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Evaluation of Water Quality of Buritis Lake

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Abstract: The implementation of natural parks in cities is a current and controversial theme. Therefore, in Lake Buritis, which is a leisure area for the population of the city of Goiatuba, Goiás, Brazil, the quality of the water was analyzed, carrying out quantitative tests of the water samples at six different points between the source and the outlet of the lake that flows into the stream, Chico À Toa. Physical–chemical tests (turbidity, pH, alkalinity, electrical conductivity, color, nitrate and hardness parameters), microbiological tests for species identification, analysis of the antimicrobial susceptibility profile, metals analysis and *Allium cepa* test, were performed. The total coliforms number in water samples was higher than the maximum value established by Brazilian legislation, demonstrating high fecal contamination during the spring in samples from an artesian well. The bacterial diversity found was large and there were many pathogenic bacteria. The *A. cepa* test demonstrated a cytotoxic potential for water from the source and outlet of Buritis Lake. Statistical tests were applied to verify existing correlations between parameters. Among the analyzed data, the highest correlation was between the color and turbidity parameters and the grouping between the metals (lead, iron, cadmium and magnesium).

Keywords: urban spring; microorganisms; pollutants; ecosystems; dry and rainy season; bacterial resistance

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1. Introduction

The process of urbanization and demographic agglomeration in urban centers has led to the creation of natural spaces aimed at leisure and recreation. Parks emerge in urban areas, reaching various applications, built in inadequate and irregular spaces in relation to structural terms and in basic sanitation [1]. In many cases, park springs are important resources that are used for water supply in many communities. Anthropogenic actions in natural environments have altered the natural water cycle, impairing soil infiltration and groundwater replacement, thus causing springs to lose their quantitative and qualitative capacities [2].

Anthropogenic activities influence the constitution of color in water by the release of domestic and/or industrial effluents into water bodies [3].

Water hardness is one of the common metal water quality problems, and important to assess when the water is used. Magnesium and calcium ions increase water hardness. Hard water interferes with washing, bathing and personal hygiene, and can cause irritation in mildly acidic conditions [4].

Water turbidity is another factor studied and is often associated with the presence of solids dissolved in suspension or colloidal, organic or inorganic material, which may be connected with a high concentration of iron [5]. The degradation of riparian forests and the intensive use of the soil contribute to the transport of polluting substances to watercourses, increasing the turbidity [6].

Water with high acidity generally stimulates the corrosive potential of the medium [7]. Finally, electrical conductivity refers to the ability of water to transmit electrical current, which results from the presence of cations and anions formed by the dissociation of other substances [8].

The evaluation of different water quality parameters is important to obtain a global view, which allows managers to perform efficient management of water resources. However, the complexity and the large number of variables and the different units of measurement (concentrations and levels of priority) impair this assessment [9,10].

The water quality index (WQI) is an efficient tool for this purpose, as it summarizes the water quality in a single number and category, also allowing comparisons of the current state with the past and at different points of a studied source. WQI models involve stages of selecting water quality parameters, generating sub indices for each parameter, calculating weight values for the parameters and aggregating to calculate the overall index. Each parameter used to calculate WQI can vary greatly according to the type of water, its uses, location and data availability [11,12].

Water quality can also be assessed by the presence of contaminants. Waterborne diseases are caused mainly by the ingestion of pathogenic microorganisms, including bacteria. Through the consumption of poor quality water, there is a risk of contracting many diseases, which can lead to death. However, only a limited number of microbial species can cause disease in a significant portion of the normal host [13]. In 2012, a study estimated that, worldwide, 502,000 deaths from diarrhea were estimated to be caused by inadequate drinking water, and 280,000 deaths resulted from inadequate sanitation [14].

Among these pathogenic microorganisms, enterobacteria are quite expressive, belonging to the bacillary family, Gram-negative, aerobic or anaerobic bacteria, and mobile or immobile, which parasitize the intestines of humans and other mammals. Waterborne diseases have as their main pathogenic agents those associated with the digestive tract, the fecal–oral route being their main form of infection [15]. Attachment XX of Consolidation Ordinance Nº 5 of the Ministry of Health [16] has quality control standards for water sources, with the purpose of producing and supplying water for human consumption and determines that water sources must be analyzed in order to quantify the number of *Escherichia coli* colonies, the main representative of the enterobacteria family.

Other factors used to assess water quality are metals. The presence of metals is fundamental for the control of the biological metabolism of several species [17]. However, some of these components show high toxicity, even at low concentrations, such as lead, cadmium (Cd) and mercury [18].

Cd is a nonessential metal, highly toxic and difficult to excrete [17]. Another metal with high toxicity is lead (Pb), which, in very low concentrations, has harmful effects on human health and the environment [19]. The metal magnesium (Mg) is a fundamental mineral in several cellular reactions [20]. Recent studies indicate that lithium (Li) is an essential element in the body.

It is necessary to monitor changes in the water quality of a river or hydrographic basin in order to support environmental protection and recovery actions [21]. The spread of chemical agents introduced into the environment, which can generate possible genetic changes in organisms, motivated the development of methodologies for the evaluation of the genotoxicity of substances. Among the bioassays, the *A. cepa* test is widely used in laboratories for the analysis of various substances that may cause possible mutagenic potential, estimated by the frequency of aberrations and chromosomal breaks, expressing valuable information in relation to the evaluation of environmental samples [22].

The tests with *A. cepa* are efficient due to their proliferation kinetics, rapid root growth, large number of cells in division, high tolerance to different cultivation conditions and easy handling, among others [23]. Environmental protection and recovery actions are necessary to ensure the quality of the river [24].

This research aimed to evaluate the water quality of Lake Buritis, in the municipality of Goiatuba, Goiás, Brazil, emphasizing (1) the condition of this lake environment based on Brazilian legislation; (2) the identification of possible data related to anthropogenic action; and (3) the contribution to the quality of life of future generations.

2. Materials and Methods

2.1. Study Location

This study was carried out at Buritis Lake in Goiatuba city, Goiás State, Brazil. Collection sofsurface water was performed at six sample points, approximately 3 L of water being collected from each point. All sampling points are shown in Figure 1.

