

Health Risks Related to the Water Quality in the Obili Fish Pond

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Abstract: A study aimed at evaluating the health risks of the water used for fish farming in the Obili pond was carried out in January 2021. The variables retained for this work were measured according to standard protocols and are of meteorological order (brightness, air temperature and humidity); physicochemical (water temperature, pH, TDS, color, turbidity, suspended matter, dissolved oxygen, carbon dioxide, electrical conductivity, alkalinity, total hardness, nitrites, nitrates, ammonium, phosphates and potassium) and biological (bacteria, protozoa and helminths). The results obtained show acidic water, weakly saturated with oxygen, nutrients (nitrogen, phosphates and potassium) on one hand and on the other hand highly charged with solid particles. Mesophilic heterotrophic aerobic bacteria (92.5%) constitute the most abundant group of bacteria. *Escherichia coli* is found only at the entrance to the pond and contributes 1% of the bacterial density. The protozoan community is dominated by coccidia (43%) and amoeba (41%). *Cryptosporidium parvum* is the most dominant species of coccidia while *Entamoeba histolytica* dominates in amoeba with 370 oocysts / L and 244 cysts / L, respectively. Nematodes occupy 2/3 of the helminth community and are dominated by *Ascaris* (240 eggs / L). *Diphyllobothrium latrum* shows the highest density in cestodes (572 eggs / L). The presence of these pathogenic organisms at densities above the standards constitutes a real health risk for the use of this water in fish farming. These parasites can directly infect fish farmers through skin penetration or concentrate on the integument and or flesh of fish and infect humans when consumed.

Keywords: Water Physico-Chemistry, Bacteria, Protozoa, Helminths, Health Risk, Obili Fish Pond

Introduction

The diseases that generally affect humans are partly linked to the quality of drainage and treatment of wastewater which is widely used in developing countries (Lalami et al., 2014, 2010). Wastewater is an important vehicle for biological (parasites, bacteria and viruses) and chemical pathogens resulting from human activities (Ajeagah Aghaïndum and Fotseu Kouam, 2019). Pathogens can be transmitted to humans during direct contact with wastewater, or indirectly by the consumption of crops irrigated with this water, or even by products of animal origin (Aquaculture and Organization, 1989; Rorat et al., 2019). These poor quality waters therefore constitute a permanent threat to both human and animal health (Ajeagah Aghaïndum et al., 2017; Kettani and Azzouzi, 2006; Talouizte et al., 2007).

The assessment of the health risk associated with water in a receptive milieu is done through multiple approaches associated with the complexity of aquatic ecosystems (Vanden Bossche and Usseglio-Polatera, 2005). The methods for assessing the quality of the

water in an aquatic ecosystem can be physicochemical and or biological. Physico-chemical methods make it possible to determine the quality of the biotope (Kosmala, 1998), while biological methods highlight the health risks linked to biological agents in the environment. These health risks can be assessed by viral, parasitic and bacterial studies (Kettani and Azzouzi, 2006; Talouizte et al., 2007).

In Cameroon, several studies have reported the health risk associated with the use of wastewater. These are those of Ajeagah Aghaïndum et al. (2007) on the evaluation of the abundance of resistance forms of two pathogenic protozoa in two aquatic biotopes in Yaoundé; (Kouam Kenmogne et al., 2010) on the reuse of wastewater in urban market gardening in the Abiergué watershed; Tsafack et al. (2019) in urban wastewater watering vegetable crops in Dschang; Tchouongsi et al., (2020) on water supply and health risks in the upstream watershed of Abiergué in Yaoundé and Ajeagah Aghaïndum et al. (2013) on ciliated protozoa and benthic invertebrates from Obili Pond. However, no data is available on the health

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risks associated with pathogens (bacteria, protozoa and helminths) in the water used in the Obili fish pond. That is why this study aims at assessing the health risks associated with the use of waters from Obili Fish Pond. Specifically, it is a question of (i) determining certain abiotic variables characteristic of the Obili fish pond, (ii) evaluating the diversity and density of bacteria, protozoa and intestinal helminths in this pond and (iii) putting highlights the risks associated with the presence of these pathogens on the health of fish farmers and fish consumers.

