Indicator of Quality of Water for Human Consumption in the Community *El Comején*, Masaya (Nicaragua)

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Abstract

Knowing the quality of water for human consumption is of utmost importance in the development of a country, since the poor quality of this vital liquid can be a source of diseases for the health of the population. The present work was carried out in the community El Comején, Masaya, in the Republic of Nicaragua, where microbiological analyzes were carried out in three sampling points (one well drilled and two taps). The physicochemical and chemical analyzes are in accordance with the norms established by CARPE, highlighting sodium as a major element with a concentration of 48.6 mg L^{-1} and potassium with 21.08 mg L^{-1}. On the other hand, biological parameters such as total coliforms, thermotolerable coliforms, *E. coli* and fecal enterococos were analyzed, being found in some sampling points, values of total coliforms of 110 NMP 100 mL^{-1} being above the established limits, requiring a treatment additional to be suitable for human consumption.

Keywords: drinling water, water resources, pollution

1. Introduction

Water is a vital element for all the living beings of the planet, since the fluvial systems maintain terrestrial life and provide water to 95% of the world population (UNECLAC, 2013). However, anthropogenic pressures, especially in the agricultural sector, represent approximately 70% of all freshwater withdrawals worldwide, and more than 90% in most countries with lower human development indexes or those considered to be developing (WWAP, 2014). The unsustainable use of water for the production of large-scale crops depletes and contaminates aquifers, reduces the flow of rivers, degrades the habitats of the life of the flora and fauna, decreasing the availability and quality of water resources (FAO, 2011). In Latin America and the Caribbean, drinking water and sanitation services are still a problem worthy of attention, as more than 13 million urban inhabitants lack improved water sources and almost 61 million lack improved facilities. of Sanitation, a situation that is even more aggravating in the rural sector (BID, 2018).

According to Jouravlev (2011) the availability and quality of water is facing the great pressures of contamination, especially by the dumping of industrial quantities of waste rich in nitrogenous and phosphorous bases that are generating high levels of eutrophication of surface waters and coastal areas, it is expected that at the rate that is being contaminated increase by 2030 to 35%. Groundwater supplies drinking water to at least 50% of the world's population, but this resource represents 43% of all water used for irrigation worldwide, 2.5 billion people depend exclusively on groundwater resources to meet their daily basic water needs (FAO, 2010).

According to Alexandros and Bruinsma (2012) to year 2050, agriculture will have to produce 60% more food globally, and 100% more in developing countries, so it becomes a strong threat to contamination for bodies of fresh water.

Given that in recent years there has been a large population growth, thus diversifying the uses of water, have generated unwanted environmental conditions, such as the growth of the number of solid waste and other anthropogenic activities that accelerate the degradation of quality of water, being a worrisome situation, since according to the United Nations World Report on Water Resources Development in 2017 in Latin America only 8% of wastewater is subjected to some type of treatment.

In Nicaragua, there is a regulation that regulates the quality control of drinking water, called the Regional Coordinating Committee of Drinking Water and Sanitation Institutions of Central America, Panama and the Dominican Republic (CAPRE), March 1994, where the methods of analysis are specified. , as well as the frequency and number of samples needed to establish quality control and the evaluation of the different measurement parameters.

According to the UNDP (2012) in Nicaragua in the 2007-2011 period, poverty and inequality among Nicaraguans were significantly reduced; the level of water and sanitation is among the lowest in the region. About 85% have access to improved water sources and about 52% use improved sanitation facilities.

This study was carried out with the support of the Center for the Investigation in Aquatic Resources of Nicaragua of the National Autonomous University of Nicaragua (CIRA/UNAN) with the objective of determining the problematic of the quality of water for consumption and of basic sanitation in the community *El Comején*, Department of Masaya, Republic of Nicaragua.