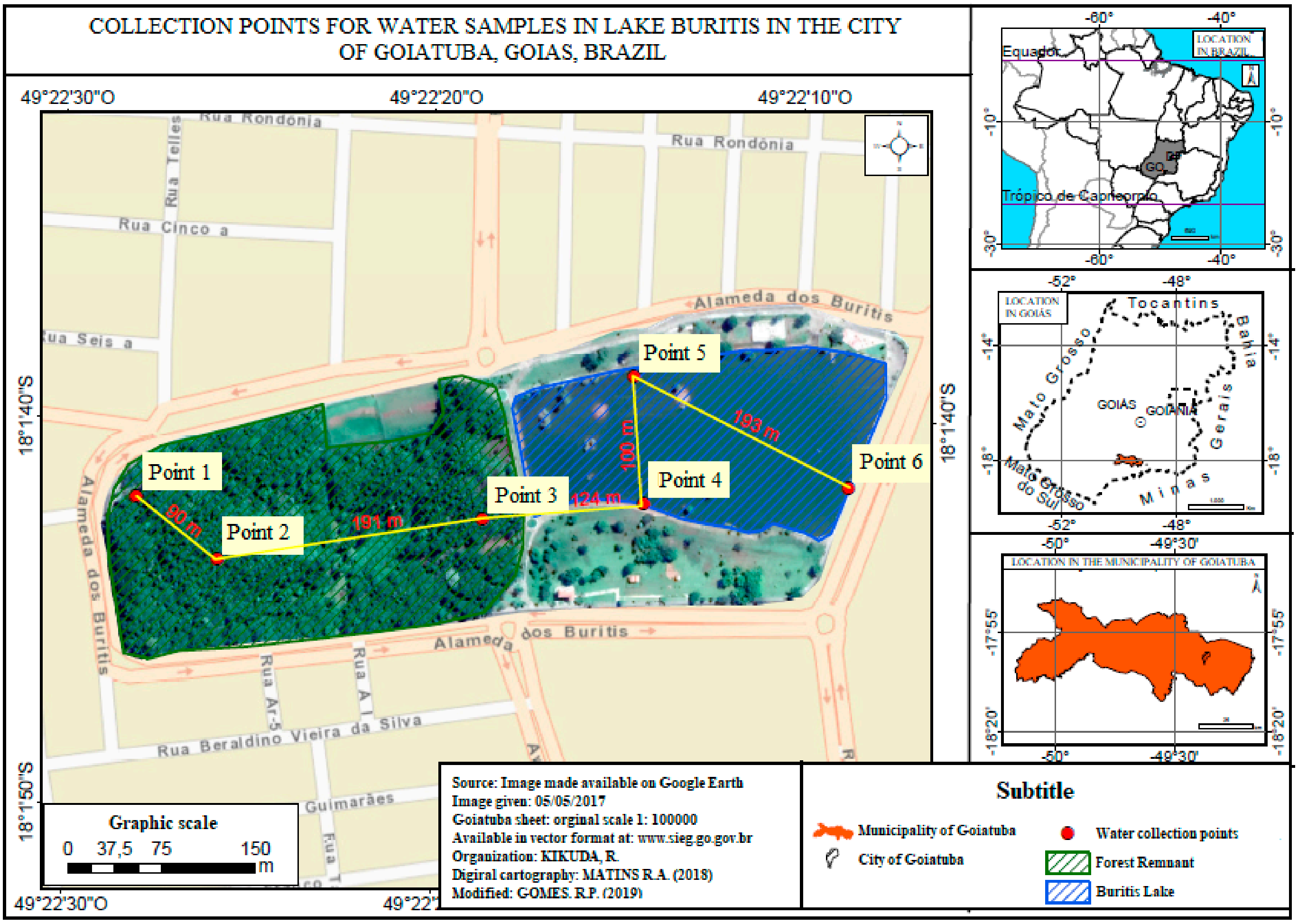

Figure 1. Sampling point location map of waters in and near Buritis Lake.

The Goiás state has two defined seasons, drought period (May to September) and rainy period (October to April), with an average annual rainfall of 1400 to 1600 mm [3]. Four sample collections were carried out at six points (shown in Figure 1), two collections for the dry period (July 2017and June 2018) and two collections for the rainy period (October 2017 and March 2018).

The water samples collected were stored in glass or polyethylene bottles and transported to the laboratory in a polystyrene box containing ice. The results obtained were compared considering 357 Resolution, CONAMA [25]. This resolution provides the classification of aquatic environments and environmental guidelines, and is also supported by Attachment XX of Consolidation Ordinance nº 5 of the Ministry of Health [16], which considers that waters collected at various points have different applications by the local community.

Point P1 (artesian well) is frequently used by the population to collect water for human consumption. Points P2, P3, P4, P5 and P6 were determined by the distances between the source and the lake; the population uses the water for recreation, leisure and animal supplies. Water at P6 is also used for irrigation of vegetables (Figure 1). We analyzed the results forP1 according to Attachment XX of Consolidation Ordinance nº 5 of the Ministry of Health [16] and the other points (P2, P3, P4, P5 and P6) according to 357 Resolution, CONAMA [25] for river class 1 and class 2.

2.2. Physical and Chemical Parameters

Analyses of the physical–chemical parameters were performed within 24 h of collection. Turbidity, pH, alkalinity, electrical conductivity, color, nitrate and hardness parameters were performed following the analytical procedures described in Standard Methods for the Examination of Water and Waste Water [26]. The parameters analyzed were to investigate if water from the source of Buritis Lake presents contamination when correlated with the possible polluting sources of anthropogenic or natural origin, associated with the use and occupation of the soil.

2.3. Microbiological Analysis

Microbiological tests were carried out on six samples from the artesian well, spring, stream and lake. After collection, the samples were processed according to the methodology of APHA [26]. Tests to identify the presence of total coliforms (TC) and thermotolerant coliforms (TTC) were carried out. In addition, 250 mL of each sample was distributed separately in culture media R-2, MacConkey and Mannitol, Kasvi®, Goiânia, Brazil. After 48 h of incubation at 30 °C, colonies with different morphological characteristics were isolated. Phenotypic identification was performed by submitting the samples to different biochemical tests. The tests performed according to Agencia Nacional de Vigilância Sanitaria (ANVISA) were: Gram staining method, oxidase and catalase enzyme verification, H_2S and indole production, lysine decarboxylase and phenylalanine deaminase, urease, citrate tests, fermentation tests with glucose, maltose and lactose, hemolysis, and gelatinase [27]. The antimicrobial susceptibility test used antimicrobial discs, and performed according to the criteria of the Clinical and Laboratory Standard Institute (CLSI) [28]. Identification of isolated bacteria in the water of Buritis Lake are in Table S1 and, antibiotic discs used for the susceptibility test of isolated bacteria in Buritis Lake are in Table S2. Susceptibility and resistance profile of isolates bacterial of water samples from Buritis Lake are in Table S3.

2.4. Metals Analysis

The sampling and preservation procedures for water samples followed the guidelines of Environmental Company of the State of São Paulo [29]. For preservation, water samples were acidified with nitric acid (HNO_3).

For the analysis of metal levels in water, 600 mL plastic containers were used. The analysis of metal concentrations in the water samples (iron (Fe), cadmium (Cd), chrome (Cr), copper (Cu), lead (Pb), lithium (Li) and magnesium (Mg)) was performed on aflame atomic absorption spectrophotometer (Analytik Jena®, Jena, Germany), model Novaa350. The samples were analyzed in triplicate, the result expressed in parts per million and then converted to µg/L units. The Analyte, flame, laps, wavelength and limit of detection (LOD) studied in this work are in Table S4.

2.5. CCME_WQI Calculation

The WQI proposed by the Canadian Council of Ministers of the Environment (CCME) was applied in this research [30].

The *CCME_WQI* is based on three main elements: F1, F2 and F3. F1 represents the number of variables that do not meet the limits stipulated for the parameters (Equation (1)).

$$\text{F1} = \frac{\text{Parameters numbers no standard}}{\text{Total parameters numbers}} \times 100 \quad (1)$$

F2 represents the frequency; that is, the number of times that the parameters were above the limits (Equation (2)).

$$\text{F2} = \frac{\text{Parameters numbers no standard}}{\text{Total numbers of analysis}} \times 100 \quad (2)$$

F3 is related to amplitude, verifying how the results of the parameters differ from the limits (Equation (5)). For its calculation, it is necessary to obtain the value of "Excluded" (Equation (3)) and "Normalized Sum of Excluded (SNE)" (Equation (4)), which represent the number of times that an individual concentration is greater than the value determined by the norms, and the departure from the values of individual analyses that were outside the established standards, respectively.

$$\text{Excluded} = \left(\frac{\text{No standard analysis value}}{\text{Value determined by the legislation}}\right) - 1 \quad (3)$$

$$\text{SNE} = \frac{\sum_{i=1}^{n} \text{excluded}}{\text{Total of analysis}} \quad (4)$$

$$\text{F3} = \left(\frac{\text{SNE}}{01\ \text{sne} + 01}\right) \quad (5)$$

After obtaining the values F1, F2 and F3, Equation (6) was used to calculate *CCME_WQI*.

$$CCME\_WQI = 100 - \left(\sqrt{\frac{\text{F1}^2 + \text{F2}^2 + \text{F3}^2}{1732}}\right) \quad (6)$$

After obtaining the results that vary from 0 to 100, they were classified into five categories: 0–44 (Poor), 45–64 (Marginal), 65–79 (Fair),80–94 (Good) and 95–100 (Excellent) [30]. The parameters used in the calculation of the *WQI* for P1 were based on Annex XX of 5 Consolidation Ordinance: pH, total hardness, turbidity, apparent color, nitrate, thermotolerant coliforms, Fe, Mg, Cd and Cu. For points P2, P3, P4, P5 and P6, the limits of 357 Conselho Nacional Do Meio Ambiente (CONAMA) Resolution were used for Class 1 and 2 waters [25]: pH, turbidity, nitrate, thermotolerant coliforms, Fe, Mg, Cd, Li and Cu.

2.6. Allium Cepa Test

The *A. cepa* test was performed according to protocols described by Fiskejo [31]. The exposed onion roots were measured to check for root growth. After processing the material, it was observed using a binocular optical microscope with 40× and 100× magnification. Three slides were prepared for each sample; 5000 cells were counted on each slide, observing how many were in mitosis, to obtain the mitotic spindle. In each slide, cells with chromosomal aberrations were also observed to obtain the mutagenic potential. The mitotic index (MI) was calculated by the number of cells in mitosis divided by the number of cells observed, multiplied by 100. The chromosomal aberrations index (CAI) index was calculated by the number of altered cells multiplied by 100 and divided by the number of cells observed [31].

2.7. Statistical Analysis

To compare the dry and rainy seasons, considering the physicochemical parameters, t tests and the Wilcoxon test for paired data were used, both applied according to the results of normality and homogeneity. Shapiro–Wilk and Kolmogorov–Smirnov tests were performed to determine normality, to complement and increase assertiveness in choosing the comparison test. The Levene test was also performed to determine the significance of homogeneity. When the Shapiro–Wilk, Kolmogorov–Smirnov and Levene tests presented $p \leq 0.05$, the data were considered nonparametric and nonhomogeneous, and consequently the Wilcoxon test was applied; on the other hand, when the *p*-test values showed results greater than 0.05, the *t* test was considered.