I. Material and methods

I.1. Study site

Created in 1948 by the colonial government on the Olézoa stream downstream from the University Hospital Center, the Obili fish pond is located in Yaoundé III Sub Division, Mfoundi department, Center region and extends between 3° 30' and 3° 58' N and between 11° 20' and 11° 40' E with an average altitude of 720 m. It is about 60 m wide and 100 m long with a depth of 1.80 m upstream and 2.5 m downstream, for a volume of 15,000 m³ according to the initial data (Ajeegah Aghaïndum et al., 2013). Since then, some of its descriptions have changed. Currently, the area and average volume correspond to 9745.84 m² and 76105.92 m³ respectively. The current maximum depth is 7 m. The activities carried out around this pond concern, among other things,

breeding and agriculture practiced upstream, the supply of fingerlings for fish farmers, the popularization of breeding methods and studies on the aquaculture ecosystem. The prevailing climate is equatorial type with four seasons and characterized by moderate precipitation (1633.33 mm / year on average) and an average temperature of 24.55 ° C. The four seasons of unequal importance are divided into a long dry season (from mid-November to mid-March), a short rainy season (from mid-March to the end of June), a short dry season (from July to mid-August) and a long rainy season (from mid-August to mid-November) (Suchel, 1987). However, this distribution of seasons is disrupted with current climate change.

I.2. Sampling station

Figure 1 shows the Obili Pond and the three sampling stations. Station S1 located at the level of the outfall has the geographical coordinates of 3° 51' 30" N and 11° 29' 57, 40" E. At the level of this station, the vegetation is dense and consists mainly of the Poaceae of the genus *Echinochloa*. Station S2 is located in the middle of the pond with coordinates 3° 51' 21.04" N and 11° 29' 58.55" E. Station S3 is located at the outlet. This station has coordinates 3° 51' 13.03" N and 11° 29' 56.74" E and has rich vegetation mainly made up of the genera *Echinochloa* and *Pistia*.