2. Material and Methods

2.1 Local

This work was carried out in the Republic of Nicaragua, specifically the community of El Comején, which is located at a distance of 10 km from the city of Masaya, limited to the North with Comején Uno, to the South with Las Flores, to the East with La Corteza and to the West with San José, this study was conducted under the coordination of the Aquatic Resources Research Center (CIRA) of the National Autonomous University of Nicaragua (Figure 1).
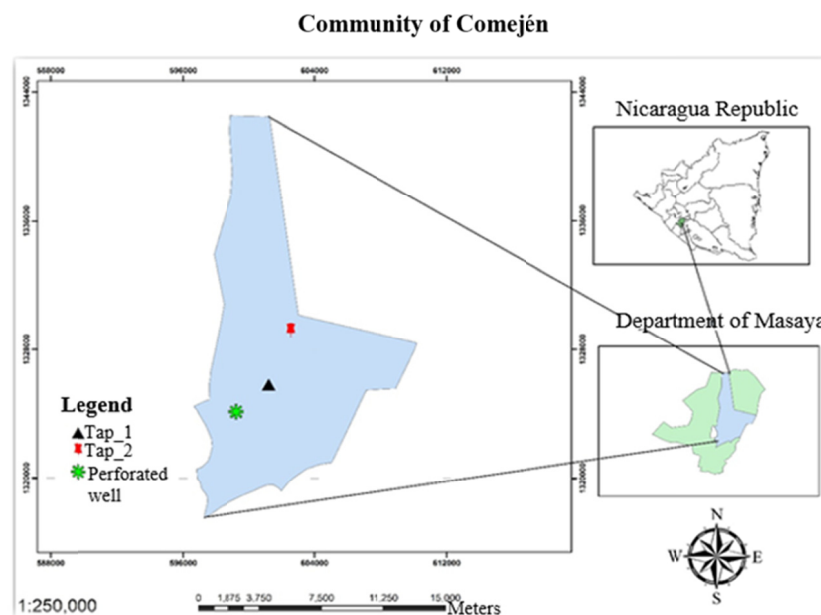

Figure 1. Comején community, Nicaragua

2.2 Sampling Points

Different sampling points were determined: one in the well drilled to the Northeast of the community of El Comején, the second point in a tap located to the north of the beginning of the distribution network and the third

sampling point in a tap that is in the final part in the southern part of the water distribution network of the project in the community of El Comején. The samples were taken, refrigerated and suitably conditioned in the absence of light until the time of analysis.

2.3 Parameters of Water Quality Indicators

Physicochemical parameters (temperature, pH, conductivity, residual chlorine and turbidity) were measured at the three sampling points, as well as bacteriological parameters (total coliforms, thermotolerable coliforms, *Escherichia coli* and *Enterococci*). At the same time, chemical indicators were also determined in the well drilled (calcium, magnesium, sodium, potassium, chlorides, nitrites, nitrates, ammonium, iron, fluorides, dissolved silica, water hardness and alkalinity), all determined in accordance with the methodology described by Mâcedo (2005).

3. Results and Discussion

3.1 Parameters of Water Quality Indicators

In Table 1, the physical-chemical parameters of field monitoring are presented in the community of El Comején, Masaya in Nicaragua for the three points studied.

Table 1. Physical-chemical parameters field in the community El Comején, Masaya-Nicaragua

pH	T (^{o}C)	Residual chlorine (mg L^{-1})	Conductivity (μs cm^{-1})	Turbidity (UTN)
Perforated Well				
7.81	28.72	0	425	0.38
Tap 1				
7.94	31.10	0	409	0.50
Tap 2				
7.87	29.91	0	417	0.44

The pH is important in the quality of water, since it controls both the balance of the chemical reactions that develop in the water and the biological activity that generally develops between values of pH 6-8 (De Souza, 2001), being the values of this work within those limits and within the recommendations (WHO, 1995). Electrical conductivity is a nonspecific property in water quality, but it gives us an idea of the total loads in solution as can be seen in Table 2, with the established parameters being higher than those recommended (WHO, 1995).

Finally, the importance of turbidity in water quality must be highlighted, since in human drinking water it protects human organisms from contamination and reflects the amount of materials, colors, minerals and organic matter present in the water, being able to be an indicator of water pollution (Espigares & Fernández-Crehuet, 1999). In this work, the parameters measured are in accordance with the established limits (WHO, 1995).

3.2 Chemical Parameters in the Well Drilled

In Table 2, the chemical parameters analyzed in the drilling well are presented.