The data contained in the variables (hardness, conductivity, turbidity, alkalinity, color and nitrate) were characterized as nonparametric and nonhomogeneous ($\leq$0.05).With this, the paired Wilcoxon test was performed to compare the dry and rainy seasons. The pH and color data were characterized as parametric and homogeneous ($p > 0.05$); thus, the t test was considered.

The variances of cytotoxicity detected by the *A. cepa* test between the collection points and the negative control were determined using the analysis of variance test (ANOVA), associated with the Games–Howell, post hoc test when the data showed non significant homogeneity; the Tukey test was used when the data showed significant homogeneity, as characterized by the Shapiro–Wilk and Levene tests. For correlation among the physical–chemical parameters, the Pearson test was applied. The significance limit of 5% was considered for the significance of the results. The tests were performed using BioEstat® 5.3 (Statsoft, Tulsa, OK, USA), Sisvar® (Statsoft, Tulsa, OK, USA) and STATISTICA software version 10.0 (Statsoft, Tulsa, OK, USA).

3. Results

3.1. Physico–Chemical Characterization of Different Water

The Table 1 shows the results obtained for the physical–chemical parameters evaluated for the urban source of Buritis Lake water; the experiments were done in triplicate.

Table 1. Results obtained from physical and chemical analyzes of water samples from the source of Buritis Lake and maximum allowed value according legislation.

Collection	Points	pH	Total Hardness (mg/L)	Electrical Conductivity (µs/cm)	Turbidity (NTU)	Alkalinity (mg/L)	Apparent Color (uH) **	Nitrate (mg/L)
July 2017 (drought season)	P1	7.82	4.30	114.10	0.50	18.50	1.80	3.90
	P2	6.51	2.90	133.70	2.74	8.50	9.20	7.70
	P3	5.66	2.60	112.70	0.86	4.00	2.50	8.50
	P4	6.81	2.65	100.50	10.6	12.00	33.30	3.50
	P5	7.03	2.75	102.20	5.75	12.25	29.80	3.20
	P6	7.15	2.80	99.92	6.41	12.50	31.40	2.80
October 2017 (rainy season)	P1	7.73	2.50	122.10	0.25	20.00	1.20	3.60
	P2	6.68	2.00	146.90	3.65	16.25	31.00	4.60
	P3	6.44	2.25	151.20	8.68	18.00	48.70	4.60
	P4	6.92	1.85	125.60	19.60	18.50	69.20	1.20
	P5	6.97	1.70	125.60	20.90	19.00	66.80	1.10
	P6	6.98	1.65	122.70	27.70	19.25	78.70	1.10
March 2018 (rainy season)	P1	7.42	0.6	123.70	0.29	20.00	0.10	4.10
	P2	5.91	0.00	196.50	1.96	9.50	11.10	12.40
	P3	6.50	0.00	149.70	5.85	15.50	39.70	6.10
	P4	7.10	0.00	106.30	3.24	17.00	24.20	2.90
	P5	6.78	0.00	94.52	4.54	16.00	23.50	2.80
	P6	6.99	0.00	76.95	3.78	16.00	18.20	1.30
June 2018 (drought season)	P1	7.71	2.00	123.50	0.22	36.00	5.10	4.30
	P2	5.71	0.70	191.40	5.12	16.00	25.50	12.20
	P3	6.46	0.85	138.40	7.46	19.50	39.80	6.30
	P4	6.38	0.75	107.30	18.50	19.00	46.40	4.60
	P5	6.67	0.75	123.70	15.00	23.50	37.90	4.90
	P6	7.03	0.95	108.00	3.59	24.00	17.10	2.70

Table 1. *Cont.*

Collection	Points	pH	Total Hardness (mg/L)	Electrical Conductivity (µs/cm)	Turbidity (NTU)	Alkalinity (mg/L)	Apparent Color (uH) **	Nitrate (mg/L)
Means		6.81	1.52	124.88	7.38	17.11	28.84	4.60
± Standard deviation		0.57	1.19	27.80	7.55	6.14	22.07	3.05
MAV * Attachment XX of Consolidation Ordinance Nº 5 of the Ministry of Health (2017)	-	6.0 to 9.5 (1)	≤500	NR ***	≤5	NR ***	≤15	≤10
MAV * 357 Resolution. CONAMA (2005)—river class 1	-	6.0 to 9.0	NR ***	NR ***	≤40	NR ***	natural color level of the water body (2)	≤10
MAV * 357 Resolution, CONAMA (2005)—river class 2	-	6.0 to 9.0	NR ***	NR ***	≤100	NR ***	≤75 (2)	≤10

* MAV: maximum allowed value; ** uH: Hazen unit (mg Pt-Co/L); (1) = recommended value; *** NR = not regulated; (2) = true color.

The apparent color of P1 was within the standards recommended for drinking water. The source samples and lake samples, on the other hand, had the most accentuated color at P4 and P5 in October; these results can be justified by the higher degree of concentration of solids from the dissolution of organic materials.

When comparing the results found in this study, it was observed that there is a significant difference ($p \leq 0.05$) for the hardness and nitrate parameters. The pH, conductivity, turbidity, alkalinity and color parameters, showed no significant difference between the periods analyzed. Changes in nitrate and water hardness, in limestone-free natural areas, can be effective indicators to determine the anthropogenic influence on water quality [32].

3.2. Microbiological

3.2.1. Multiple Tube Results

The results of the sample from P1 were compared with the values recommended by Attachment XX of Consolidation Ordinance Nº 5 of the Ministry of Health [16], and originated from an artesian well. For the other samples from P2, P3, P4, P5 and P6, we compared these with the standards established for Class II waters, established by CONAMA [25]. The data are reported in Table 2.

The data obtained for the presence of TC from the artesian well samples showed contamination in the analyses from March and June 2018; these results show that the water samples do not meet the recommendations of the current legislation for water intended for human consumption.

The presence of FC in the water indicates poor quality and highlights the potential risk of pathogenic organisms [33]. In this way, the population that uses the water for consumption without any type of prior treatment may be putting their health at risk.

Elevated TC concentrations were observed in all samples of collected surface water. Therefore, it was not possible to estimate whether the main source of contamination was of natural or anthropogenic origin, due to urban dumping through rain galleries that flow close to the collection points.

Regarding the TTC, represented mainly by bacteria *Escherichia coli*, the Consolidation Ordinance Nº 5 of the Ministry of Health [16] limits human consumption to water samples free of this fecal bacterium; therefore, the water from P1 was inappropriate for human consumption. The other points showed values higher than the maximum allowed (1000 TTC per 100 mL), according to 357 Resolution [25].

Table 2. Bacterial count of water samples, by most probable number, from Buritis Lake and maximum allowed value according legislation.

Collect	Samples	MPN TC */100 mL	MPN TTC **/100 mL
July 2017 (drought season)	P1	ND ***	ND ***
	P2	≥1600	≥1600
	P3	≥1600	≥1600
	P4	≥1600	900
	P5	≥1600	≥1600
	P6	≥900	900
October 2017 (rainy season)	P1	ND ***	ND ***
	P2	≥1600	≥1600
	P3	≥1600	≥1600
	P4	≥1600	≥1600
	P5	≥1600	≥1600
	P6	≥1600	≥1600
March 2018 (rainy season)	P1	7	4
	P2	≥1600	280
	P3	≥1600	350
	P4	≥1600	≥1600
	P5	≥1600	≥1600
	P6	≥1600	350
June 2018 (drought season)	P1	2	≤ 2
	P2	≥1600	17
	P3	≥1600	34
	P4	≥1600	≥1600
	P5	≥1600	≥1600
	P6	≥1600	500
MAV Attachment XX of Consolidation Ordinance Nº 5 of the Ministry of Health (2017)	-	ND ***	ND ***
MAV 357 Resolution, CONAMA (2005)—river class 1	-	200	NR ****
MAV 357 Resolution, CONAMA (2005)—river class 2	-	1000	NR ****

* TC: total coliforms; ** TTC: thermotolerant coliforms; *** ND: not detectable by the technique used; **** NR = notregulated.

The reaches just below the collection points are used for irrigating vegetables. As a consequence of the results observed, it is clear that this practice is unsafe, since pathogenic microorganisms can contaminate these foods [33]. De Oliveira et al. [15] also report contamination of water by TC and TTC at the source of the Barreirinho stream, located at Ibirité municipality, Minas Gerais state, Brazil. The contamination possibly occurred through the discharge of urban waste. In this sense, it is suggested that further studies be carried out to investigate the origin of this possible contamination.