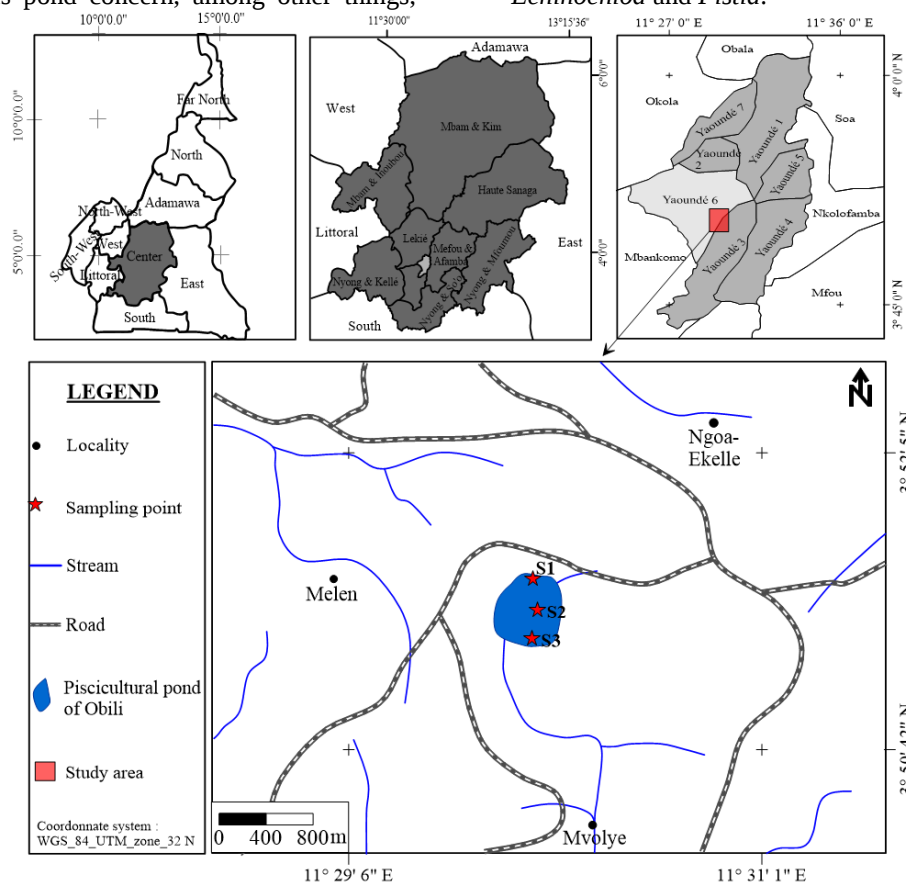


Figure 1: map presenting sampling stations on Obili Pond

I.3 Sampling and physicochemical analysis methodology

The measurements of the physico-chemical parameters took place both in the field and in the laboratory following the recommendations of APHA (1998) and Rodier *et al.* (2009). In the field, the geographical coordinates, the luminosity (Lux), the humidity rate (%), the air temperature (°C), the water temperature (°C) and the saturation rate in dissolved oxygen (%) were measured respectively using a Garmin Extres 20 brand GPS, a Testo 540 brand luxmeter, a Testo 610 brand thermo-hydrometer and a HACH brand oximeter HQ30d. Likewise, pH (UC), electrical conductivity ($\mu\text{S} / \text{cm}$) and total dissolved solids (mg / L) were measured using a HACH HQ 14d brand TDS conductivity meter. For physico-chemical parameters measured in the laboratory (SS, turbidity, color, sodium hypochlorite, NH_4^+ , NO_2^- , NO_3^- , PO_4^{3-} , alkalinity, oxidability, carbon dioxide, potassium and total hardness), the water samples were sampled without blowing bubbles at each station using 250 and 1000 mL double-capped polyethylene bottles and transported in a refrigerated chamber to the Hydrobiology and Environment laboratory of the University of Yaoundé 1. The Suspended Solid, turbidity, sodium hypochlorite and water color were measured by colorimetry with the Hydrotect HT1000 spectrophotometer. While measurements of the contents of water in different forms of nitrogen (NH_4^+ , NO_2^- , NO_3^-), phosphates (PO_4^{3-}), potassium (K^+) and total hardness (mg / L of CaCO_3) were made using the appropriate reagents and read on the Hydrotect HT1000 spectrophotometer. Alkalinity, carbon dioxide and oxidability were determined by volumetry using specific reagents.

I.4. Biological analyzes

I.4.1 Sampling

The water samples intended for the biological analyzes were taken at each station following the recommendations of Rodier *et al.* (2009). For the bacteriological analyzes, the water samples were taken using glass bottles of 100 mL previously sterilized in an autoclave at 120 °C, filled to the brim and store in a refrigerated enclosure. As for the water samples intended for the analyzes of the forms of resistance of the intestinal parasites, after a slight agitation of the micro habitats to allow the suspension of the parasites, 1 L of water was taken using the sterile polystyrene vials, then fixed with 2 mL of 10% formalin. All of the samples were transported to the laboratory for analysis.

I.4.2 Identification techniques and enumeration of bacteria

In the laboratory, the bacteriological analysis of the water samples focused on the search for Mesophilic Aerobic Heterotrophic Bacteria (MHAB), Fecal

Streptococci (FS), Total Coliforms (TC), Fecal Coliforms (FC) and *Escherichia coli* (*E. coli*). The method of analysis used is the plating technique on Mac Conkey agar culture medium, then poured into petri dishes 90 mm in diameter (Devane *et al.*, 2020; Nola *et al.*, 1998). A 1 mL sample of water was placed in a sterile, empty petri dish; then, the culture medium was poured and then maintained in super cooling at 45-50°C. The whole (sample) was left until completely solidified before incubation at the appropriate temperatures. After an incubation period of 24 hours at room temperature (25°C) of Plate Count Agar (PCA) medium for MHAB, 37°C on BEA medium for SF and Endo medium for TC and a temperature of 44°C on Endo medium for FC and *E. coli*, the growth of different colonies were observed. The quantitative analysis consisted of the enumeration of bacterial colonies. The results were expressed as the number of Colonial Forming Units per milliliter (CFU / mL). The count of the germs isolated was carried out by direct counting of all the colonies on a Petri dish. *E. coli* colonies are recognizable by their metallic sheen unlike CFs which gives red colonies with a metallic sheen.

I.4.3. Parasite concentration techniques

The sedimentation technique was used for the quantification of protozoa. The samples were previously allowed to sediment for 24 hours then the supernatant was poured in and the volume of the pellet was collected. In fact 5 mL of sample were taken and introduced into a test tube then, 1 mL of 10% formalin was added to ensure the fixation of the organisms at the end, 5 mL of distilled water and 2 drops of lugol were successively added. While the formalin-ether concentration technique was used for the quantification of helminth eggs and larvae, in fact 5 mL of the pellet was introduced into a test tube followed by 2 mL of 10% formalin and 3 mL of ether were added successively. The mixture obtained for each of these two techniques was brought to centrifugation at 1500 revolutions / min for 5 min. Subsequently, 2 drops of the pellet were taken and placed on a microscope slide and covered with a coverslip for identification.