Table 2. Chemical parameters analyzed in the drilling well in the community El Comején, Masaya-Nicaragua

Parameters	Concentration
Ca^{2+} (mg L^{-1})	20.04
Mg^{2+} (mg L^{-1})	9.23
Na^{+} (mg L^{-1})	48.6
K^{+} (mg L^{-1})	21.08
Alkalinity (mg L^{-1} CaCO$_3$)	176.2
Hardness (mg L^{-1} CaCO$_3$)	88.00
Fe^{3+} (mg L^{-1})	< 0.02
SiO_4^{2-} (mg L^{-1})	54.07
F^{-} (mg L^{-1})	0.26
NH_4^{3+} (mg L^{-1})	0.024
NO_2^{-} (mg L^{-1})	< 0.003
NO_3^{-} (mg L^{-1})	13.31

The major ions present in water are Ca^{2+}, Mg^{2+}, Na^+ and K^+. Sodium is an essential element in the body, involved in the transmission of nervous impulse as well as participating in the processes of muscle contraction, potassium, related to the maintenance of heart rate and cellular integrity and on the other hand calcium is crucial in the processes of bone formation and blood coagulation (Sizer & Whitney, 2003). Of all of them, sodium has a higher concentration, with a value of 48.6 mg L^{-1}. Sodium is one of the most abundant elements on Earth, being soluble in water (Lucas et al., 2014). This ion reaches water from natural sources by leaching from rocks or from effluents from agricultural activities (Von Sperling, 2007). Potassium is associated with aluminosilicates and feldspar minerals, reaching groundwater as a result of mineral dissolution and, on the other hand, as decomposition of plants and agricultural residues (Clesceri et al., 1999).

The composition of the macro constituents reflects the low mineralization values. The dissolved salts are in concentration that are within the ranges for fresh water (Custodio & Llamas, 1996), and the values of each of them are within the maximum admissible values for water for human consumption according to the norm (CAPRE, 1993).

For its part, alkalinity is defined as the ability of water to maintain its pH despite receiving acid or alkaline solution, the main effect of alkalinity being its reaction with certain cations in water, which leads to the formation of precipitates (Jiménez, 2001). According to the alkalinity ranges for fresh water provided by (WHO, 2016), the water studied has high alkalinity since water with values higher than 150 mg L^{-1} of $CaCO_3$ are considered as high alkalinity.

The hardness of the water is mainly related to the amount of calcium and magnesium salts dissolved in it, being the degree of hardness in these salts, proportional to the concentration of said ions in the water (Rodriguez, 2009). This ion reaches water from natural sources by leaching from rocks or from effluents from agricultural activities. In this work were detected concentrations of Calcium of 20.04 mg L^{-1} and magnesium of 9.23 mg L^{-1} being within the normal parameters for water for human consumption according to the norm (CAPRE, 1993). The value obtained for the hardness of the water in this work is 88.00 mg L^{-1} $CaCO_3$ classified as hard water (range 121-180 mg L^{-1} $CaCO_3$) According to the WHO, 1995 this range is in the recommended values that is 50 mg L^{-1} $CaCO_3$ or of total hardness expressed as calcium carbon.

As for iron, according to the (OPS, 1987) its presence in natural waters can be a consequence of the dissolution of rocks and minerals, in the water it occurs mainly in the bivalent and trivalent states (ferrous and ferric). In this work, the iron concentration found was lower than 0.02 mg L^{-1}, being below the value admissible by the World Health Organization, which establishes the maximum value in water for human consumption of 0.3 mg L^{-1}. It is an element that despite being beneficial to the body, when it is ingested in the human body in high concentrations, causes certain neurological disturbances as is the case of Alzheimer and Parkinson's disease as accumulation in body tissues (Fernández et al., 2007).

Other parameter determined was the content of dissolved silica, whose concentration is due to the dissolution of rocks containing silica such as quartz or sandstone. The concentration of dissolved silicates in this study was 54.07 mg L^{-1} higher than the values determined by Twort et al. (2000) where concentrations vary between 1 mg L^{-1} for swampy waters and up to 40 mg L^{-1} for hard waters. According to the same author, no evidence has been found that constitutes health hazards, causing problems only in water pipes.

An analyte that can cause great problems for human health in water for human consumption is the presence of fluorides, being a problem worldwide. Fluoride concentrations come from fluorine, as it is an important element in the earth's crust, associated with fluorite or calcium fluoride, cryolite and apatite (Trejo-Vázquez et al., 1997). According to the World Health Organization, the fluoride levels in water for human consumption is 1.0 mg L^{-1} (WHO, 2006), with the level determined below the established values. This variation in fluoride concentrations in aquifers depends on several factors, mainly, the concentration of fluoride in the mineral, decomposition, discoloration, residence time and kinetics of the chemical reaction (Saxena & Ahmed, 2001).