3.2.2. Phenotypic Identification

Analyzing the six sampling points in the four collections performed, 177 bacterial genera were isolated and the frequency distribution of Gram-positive and Gram-negative isolates can be seen in Figure 2. Table 3 shows all the bacterial isolates that were identified by biochemical tests performed on samples from the four collections. In the rainy season (July 2017), the bacteria most frequently isolated were *Enterobacter aerogenes* with 10% (4/40) and *Pantoea agglomerans* 10% (4/40). In rainy season (October 2017), the highest frequency was for *E. aerogenes*, *Moraxella* spp. and *Staphylococcus saprophyticus*, all with 10.5% (4/38) frequency. During the rainy season (March 2018) the species with the highest frequency of identification was *Bacillus* spp. with 13.6% (6/44). In the drought season (June 2018), the highest frequency of isolated species was for *Enterococcus* spp., 15.2% (7/46).

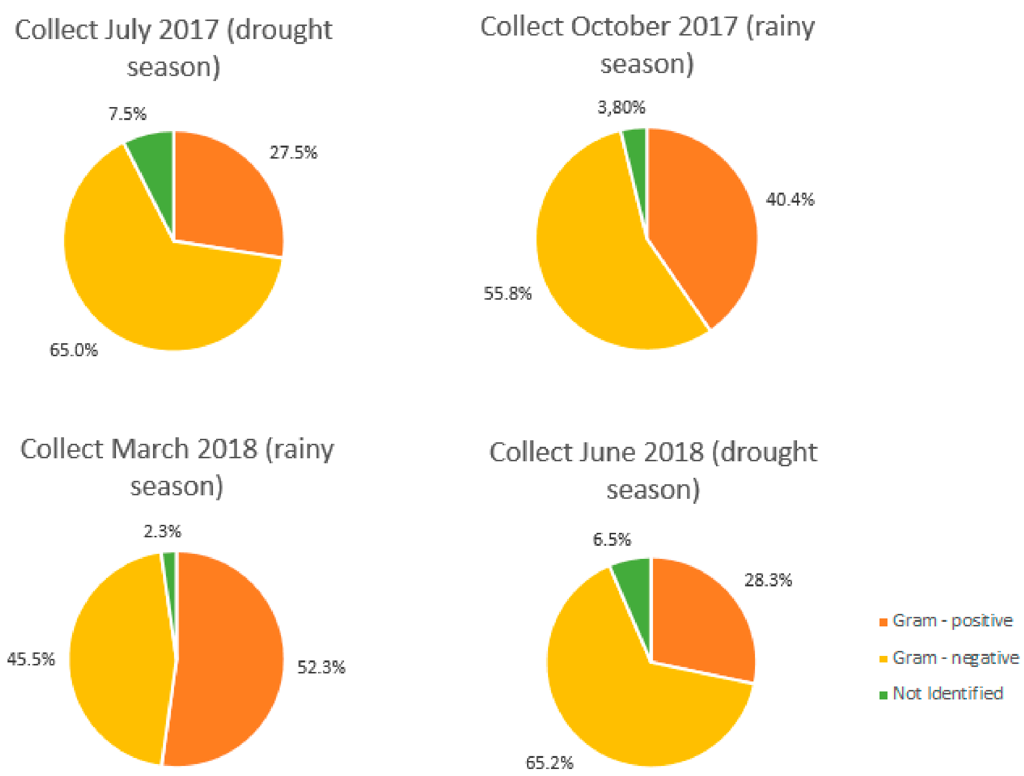

Figure 2. Distribution of isolated bacteria in Buritis Lake.

Table 3. Percentage values presented by bacterial isolates from the water of Buritis Lake, in view of exposure to antimicrobials.

Antimicrobials	**Amoxicillin**	**Ampicillin**	**Cefepime**	**Cefoxitin**	**Ceftazidime**	**Ceftriaxone**	**Aztreonam**	**Ciprofloxacino**	**Amikacin**	**Tetracycline**	**Sulfazotrim**	**Gentamycin**	**Ampicillin + Sulbactam**	**Piperacyclin**	**Amoxicillin + Clavulanate**	**Chlorphenphenol**	**Penicillin**	**Rifampicin**	**Clindamycin**	**Erythromycin**	**Linezolid**	**Novobiocin**
I (%)	0.0	3.9	3.1	0.0	3.1	4.1	1.75	2.9	0.0	1.1	3.3	4.1	0.0	0.0	9.1	0.0	0.0	0.0	5.3	2.6	0.0	0.0
R (%)	47.1	50.1	12.3	6.2	10.8	10.2	1.7	4.8	6.2	9.5	10.9	14.3	50.0	100.0	59.1	5.9	71.8	56.4	63.2	48.7	56.4	70.0
S (%)	52.9	45.1	84.6	93.7	86.1	85.7	96.5	92.2	93.7	89.4	85.9	81.6	50.0	0.0	31.8	94.1	28.2	43.6	31.6	48.7	43.6	30.0
TN	17.0	51.0	65.0	16.0	65.0	49.0	57.0	103.0	64.0	94.0	92.0	98.0	6.0	43.0	22.0	17.0	39.0	39.0	38.0	39.0	39.0	40.0

Percentage of isolates R: resistant; S: sensitive; I: intermediaries: TN: total number of isolates tested.

Among the two collections carried out during the rainy season and the two collections carried out during the dry season, 38 and 46 different species were identified and isolated, respectively, showing consistency between environmental microorganisms and human pathogens, regardless of the season in which the water samples were collected. It is suggested that this frequency of isolated species is due to human interference in the natural processes of the lake.

These data suggest that the water from the artesian well (P1), according to the microbiological standard, established by the Consolidation Ordinance Nº 5, of Ministry of Health [16], may be considered unfit for human consumption. On the other hand, the water from the source of Buritis Lake (from the reach between P2 and P6), used without previous treatment, can damage human health, observing that it has been used for irrigation of vegetables and leisure activities without prior treatment. However, to confirm this information, further studies are needed.

3.2.3. Antimicrobial Resistance Test

The percentage of the isolates in response to exposure to antimicrobials is shown in Table 3. The tested antimicrobials that demonstrated the highest percentage of resistant strains are: piperacyclin (100% resistance); penicillin (71.79% resistance); clindamycin (63.16% resistance); amoxicillin plus clavulanate acid (59.09% resistance); linezolid and rifampicin (both with 56.41% resistance). Aztreonam was the antimicrobial with the lowest percentage of resistance (1.75%).

3.3. Metals

Metals were evaluated and the data are shown in Table 4.

Table 4. Results of the analysis of metals present in the water of Buritis Lake and maximum allowed value according to legislation.

Collection	Samples	Pb (µg/L)	Fe (µg/L)	Mg (µg/L)	Cd (µg/L)	Li (µg/L)	Cu (µg/L)
July 2017 (drought season)	P1	<LOQ″	0.10	0.20	<LOQ″	0.55	1.00
	P2	<LOQ″	6.10	12.20	<LOQ″	0.49	2.30
	P3	<LOQ″	6.70	13.40	<LOQ″	0.65	1.40
	P4	<LOQ″	19.40	38.80	<LOQ″	0.55	1.10
	P5	<LOQ″	24.90	49.80	<LOQ″	0.55	1.50
	P6	<LOQ″	14.60	29.20	<LOQ″	0.49	1.10
					<LOQ″		
October 2017 (rainy season)	P1	0.10	1.12	0.31	<LOQ″	0.09	0.20
	P2	0.07	5.13	0.04	<LOQ″	0.09	0.10
	P3	0.08	3.00	0.67	<LOQ″	0.01	0.40
	P4	0.13	3.29	0.64	<LOQ″	0.07	0.30
	P5	0.14	1.95	0.73	<LOQ″	0.07	0.40
	P6	0.12	31.01	0.59	<LOQ″	0.08	0.40
					<LOQ″		
March 2018 (rainy season)	P1	<LOQ″	3.00	360.00	<LOQ″	0.03	0.10
	P2	<LOQ″	2.00	160.00	<LOQ″	0.02	0.10
	P3	<LOQ″	97.00	170.00	<LOQ″	0.02	0.20
	P4	<LOQ″	3.00	130.00	<LOQ″	0.02	0.60
	P5	<LOQ″	1.00	140.00	<LOQ″	0.02	0.20
	P6	<LOQ″	23.00	140.00	<LOQ″	0.00	0.30
June 2018 (drought season)	P1	0.14	3.20	353.00	0.03	0.09	0.23
	P2	0.10	58.60	208.00	0.00	0.05	0.05
	P3	0.12	90.90	166.00	0.03	0.02	0.25
	P4	0.13	50.20	155.00	0.05	0.01	0.50
	P5	0.07	60.90	158.00	0.06	0.02	0.31
	P6	0.11	12.70	153.00	0.08	0.01	0.31
Means		0.05	21.78	101.65	0.01	0.18	0.56
± Standard deviation		0.05	28.72	107.38	0.02	0.23	0.56
MAV Consolidation Attachment XX of Consolidation Ordinance Nº 5 of the Ministry of Health (2017)	-	0.01	300.0	NR **	5.0	NR **	20,000
* MAV 357 Resolution, CONAMA (2005)—river class 1	-	0.01	300.0	NR **	1.0	25,000	9.0
* MAV 357 Resolution, CONAMA (2005)—river class 2	-	0.01	300.0	NR **	0.1	2000	9.0

* Maximum allowed: MAV; not detected: <LOQ″; CONAMA: National Council for the Environment; ** NR: not regulated.