I.4.4. Identification and enumeration

The observations were carried out thanks to the YVENEM microscope with 40X and 100X objectives and the identification was made using measurements taken with the help of an ocular micrometer and thanks to the of the WHO bench aid of 1994 (World Health Organization, 1994) and the identification keys of Cheikhrouhou (2010). The count was made using the formula proposed by (Ajeagah Aghaindum *et al.*, 2010) thus the number (X) of parasites in 1 L of sample was calculated using the following formula:

$$X = \frac{y \cdot Vx}{Vy}$$

Where: V = pellet volume in 1 L of sample, Vy = pellet volume used for observation, y = number of eggs observed in Vy.

I.4.5 Statistical analysis

The comparisons of the microbiological and physicochemical data obtained were carried out using the Anova one-way test and the Student *t* test. Correlations between variables were performed using Pearson's *r* test. These analyzes were performed using SPSS 20.0 software.

II. Results and discussion

II.1 results

II.1.1 Abiotic variables

In Obili Pond, the variables showed no significant difference at the 5% level between the sampling stations. Table 1 indicates that the percentage of humidity in the air varied from 50.1% to 66.6% with an average of $57.2 \pm 8.3\%$. The air temperature fluctuated between 27.88°C and 36.33 °C with an average of $32.6 \pm 4.3^\circ\text{C}$ while the water temperature presented values between 22.7°C and 26°C with an average of $24.2 \pm 1.2^\circ\text{C}$. Oxygen saturation was low at stations S1 and S3, but high at station S2. These values were between 28.5% and 70.1% with an overall average of $45.5 \pm 21.8\%$. The oxidability

values were low (0.2 -1.9 mg / L) with an average of 0.5 ± 0.3 mg / L of oxygen. The highest values of electrical conductivity, pH, TDS, color and turbidity were recorded at station S1. Overall, the waters turned out to be acidic with values less than or equal to 5.5 UC and carbon dioxide contents varying between 7.04 mg / L and 15.84 mg / L with an average of 10.5 ± 4.6 mg / L. The values of the electrical conductivity were high and varied from 1581 $\mu\text{S} / \text{cm}$ and 1613 $\mu\text{S} / \text{cm}$ with an average of 1592.6 ± 17.6 $\mu\text{S} / \text{cm}$. Alkalinity and total hardness showed values between 12 and 20mg / L, 8 and 16 mg / L respectively. TDS and color have included values between 793 mg / L and 806 mg / L and 299 Pt.Co and 366 Pt.Co respectively. The nutrient levels in the water (nitrites, nitrates and phosphates) were low throughout the pond. The nitrite (NO_2^-) concentrations varied between 0.07 mg / L and 0.25 mg / L with an average of 0.15 ± 0.09 mg / L. The nitrate values fluctuated between 0.01 mg / L to 0.05 mg / L with an average of 0.03 ± 0.02 mg / L. The phosphate values (PO_4^{3-}) fluctuated between 0.47 mg / L and 0.78 mg / L with an average 0.63 ± 0.15 mg / L. The ammonium (NH_4^+) contents presented values between 0.32 mg / L and 0.87 mg / L with an average of 0.67 ± 0.30 mg / L. The potassium contents were low with values between 3.4 mg / L and 3.8 mg / L with an average of 3.6 ± 0.2 mg / L.