Nitrogen compounds are also present in natural waters and related to the nitrogen cycle, being its most abundant form in the atmosphere, being as a gaseous form with 78% volume, and in an oxidized form an important fraction in soils and organic substances (Miguel-Hernández & Vázquez-Taset, 2006).

The same author, argues that nitrates are dissolved in water for human consumption, from the rocks of the subsoil and rarely by bacterial oxidation or from organic matter. In polluted or underground water does not exceed 10 mg L^{-1}.

The nitrite in the state of intermediate oxidation of nitrogen, either by oxidation of ammonium to nitrate, or by reduction of nitrates, its presence is indicative of great microbiological activity. The nitrites naturally in water,

according to Guerra (1979), are found in soils that contain pH values higher than 7.7, although nitrogen fertilizers can also directly produce nitrites instead of nitrates when they are applied in alkaline soils from pH from 7 to 7.3 therefore, the slight existence of nitrite ions, are in line with the pH value determined in this work. The study carried out, the nitrite concentration is < 0.003 mg L^{-1}, according to the CAPRE standards (1993) the admissible value is 0.10 or 3.00 mg L^{-1}, the nitrate present 13.31 mg L^{-1}, according to the CAPRE standards (1993), the admissible value is 50.00 mg L^{-1}, and for ammonium it is 0.024 mg L^{-1}, the maximum value admissible according to the CAPRE standards, 1993 is 0.5 mg L^{-1}.The three analytes are below what is established by the CAPRE (1993) standards, that is, the three parameters are apt to be used in water for human consumption.

3.3 Microbiological Parameters

In Table 3, the values of total coliforms, thermotolerable coliforms, *Escherichia coli* and *Enterococcus faecalis* are considered for the well drilled.

Table 3. Microbiological parameters

Parameters	Perforated well	Tap 1	Tap 2
Total coliforms (NMP 100 mL^{-1})	4.5	110	110
Thermotolerable coliforms (NMP 100 mL^{-1})	N.D.	N.D.	3.1
E. coli (UFC g^{-1})	N.D.	N.D.	1.3
Enterococcus faecalis (UFC 100 g^{-1})	N.D.	N.D.	6.8

Note. N.D. = No Detected.

The presence of total coliforms is lower in the well drilled than in the two taps analyzed, being a parameter that must be interpreted according to the type of water, since the water that suffered disinfection, the total coliforms must be absent (Rego, Barros, & dos Santos, 2010). The results of the TCs exceed the limits established by the water quality standards for human consumption that according to the WHO, 1995. No bacteriological contamination should be detected; in the CAPPRE standard, 1993. In order for water to be consumed, the maximum admissible value must be negative.

Thermotolerant coliforms are found in the intestinal tract of both humans and warm-blooded animals, being an important parameter in water for evaluating deficient hygienic-sanitary conditions (Silva et al., 2006), being only detected in tap 2 with a value of 3.1.

On the other hand, *E. coli* belongs to the Enterobacteriaceae family, being a facultative anaerobic bacterium, being one of the indicators of faecal contacmination most used in water quality (Larrea-Murell et al., 2013). It was only detected in refrigerator 3 with a value of 3.1 CFU g^{-1}. The *Enterococus* genus is considered an efficient indicator to assess the quality of water since it is very resistant to the saline conditions of this medium and related to respiratory diseases, conjunctivites and dermatitis (Vergaray et al., 2007), being found only in tap 3 of the studied points.

Given the results of the microbiological parameters, from the bacteriological point of view the water of these three points can't be used for human consumption; however, it is recommended that an adequate methodology be established for its chlorination and monitoring of residual chlorine and other bacteriological analyzes be developed.

4. Conclusion

This work highlights the importance of carrying out water quality studies, especially in rural communities such as the one studied in this work where the continuous control of quality analytical parameters are scarce and in certain cases non-existent. The chemical parameters include high concentrations of calcium and potassium, mainly due to the types of minerals in the soil and, among the biological parameters, a high concentration of total coliforms in the taps, mainly due to the filtration of anthropogenic or waste residues animals.

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