Regarding the chemical parameter Fe, it was observed in all samples; the concentration values were lower than allowed (maximum value of 0.3 mg/L). Cd was detected in the

June collection (2018) and presented values within the standard established by current legislation. Pb was detected in the samples collected October 2017 and June 2018. In all samples, the concentration of Cu and Li presented below the permitted value established by Brazilian legislation.

3.4. CWQI Results

The indices for each sampling point were calculated, including collections from different seasonal periods and also for the rainy and drought seasons. The CWQI was analyzed not taking into account the seasonal period (Figure 3). In the CWQI analysis for Buritis Lake, results were observed to fall into the regular and good water category for this particular environment.

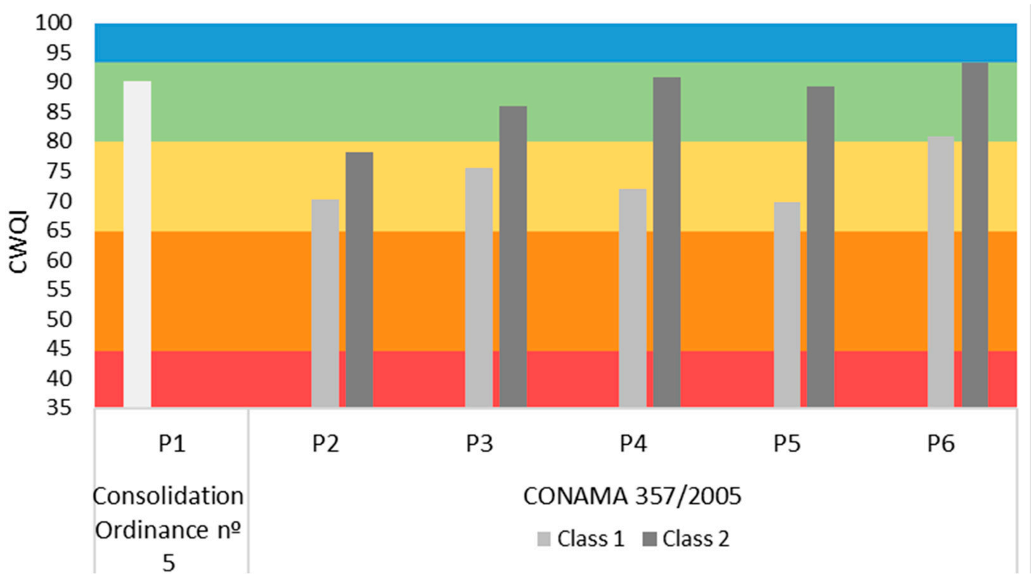

Figure 3. Water quality indices for Buritis Lake, encompassing results for rainy and drought seasons.

Among the values included together in the calculation of the CWQI, 24 were outside the established limit, considering all the points studied and the limits for class 2 of the 357/2005 CONAMA Resolution. The parameters that contributed to the decrease in the indices were TTC, pH and nitrate. In general, among the results outside the established limit, 75% were related to the TTC parameter, 12.5% to pH and 8.5% to nitrate.

In relation to P1, the results were evaluated from the perspective of the Legislation for drinking water, with the microbiological parameter TTC being responsible for the decrease in the index. The Brazil Ministry of Health [16] establishes that for water for human consumption, the fecal pollution indicator must be absent. Evaluating the CWQI during the rainy and drought seasons, the fecal pollution indicator presented a lower index than that observed during the drought season. This result is justified due to the influence of the F3 element, in relation to the limit established by the standard. This element is used in the calculation that evaluates the distance from the result, considering that the result of the TTC parameter was higher in the rainy season.

P1 is a spouting well from which the population of the city of Goiatuba, GO, seeks water for human consumption, despite having a water supply system in the city. The samples collected at P2, P3, P4, P5 and P6 are from superficial sources and, therefore, were evaluated according to the limits established by 357/2005 CONAMA Resolution. These points are located inside an area of relevant ecological interest (ARIE). Therefore, because it is a preservation area, two categories were used to calculate the index: Class 1, with more restrictive maximum values (VMP), and Class 2, with less restrictive limits.

The samples collected at P2 and P3 showed results above the VMP for the parameters TTC and pH and, only at P2, showed higher values for nitrate. AtP2, there is a spring that receives water from P1 in the same place where a channel is formed upstream from where it reaches the lake. There are pipes next to P2that discharge rain water at that same place, thus impacting water quality from that point. It is observed that for the two class evaluations for the samples atP2, the results were categorized as regular; therefore, actions are needed to protect water quality.

In restrictive assessment, for the class 1 water, the CWQI showed lower values when compared with CWQI of the class 2 water. TC and turbidity are the two parameters used in the calculation that differ in the CWQI among the classes; however, TTC is the main parameter responsible for the resulting value of the index.

As for seasonality, there was no relevant gap among the indices for the rainy and drought seasons (Figure 4) at P2 to P6. However, for class 2, the predominant categorization is Good.

CWQI Results

Seasonal Period

Points	General		Rainy		Drougth	
P1	90.2		88.4		91.8	
	Class 1	Class 2	Class 1	Class 2	Class 1	Class 2
P2	70.1	78.2	69.3	78.2	70.9	78.1
P3	75.5	85.9	77.8	92.2	75.9	85.3
P4	72	90.8	69.7	89.2	74.7	89.2
P5	69.7	89.2	69.7	89.2	69.7	89.2
P6	80.9	93.2	77.8	92.2	84.5	92.2

Figure 4. General water quality indices by period and for the points studied, using as a basis for the limits of the parameters established in Annex XX of Consolidation Ordinance N°. 5 for P1 and the other points (P2 to P6) according to CONAMA resolution N° 357 for class 1 and 2.

3.5. *Allium cepa* Test Results

The observed results, after the analysis of the meristematic cells submitted for treatment with the water from Buritis Lake, are shown in Table 5.

The root growth of *A. cepa* roots, submitted for treatment of the first collection (July 2017), did not show a significant difference ($p > 0.05$), indicating cytotoxicity of the analyzed samples, except P6 that showed a significant difference ($p < 0.05$). The analysis of the MI, for the samples collected in July 2017, showed a significant difference between the samples ($p = 0.002$), indicating the significant difference inP6 relative to the negative control; this result can be correlated with the accumulation of anthropogenic residues found at the site. The other parameters showed a significant reduction ($p \leq 0.05$).

The data corroborate with studies carried out in the metropolitan Rio de Janeiro region, Rio de Janeiro state, Brazil, where the cytotoxicity of a water sample was identified [33].

The evaluation of the CAI for July 2018 revealed that P5 presented the greatest chromosomal damage, possibly due to the presence of pollutants from local anthropogenic action. As for genotoxicity, there was no statistical difference for the CAI between the collection points and the negative control. This result indicates that the spring water physicochemical parameters were within allowable limits defined by the legislation. However, samples have a direct effect on DNA integrity due to the presence of toxic substances such as metals. However, it was not possible to identify the substances that caused the chromosomal damage, due to water having a mixture of components.

Table 5. Characterization of mutagenicity and cytotoxicity of water samples from Buritis Lake by the *A. cepa* test.