Table 1: summary of some abiotic data

Parameters	S1	S2	S3	Min	Max	Mean $\pm$ SD
Air temperature (°C)	36.33	33.72	27.88	27.88	36.33	32.6 ± 4.3
Humidity (%)	50.1	55.8	66.6	50.1	66.6	57.2 ± 8.3
Luminosity (Lux)	26200	24350	22990	22990	26200	24513.3 ± 1611.2
Water temperature (°C)	26	24	22.7	22.7	26	24.2 ± 1.2
Dissolved oxygen O_2 (mg/L)	2.51	5.04	2.06	2.06	5.04	3.2 ± 1.6
Percentage of dissolved oxygen (%)	37.9	70.1	28.5	28.5	70.1	45.5 ± 21.8
pH (UC)	5.5	5.45	5.41	5.41	5.5	5.45 ± 0.04
Electrical conductivity ($\mu\text{S}/\text{Cm}$)	1613	1584	1581	1581	1613	1592.6 ± 17.6
TDS (mg/L)	806	793	795	793	806	798 ± 7
Turbidity (FAU)	34	20	21	20	34	25 ± 7.8
Color (Pt,Co)	366	299	309	299	366	324.6 ± 36.1
Suspended solids (mg/L)	104	106	102	102	106	104 ± 2
Nitrates (mg/L NO_3^-)	0.01	0.03	0.05	0.01	0.05	0.03 ± 0.02
Nitrites (mg/L NO_2^-)	0.25	0.14	0.07	0.07	0.25	0.15 ± 0.09
Phosphates (mg/L of PO_4^{3-})	0.66	0.78	0.47	0.47	0.78	0.63 ± 0.15
Ammonia (mg/L of NH_4^+)	0.87	0.32	0.84	0.32	0.87	0.67 ± 0.30
Carbone dioxyde (mg/L)	7.04	8.8	15.84	7.04	15.84	10.5 ± 4.6
Alkalinity (mg/L)	12	18	20	12	20	16.6 ± 4.16
Total hardness (mg/L of CaCO_3)	8	15	16	8	16	13 ± 4.3
Potassium (mg/L of K)	3.8	3.4	3.6	3.4	3.8	3.6 ± 0.2
Sodium hypochlorite (% NaOCl)	3.3	2.1	1.4	1.4	3.3	2.26 ± 0.96
Oxydability (mg/L)	1.19	0.2	0.4	0.2	1.19	0.5 ± 0.3

II.1.2 Variation in microbiological parameters

II.1.2.1 Abundance of bacteria and intestinal parasites

Microbiological analysis identified the two groups of intestinal parasites and bacteria in varying proportions (Figure 2). The abundance of bacteria identified (83%) largely dominates that of resistance forms of protozoa (9%) and helminths (8%) (Figure

2A). Bacteriological analysis shows that MHAB bacteria have the highest density (92.5%), followed by TC (4%) and CF (2%), the lowest percentage was with FS (0.5%) (figure 2B). Parasitological analysis allowed the identification of three groups of protozoa with a dominance of coccidia, i.e. 43% represented by the species *Cryptosporidium parvum*, *Cyclospora cayetanensis* and *Isospora belli*, followed by

amoebae (41%) with the species *Entamoeba histolytica*, *Entamoeba hartmanni*, *Iodamoeba butchili* and *Endolimax nana*. The flagellates presented the lowest density; either 16% represented by the species *Chilomastix mesnili*, *Enteromonas hominis* and *Giardia intestinalis* (Figure 2C). On the other hand, only two groups of helminths were

identified with a dominance of nematodes, either 65% represented by the species *Strongyloides* sp., *Ascaris* sp., *Ankylostoma duodenale*, *Trichuris trichiura*, *Enterobius vermicularis*, *Trychostrongylus* sp. and 35% of the cestodes represented by the species *Diphylobothrium latrum*, *Hymenolepis nana*, no trematode eggs were observed (Figure 2D).

