle zone (section 2) and of 8.1 in the lower zone (section 3); Therefore, this value can be considered as the natural pH of this body of water. According to De Miguel and Vázquez [11] "Ammonium and nitrates are considered chemical indicators of degradation processes of organic matter", regarding the latter, concentrations fluctuated between 0.01 and 0.04 mg/L, evidencing low concentration of organic matter; this is confirmed by the absence of coliforms and Escherichia coli in the body of water. On the other hand, nitrate values vary during the four sampling periods between 8.8 mg/L and 10.6 mg/L indicating low contamination by nitrogen compounds from fertilizers and sanitary waste, among others.

Dissolved oxygen, as observed in the results of the sampling sections, had an average concentration of 8.3 mg/L O₂, indicating that the body of water is in favorable conditions for the distribution of aquatic biota; which is a good indicator since according to Carrillo, et al. "When dissolved oxygen in water is available in sufficient concentrations to keep ecosystems in good condition, aerobic organisms will use it and produce substances that are harmless to aquatic ecosystems." [12].

Table 1. Physicochemical and microbiological parameters in “La Brava” creek during 2018.

| Analysis | Unit | Dec. (2017)-Feb. | Mar.-May. | Jun.-Aug. | Sep.-Nov. |
|----------|------|-----------------|-----------|-----------|-----------|
| pH       |      | S1  S2  S3      | S1  S2  S3| S1  S2  S3| S1  S2  S3|
| Turbidity| NTU  | 1.4  0.8  0.9   | 0.7  0.6  0.6 | 0.4  0.5  0.7 | 0.1  0.0  0.3 |
| Conductivity | µS/cm | 196  196  202   | 198  201  195 | 201  197  203 | 184  182  187 |
| Suspended solids | mg/L | 26   30   27    | 31   31   29  | 29   32   35  | 31   32   32  |
| Color | Pt/Co Scale | 36  19  17      | 17   15   13  | 23   18   17  | 21   25   18  |
| Hardness | mg/L CaCO₃ | 74   81   81    | 78   77   77  | 79   79   78  | 85   86   87  |
| Alkalinity | mg/L CaCO₃ | 78   79   80    | 82   81   78  | 81   80   83  | 77   70   73  |
| Dissolved oxygen | mg/L O₂ | 9.8  8.3  7.2   | 9.8  8.1  7.1  | 9.7  8.3  7.1  | 8.1  8.3  8.2  |
| BOD5 | mg/L O₂ | 1.3  1.3  1.6   | 1.5  1.8  1.7  | 1.5  1.7  1.9  | 1.4  2.0  1.8  |
| COD | mg/L O₂ | 16   17   17    | 16   16   18  | 15   14   15  | 16   14   14  |
| Nitrates | mg/L | 0.04  0.03  0.03 | 0.03  0.02  0.02 | 0.02  0.04  0.02 | 0.03  0.02  0.04 |
| Nitrates | mg/L | 9.4  10.4  10.6 | 10.0  10.1  10.0 | 9.0  9.5  10.0 | 7.6  8.6  9.5 |
| Phosphates | mg/L | 0.33  0.35  0.34 | 0.35  0.36  0.36 | 0.37  0.39  0.38 | 0.39  0.38  0.39 |
| Total coliforms | CFU/100 mL | 0.0  0.0  0.0 | 0.0  0.0  0.0 | 0.0  0.0  0.0 | 0.0  0.0  0.0 |
| E. Coli | CFU/100 mL | 0.0  0.0  0.0 | 0.0  0.0  0.0 | 0.0  0.0  0.0 | 0.0  0.0  0.0 |
Organic contamination estimation was carried out by determination of oxidizable matter present in the water, this matter is capable of oxidation due to the oxygen available in the medium [13]. The COD oscillates within the range of 12 mg/L to 19 mg/L, indicating a low level of contamination from degradable and non-degradable organic material. Likewise, a low BOD5 was observed throughout the sampling route in the year 2018 (Table 1).

In relation to the contamination indices (CI), that measure the degree of contamination using values between 0 and 1, it was found that the basin, on average, has low contamination with slight anthropic alteration. The values of mineralization (MICI) and organic matter (OMCI), is in the range of 0.2 to 0.4. Suspended solids (SUSCI) had the lowest weighting in comparison to the other indexes measured. In the case of pHCI (pH), section 2 presented the highest level of contamination related to pH, reaching the moderate level; However, by averaging each of these indices and calculating the general CI, it takes a value of 0.17. Giving a general contamination denoted as "none", indicating low alteration by human activities, such as agriculture, livestock and domestic waste discharge.

Table 2 shows a comparison of the values for the contamination indicators, where it was identified that the CI with the greatest contribution are MICI and OMCI, that is, contamination by mineralization and organic matter; since they are the highest values in comparison with SUSCI and pHCI, which have values between 0.071 and 0.030 respectively. Although the values of MICI and OMCI in the three points on average are 0.28 and 0.30, the pollution is low and according to the current regulations does not represent risk to human health, therefore simple purification processes such as disinfection and stabilization should be sufficient treatment.

### Table 2. Contamination indices in “La Brava creek” during 2018.

| Index   | Section 1 | Section 2 | Section 3 | Classification |
|---------|-----------|-----------|-----------|----------------|
| MICI    | 0.21      | 0.32      | 0.33      | Low            |
| OMCI    | 0.33      | 0.31      | 0.31      | Low            |
| SUSCI   | 0.07      | 0.072     | 0.07      | None           |
| pHCI    | 0.035     | 0.052     | 0.038     | Mid-Low        |

### 4. Conclusions

The water quality of the La Brava creek, in Ocaña Norte de Santander, was analyzed. using physicochemical and biological parameters to determine quality indexes that allow an overview of the conditions of the study area, this information is crucial in decision making regarding management processes. It can be seen that throughout the micro basin there is low contamination, several of the analyzed parameters show homogeneity and low values. Therefore, much of the surrounding areas are being preserved. Further development of anthropic activities such as livestock and agriculture may generate impacts in the ecosystem and in turn in the water, contributing to an alteration of the sustainability of the water resource, which is based on integral management by linking land use, water management and social dynamics, thus continuous monitoring and responsible development is needed to guarantee access and quality to this resource for present and future generations.

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