Collection	Samples	Mean of GR (cm)	MI (% Means ± SD)	CAI (% Means ± SD)
July 2017 (drought season)	P1	4.93	55.1 ± 4.24	0.23 ± 0.13
	P2	4.22	58.24 ± 1.87	0.5 ± 0.20
	P3	3.9	59.44 ± 5.88	1.51 ± 0.07
	P4	4.27	50.36 ± 3.65	0.96 ± 0.08
	P5	3.52	51.07 ± 3.46	0.94 ± 0.14
	P6	3.5	32.34 ± 7.70	0.32 ± 0.23
	NC	4.53	51.03 ± 4.58	0.52 ± 0.14
October 2017 (rainy season)	P1	6.52	52.98 ± 17.16	0.83 ± 0.19
	P2	5.6	56.93 ± 7.42	0.93 ± 0.49
	P3	6.08	55.07 ± 10.77	0.73 ± 0.10
	P4	5.32	48.17 ± 7.18	0.86 ± 0.12
	P5	4.67	51.45 ± 8.09	0.47 ± 0.21
	P6	7.01	30.61 ± 4.47	0.67 ± 0.21
	NC	4.48	53.96 ± 1.51	0.51 ± 0.16
March 2018 (rainy season)	P1	3.73	49.65 ± 13.98	0.27 ± 0.13
	P2	4.04	30.61 ± 4.47	0.35 ± 0.08
	P3	3.98	42.89 ± 15.19	0.19 ± 0.11
	P4	5.53	48.17 ± 7.18	0.24 ± 0.02
	P5	3.27	46.69 ± 4.77	0.25 ± 0.09
	P6	5.20	53.19 ± 5.75	0.21 ± 0.03
	NC	3.88	55.89 ± 1.82	0.41 ± 0.17
June 2018 (drought season)	P1	4.11	44.65 ± 11.77	0.27 ± 0.08
	P2	3.87	52.11 ± 8.05	0.18 ± 0.06
	P3	3.74	51.00 ± 2.23	0.27 ± 0.17
	P4	3.64	49.73 ± 7.55	0.25 ± 0.02
	P5	4.45	55.67 ± 2.17	0.28 ± 0.09
	P6	4.11	44.51 ± 9.22	0.28 ± 0.06
	NC	4.04	55.18 ± 3.03	0.23 ± 0.04

RG: root growth; MI: mitotic index; CAI: index of chromosomal aberrations; NC: negative control; SD: standard deviation.

The statistical analysis for the root growth of the meristematic cells of *A. cepa*, from the collection carried out in October 2017, showed no significant difference (p = 0.207) between the samples and the negative control. The result of the MI of the second collection confirms the results of cytotoxicity, based on root growth (p = 0.07), between the negative control and the samples from P1, P2, P3, P4, P5 and P6. The CAI of that collection indicated that there was no significant difference between the sample points and the negative control (p = 0.194).

The results of the March 2018 analyses indicated that the root growth of the meristematic cells of *A. cepa* showed a significant difference ($p \leq 0.0001$) between the samples and the negative control. The post hoc test ($p \leq 0.05$) indicated a significant difference for P2 in relation to the negative control. The MI indicated a significant difference between the negative control and P2 (p = 0.008). The post hoc analysis (Games–Howell test) of the treatment showed no significant difference for the sample from P2 (p = 1.164).

The results of the June 2018 analyses showed that the root growth of *A. cepa* meristematic cells showed no significant difference (p = 0.323) between the samples and the negative control. The MI indicated that there was no significant difference between the negative control and the sampling points (p = 0.372). The CAI, showed no significant difference between the samples and the negative control (p = 0.877).

The difference between the results of the July and March 2018 analyses can be interpreted as resulting from the difference in the concentration of pollutants in the water, due to natural factors such as rain. This finding applies to the data presented here.

In the March 2018 collection, a large number of abnormalities were found in the water samples collected at P2, which may have been caused by the presence of polluting residues coming from storm galleries that flow close to P2.

3.6. Correlation of Parameters

To relate the data, principal component analysis (PCA) was applied to correlate the data obtained in this study, which is shown in Figure 5. Components 1 and 2 present values of 26.31% and 19.29% of the total variation, respectively. However, some parameters were analyzed and they only showed strong correlation with each other. The parameters Mg, alkalinity, Pb and Cd demonstrate large positive factor loads on component 1, strongly influencing component 1. However, the parameters Cu, total hardness, Li and CAI exhibit large negative factor loads on component 1, negatively influencing the component. On the other hand, component 2 was influenced positively by pH and negatively by the color, turbidity, TC and TTC parameters.

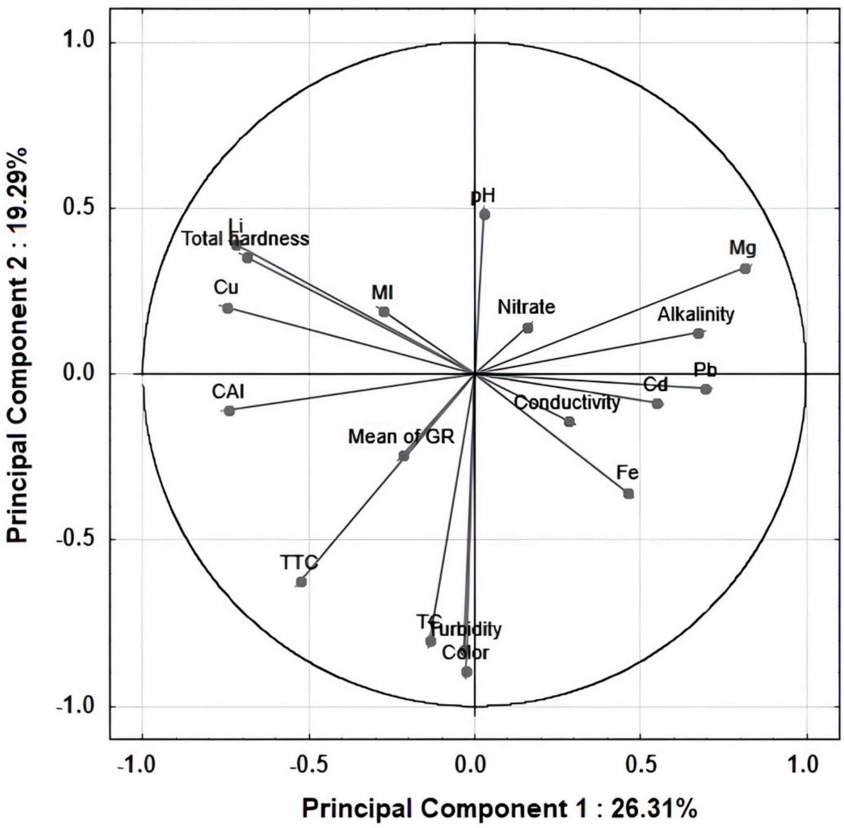

Figure 5. Principal component analysis referring to the data of physicochemical parameters, metals and quantification of total and thermotolerant coliforms of water samples from Buritis Lake.

Groups that have an influence on the components have associations with each other, which are confirmed by the Pearson correlation data presented in Table 6. The strongest correlation found is between turbidity and color, with a positive correlation of 0.92, which can also be seen in Figure 5; both have close factor loads. Similarly, TC has a positive correlation with color (0.55) and turbidity (0.43). Other strong positive correlations are between Pb and Cd (0.78), Li and Cu (0.86) and nitrate and conductivity (0.77). The most accentuated negative correlations are with pH and nitrate (−0.70) and pH and TC (0.72). The correlation exists between metals in the same hydrologic body because it is caused by the interaction that these metals can have with other metals [34]; this may be one of the explanations for the correlations found.

Table 6. Pearson's correlation referring to the data of physicochemical parameters, metals and quantification of total and thermotolerant coliforms of water samples from Buritis Lake.

	pH	Total Hardness	Conductivity	Turbidity	Alkalinity	Color	Nitrate	Pb	Fe	Mg	Cd	Li	Cu	TC	TTC	Mean GR	MI	CAI
pH	1.00																	
Total Hardness	0.32	1.00																
Conductivity	−0.52	−0.17	1.00															
Turbidity	−0.10	−0.06	−0.07	1.00														
Alkalinity	0.57	−0.14	−0.08	0.12	1.00													
Color	−0.16	−0.11	0.03	0.92	0.08	1.00												
Nitrate	−0.70	−0.14	0.77	−0.40	−0.37	−0.39	1.00											
Pb	−0.09	−0.22	0.12	0.11	0.62	0.04	0.16	1.00										
Fe	−0.37	−0.38	0.22	0.23	0.06	0.30	0.25	0.43	1.00									
Mg	0.05	−0.59	0.13	−0.31	0.50	−0.35	0.24	0.52	0.27	1.00								
Cd	0.02	−0.22	−0.13	0.13	0.52	0.01	−0.06	0.78	0.31	0.35	1.00							
Li	−0.01	0.74	−0.29	−0.25	−0.53	−0.32	0.10	−0.31	−0.20	−0.39	−0.25	1.00						
Cu	−0.05	0.63	−0.31	−0.12	−0.55	−0.19	0.04	−0.31	−0.20	−0.45	−0.19	0.86	1.00					
TC	−0.72	−0.37	0.11	0.43	−0.44	0.55	0.12	−0.02	0.33	−0.29	0.08	−0.10	0.09	1.00				
TTC	−0.26	0.09	−0.25	0.52	−0.31	0.53	−0.29	−0.26	−0.19	−0.53	−0.05	0.11	0.35	0.60	1.00			
Mean GR	0.29	0.18	0.03	0.30	0.17	0.31	−0.36	−0.28	−0.26	−0.48	−0.24	−0.30	−0.20	−0.07	0.16	1.00		
MI	−0.07	0.27	−0.14	−0.24	−0.08	−0.25	0.04	0.02	−0.04	−0.16	0.02	0.21	0.26	0.00	0.16	0.02	1.00	
CAI	−0.19	0.52	−0.09	0.07	−0.45	0.07	−0.03	−0.38	−0.32	−0.60	−0.32	0.46	0.38	0.16	0.44	0.27	0.30	1.00

Correlations in bold indicate significant correlations with $p \leq 0.05$.TC: total coliforms. TTC: thermotolerant coliform. Mean GR: mean growth root. MI: mitotic index. CAI: chromosomal aberrations index.