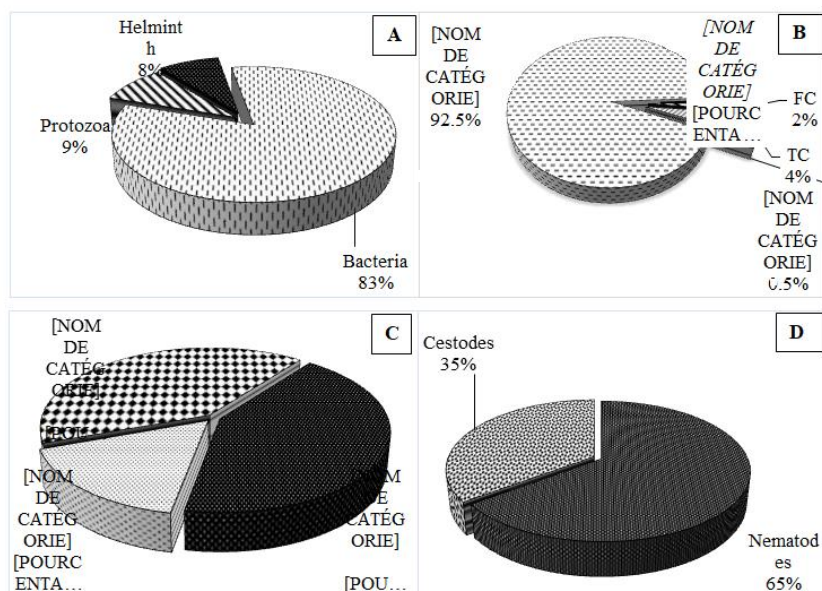


Figure 2: global relative abundance of pathogens (A), relative abundance of bacteria (B), relative abundance of protozoa (C) and relative abundance of helminths (D)

II.1.2.2 Spatial variation in the density of the bacteria identified

A study of the spatial variation of the groups of bacteria in the Obili fish pond revealed that *E. coli* is present only at the entrance to the fish pond while the other bacteria are present throughout the pond. The center of the Pond was the least exposed to bacteria with an abundance of 2570 CFU / mL against 2620 CFU / mL at the entrance and 34780 CFU / mL at the exit of the Pond. The densities of ST and MHAB

increase from the inlet to the outlet of the pond waters. MHAB were the densest with an average of $12360 \pm 18,810$ CFU / mL unlike SF which were the least abundant with an average of 63.33 ± 58.59 CFU / mL. The TCs and FCs are homogeneously dispersed throughout the pond and the FCs made up almost one-third of the TCs present in the medium. The average FC / FS ratio is greater than 7 and reveals that the bacterial pollution of the Obili fish pond is mainly of human origin.

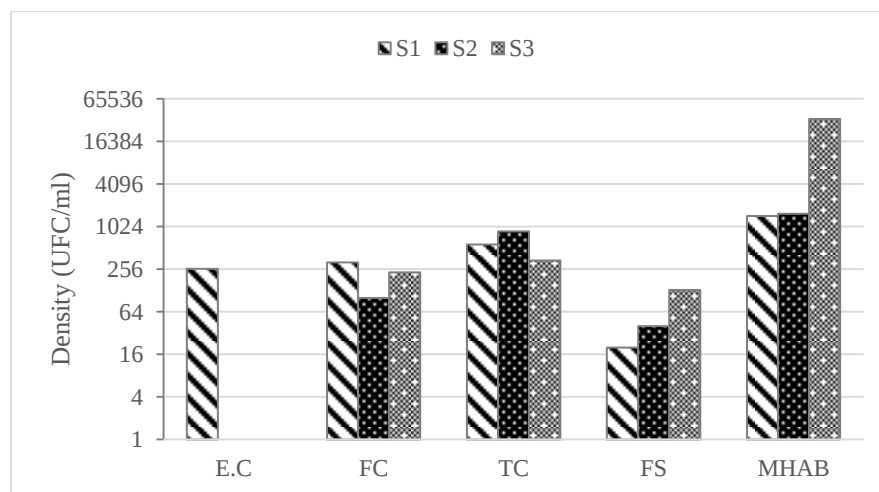


Figure 3: spatial distribution of different groups of bacteria in the Obili pond

II.1.2.3 Spatial variation in the density of resistance forms in protozoa

For all the protozoan species identified, the highest densities were obtained at station S1. As regards amoebae, *E. histolytica* presents the highest density, either 420 cysts/L, while the lowest densities (0 cysts/L) were obtained at stations S2 and S3. In Coccidia group, *C. parvum* presents the highest

density, either 740 oocysts / L (S1), while the lowest densities (0 oocysts / L) were obtained at stations S2 and S3. Concerning flagellates, *E. hominis* has the highest density, either 350 cysts/L at the entrance to the Pond, while the lowest densities (0 cysts/L) were obtained at the exit of the Pond (*C. mesnili*, *E. hominis*, *G. intestinalis*) (Figure 4).