4. Discussion

According to 357 Resolution CONAMA, the pH must remain between 6.0 and 9.0; in the samples evaluated, the pH varied between 5.66 and 7.67, in compliance with current legislation. The pH at P6 was close to neutral, while P2 had the most acidic pH. Similar research results were found fora stream belonging to a conservation area in the State of São Paulo [35]. The authors point out that most bacteria in the aquatic environment develop best with a pH between 6.5 and 7.5. It is noteworthy that large variations in pH impair the chemical and biological balance of water resources [36].

Regarding the turbidity parameter, it can be seen that P2 to P6 were below the maximum limit allowed by Resolution 357 [29]. Water at P1, since it is used for consumption, was evaluated in accordance with the limits established by Consolidation Ordinance nº 5; it is also within the values allowed for this parameter. Turbidity is directly related to solids that are dissolved and suspended in water. These solid particles cause turbidity that can protect bacteria from disinfection, since these solids can involve the microorganisms and hinder the action of the disinfectant [37].

Regarding electrical conductivity, the CONAMA 357 legislation does not establish limits, but CETESB [29] indicates that values above 100 µS/cm correspond to the presence of pollutants in water. In this study, the sample collected at P6 during July 2017 and samples collected at P5 and P6 during March 2018 are below the level specified in CETESB. Electrical conductivity of water does not pose a risk to human health, but when found in excess it poses a risk and the water is unpleasant to taste [38].

Regarding total hardness, it is observed that the samples of this study can be considered as soft water because they presented values below the maximum established for this category of water. According to the legislation [38], in water bodies with reduced hardness, the biota is more sensitive to the presence of toxic substances, because toxicity is considered to be inversely proportional to the degree of hardness, as hardness has the effect of reducing the toxicity of metals such as copper, zinc and lead [4].

For alkalinity, the results obtained in this study for P1 were below 20 mg/L $CaCO_3$, which demonstrates slight alkalinity in the water of the tested well. Low alkalinity waters

(<24 mg/L for $CaCO_3$), as observed in the samples collected from P2, P3, P4, P5 and P6, have low buffering capacity, being susceptible to pH changes. The alkalinity of the water is mainly related to the presence of hydroxide, carbonate and bicarbonate ions. This parameter provides information for the study of the corrosive or fouling characteristics of the analyzed sample [39].

Nitrate only exceeded the allowed value (CONAMA 357 Resolution [25]) at P2, collected during March and June 2018. The concentration of nitrate depends on leaching processes of soil organic matter, resulting from rain fall and related to biogeochemical processes [40]. The occurrence of nitrate concentrations, with a significant difference related to seasonality, may be the result of pollution sources near rain galleries. Furthermore, according to Agrizzi et al. [40], a high concentration of nitrate can be due to the accumulation of manure from animals that use the location for drinking, or probably the lack of adequate sanitation in the area.

Concerning the microbiological analyses from this study, TTC, represented mainly by *Escherichia coli* bacteria, the Consolidation Ordinance Nº 5 of the Ministry of Health [16] limits human consumption to water samples free of this fecal species; therefore, the water sampled at P1 was inappropriate for human consumption. The other points showed values higher than the maximum allowed (1000 TTC per 100 mL), according to 357 Resolution, CONAMA, [25].

The most abundant bacterial family found was Enterobacteriaceae; the most consistently occurring genera were *Enterobacter* spp., *Pantoea* spp., *Listeria* spp., *Klebsiella* spp. and *Sphingimonas* spp. The results found by Nascimento et al. [41], in the rivers of the semiarid region of Rio Grande do Sul state, Brazil, are similar to the results found in this research. The authors associated the large number of enterobacteria found in water to the contamination of the sites by fecal material of human or animal origin.

One factor that should be noted in this research is the high frequency of *Enterobacter* spp. and *Klebsiella* spp., which are are highlighted by ANVISA [42] as bacteria related to infections in the community, usually transmitted by contaminated water or food. Another very relevant factor is the presence of *Chromobacterium violaceum*, which despite being a common microorganism in soil and water, can cause serious infections and can lead to death [43].

In relation to the Gram-positive isolates, *Staphylococcus* spp. were one that presented in greater number; species of this genus are considered to be one of the most serious human pathogens [43]. The genus *Staphylococcus* spp. constitute the resident or transitory microbiota of humans, related to primary bloodstream infection, lower respiratory tract infection, infection of surgical sites, among others, and, furthermore, may be resistant to a wide range of antimicrobials [43].

On the other hand, the bacterial resistance was studied in this work; antimicrobial-resistant bacteria are a major public health problem as they lead to infections that trigger higher morbidity, mortality and higher treatment costs than those caused by susceptible bacteria of the same species [44].

Many environmental bacteria have the ability to use antimicrobials as a carbon source and thus survive in environments that have high concentrations of such drugs [45]. Bacteria with this characteristic are important reservoirs of bacteria resistance genes that colonize and infect humans [38].

The results of antimicrobial resistance found in this study are similar to those reported by Bortoloti et al. [45] for water sampled close to urbanized areas in Itajubá municipality, Minas Gerais, Brazil. Bacterial resistance limits treatment options, which can prolong the severity or duration of diseases [46]. Bacteria found in water, resistant to antimicrobials, pose health risks.

According to Vaz-Moreira [47], the risk to human health occurs when there is direct transmission of bacteria through the consumption of water or, indirectly, through the transmission of resistance genes. Narciso-da-Rocha and Manaia [48] also reinforce the importance of the environment in the dissemination of bacteria resistant to antimicrobials, which can become clinically relevant opportunistic agents.

Some isolates in this study such as *Staphylococcus* spp., *Aeromonas* spp., *Enterobacter aerogenes*, *Proteus vulgaris*, *Enterobacter cloacae* showed resistance to at least one agent in three or more antimicrobial categories, characterizing them as multidrug-resistant (MDR). MDR bacteria are a worldwide problem—millions of people develop infections annually by these organisms and are therefore more prone to treatment failures, prolonged hospitalizations, stay in intensive care units (ICU), invasive procedures and death [49].

In this study, the concentrations of metals in water were also verified. Few studies have investigated the concentration of metals in water samples from urban lakes, which is important owing to metal accumulation, persistence and negative effects for both environmental and human health [50].

Fe, when in high concentrations, can cause changes in the color of water, stain objects and interfere with the supply system [51]. Iron is a vital mineral for cellular homeostasis [28], but excessive consumption of Fe can cause hemochromatosis, a disease characterized by the accumulation of this metal in the liver, pancreas, heart and pituitary [52]. We report acceptable values according to the Consolidation Ordinance nº 5 of the Ministry of Health [16] and Resolution 357, CONAMA [25], and these changes described above can also occur, which was found in our studies. Li is a simple element found in small amounts in vegetables, plant-derived foods and drinking water; therefore, in small amounts, it does not cause harm [19], so the Li concentrations found in our study cannot cause adverse reactions.

A study of an urban lake in eastern China assessed the risk coefficient for aquatic species in the lake, indicating the metal concentrations to affect 10% of the species were 0.00017 mg/L Cu, 0.015 mg/L Pb, 0.00095 mg/L Cd. Values for other metals were also provided [53].

Wang et al. [54,55] reported that Cu is among the metals of greatest concern and risk for the studied lakes in China; Park et al. [56] reported the same for Korean rivers. Fu and collaborators [50] reported that although Cu and zinc (Zn) are essential nutritional elements, they can cause toxic effects mainly in aquatic species. Humans have two detoxifying organs, kidneys and liver. Fish can be from 10 to 100 times more sensitive to Cu than mammals.

In addition, these reports attributed the increase in these metals in aquatic environments due to the increase in production in China and discharges of industrial waste, tailings, leachate and atmospheric deposition from industrial and mining manufacturers. Yilmaz and collaborators [57] highlight that the levels of heavy metals found in fish, at the top of the aquatic food chain, can reach values higher than those found in water or sediment, and reach humans at some level of exposure and absorption. Among the metals that can be absorbed and accumulated by fish are Cu, Zn, Cr, Cd, Pb and mercury.

According to Muniz [58], Cd occurs naturally in the environment. Cd can also be found in phosphate-based agricultural fertilizers. According to the International Fertilizer Industry (IFI) [59], when absorbed by the human body, it can cause problems to the cardiovascular, gastrointestinal, neurological, renal, reproductive and respiratory systems, causing development problems in embryos and act as a carcinogenic agent [59]. Pb is easily introduced into the environment through a variety of human products and processes [60]. According to the International Public Health Program (IPHP), Pb contamination interferes with the production of hemoglobin, can cause renal dysfunction, mental retardation and cause several types of cancer [61]. The World Health Organization (WHO) established a reference value for Pb in drinking water of 0.01 mg/L [62].

Mg deficiency is associated with reduced integrity and function of cell membranes in several diseases: cardiovascular; preeclampsia/eclampsia; leakage; hypertension; diabetes mellitus; bronchial asthma; disorders of the immune system, among others [61]. In contrast, Li is found naturally in trace quantities in plants, plankton and animals. In vertebrates, the concentration is relatively low [62].

Concerning CWQI results, Silva and collaborators [63] reported the following situation in parks in the city of Curitiba/PR: the population stores water in 20L gallons that is collected at locations scattered throughout the area. Since the water is not intended for human consumption and consequently does not comply with potability standards, water consumption can pose health risks. Once the presence of the fecal contamination indicator is detected, there may be the presence of other pathogenic microorganisms.

We used the *A. cepa* test in this study to verify the cytotoxicity of the tested substrate through the cell growth rate, which may be increased or decreased [64]. The significant reduction in MI relative to the negative control may indicate alterations suggestive of being derived from the chemical action of the extract on the growth and development of the exposed organism [65].

According to Datta [66], the *A. cepa* test is a sensitive test for chemicals and pollutants that pose environmental risks, since the root tip is the part of the plant that has the most contact with chemicals and pollutants found in water or soil. This study is corroborated by the studies by Bhat and collaborators [67], who demonstrated sensitivity to the harmful effects of environmental risks. It also corroborates the results found by Singh [68], who analyzed the water quality of the Gomti River, India, by using the *A. cepa* test that indicated environmental pollution.

Reduced rainfall for long periods, depending on variations, can dilute effluents and alter the cytotoxic effects in natural systems [69]. Five urban lakes were evaluated by water samples using the *A. cepa* test and the presence of mutagenic and cytotoxic activities were detected, with a high potential for inhibition of the cell cycle, indicating that the results experience seasonal influences. During drought, there is a higher concentration of pollutants due to the reduction in the volume of water and greater transport of cytotoxic substances in the rain [70].

The results ruled out genotoxic and mutagenic activity of the samples and corroborate with results presented in the analyses of Rio da Ilha, Minas Gerais, Brazil, that did not demonstrate genotoxic alterations; however, this report presented significant data on cytotoxicity [32], which was also demonstrated in our studies.

According to Migid [71], a reduction in the mitotic index below 22% in relation to the negative control can cause lethal effects in the test organism, according to Fontana, et al. [72] a reduction below 50% generally has sublethal effects. In this way, the results demonstrate that only P6 collected on July 2017 and October 2017, and P2 collected on March 2018, have potential lethal effects, with a 22% decrease in relation to the control, for the organism hated as a model. This may cause serious damage to the health of the population that consume or uses these waters that showed a 22% decrease in MI compared to the test control. Strain was found in substances such as glyphosate [73], cigarette butt leachate [74], latex [75] and effluents from the fabric dyeing industry [76].

A study of a river source in an urban perimeter evaluated the indirect and direct anthropogenic contamination by the *A. cepa* test, demonstrating that the MI had variation in relation to the negative control of the samples and detected DNA instability, indicating substances in the water with mutagenic, genotoxic and cytotoxic potential, attributing that direct anthropogenic contamination maximized the damage, potentially causing a possible risk to the population's health [77]. These data corroborate with the data reported here that indicate some type of disturbance in the MI, which can also be attributed to anthropogenic pollution.

Gomes and collaborators [38] show parameter correlation that also relate physical–chemical parameters, and some metals using PCA found a component 2 value of 19.60%. These results corroborate with this study since we found similar values. The use of multivariate analysis, mainly involving correlations, contributes to an approach on the common origin of the physical–chemical parameters [78].

It can be suggested that some metals have a common origin, since these showed some significant correlations, such as those for Pb with Fe and Cd. Rahman et al. [76] found strong positive factor loads in the PCA for Cu, Cd and Pb, which collaborates with our study, since we also found correlation between Cd and Pb [75]. PCA of risk quality and monitoring data is an efficient statistical tool to explore the complex relationships that exist among physical–chemical and microbiological parameters [76].

We prove the theory in which it was possible in this study to group parameters that were not previously grouped. In a PCA analysis of the São Franscisco River for metal concentration, it was possible to group the metals Cd, Pb, Co and Ni [77]. Comparing with our studies, we were only able to group Cd, Pb and Fe.

The angle between the projections is usually conditioned by Pearson's correlation; the smaller the angle, the stronger the correlation [78]. This was proven in this study when related to some parameters, analyzing, it is possible to prove some of these results, such as Cu, Li and total hardness.

Correlation analysis applied to water chemistry and metals is considered strong when $r \geq 0.70$ and moderately strong when $r \leq 0.70 \geq 0.50$ [79]. Thus, Pearson's correlation analysis indicates strong and moderate relationships in the lake. The highest correlation found was between water and color, which was also found by Kasvi [80].

5. Conclusions

The analysis of the physical–chemical parameters and the contamination by metals showed that the water quality conditions can be considered good, according to current Brazilian standards, for the parameters pH, total hardness, turbidity, alkalinity and apparent color. The electrical conductivity and nitrate parameters showed values higher than the allowed value; therefore, they could indicate pollution by anthropogenic action.

The number of TCs in water samples was greater than the maximum value established by Brazilian legislation, demonstrating fecal contamination in water samples from the artesian well, from its source in Buritis Lake. The bacterial diversity found is considerable, since most isolates can cause human diseases, requiring attention from public health. This bacterial diversity has several origins, including natural. However, human influences should be investigated, especially fecal contamination. The surveys of antimicrobial resistance in water require more attention owing to its importance for the health of organisms. It is important to highlight that the water from the artesian well should not be used for human consumption, without first having treatment for its contamination; it is suggested that a competent public authority carry out awareness actions of the population, regarding the risks of this practice. Similarly, it is not safe to use the water that drains from the lake to irrigate vegetables that will be used for raw consumption. However, the microbiological method is only based on classical microbiology, which cannot identify the non cultivated microorganisms. The authors suggest the test limitation, and point out using high-throughput sequencing techniques for supplementation.

Although this study used microbiological methods based on classical microbiology, our study achieved excellent results, with important data for the literature and for the population that uses this aquatic environment. The authors suggest future studies of metagenomics and high-throughput sequencing for better understanding and advancement in the area of environmental microbiology.

Considering the data on root growth and especially MI values, a cytotoxic potential for the spring and water discharged from Buritis Lake, in Goiatuba city, Goiás state, Brazil, is suggested. On the other hand, mutagenicity potential of the lake water, sampled at the other points described in the report, is not assumed. However, the mutagenic potential of the pollutants would be detected after the application of a *Salmonella* test. These elements, even of natural origin, can have toxic effect potentiated when joined to anthropogenic components, which would reduce the environmental quality of the lake and increase the risks of environmental, social and economic damages for the local population.

With the correlation analysis and multivariate analysis by PCA, it was possible to group the parameters evaluated in this report, which suggest the possibility of related groups that may have the same source of pollution.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/w14091414/s1, Table S1: Identification of isolated bacteria in the water of Buritis Lake, Table S2: Antibiotic discs used for the susceptibility test of isolated bacteria in Buritis Lake, Table S3: Susceptibility and resistance profile of isolates bacterial of water samples from Buritis Lake, Table S4: Analyte, flame, laps, wavelength and LOD studied in this work.

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