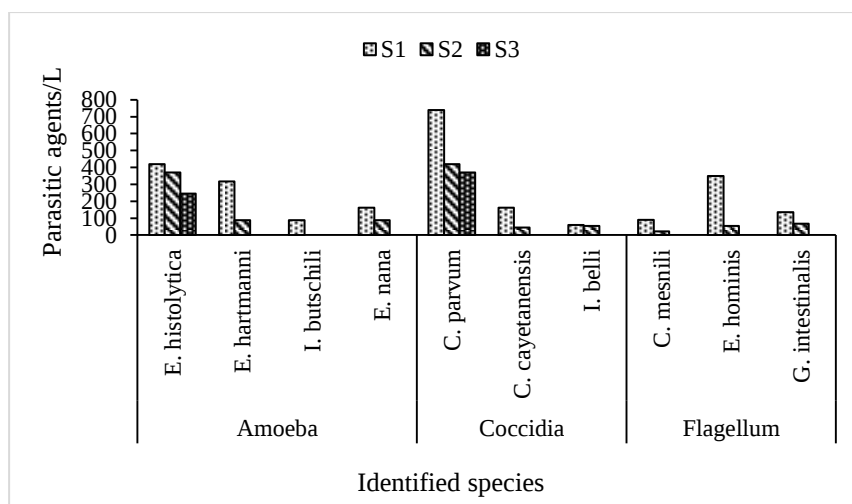


Figure 4: spatial distribution of different groups of protozoa in the Obili pond

II.1.2.4 Spatial variation in the density of resistance forms of identified helminths

With the exception of *D. latrum* and *Trichostrongylus* sp., the highest densities of the helminths identified were obtained at the entrance to the Pond. As for nematodes, *Ascaris* has the highest density, 594 eggs / L (S1), followed by *Ankylostoma duodenale* 386 eggs / L (S1) while the lowest densities of nematodes

(0 eggs / L) were obtained at stations S1 and S2 (*Trichostrongylus* sp.), S3 (*A. duodenale*), S2 (*T. trichiura*), S2 and S3 (*E. vermicularis*). For cestodes *D. latrum* has the highest density, either 572 eggs / L (S2), while the lowest densities (120 eggs / L) were obtained at S3 stations (*D. latrum*, *H. nana*) (figure 5).

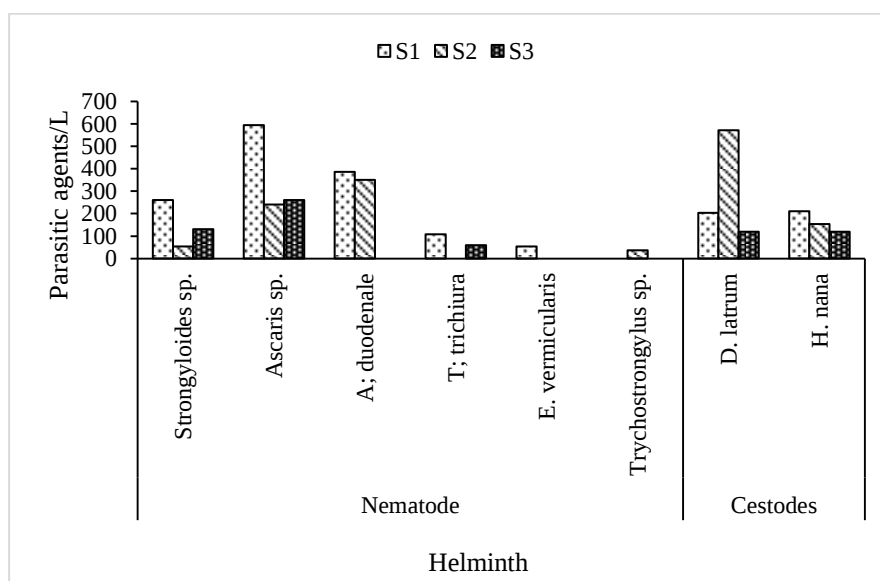


Figure 5: spatial distribution of different groups of helminths in the Obili pond

II.1.2.5 Relationship between environmental variables and pathogens

Table 2 shows significant correlations obtained between certain variables. Significant and positive correlations were observed between the following abiotic variables: luminosity with water temperature (0.999*), pH (1.00*) and NaOCl (0.998*); the water temperature with pH (0.998*), nitrites (0.998*) and NaOCl (1.00*); TDS with color (1.00**) and oxidability (0.999*); color with oxidability (0.999*) and nitrites with NaOCl (0.999*). Likewise, significant and negative correlations were obtained between conductivity and hardness (-1.00*), and nitrates and pH (-0.998*).

Positive significant correlations were obtained between certain physicochemical and biological parameters. Thus the temperature is correlated with the density of *H. nana* eggs ($p = 1.00^*$); dissolved

oxygen to *D. latrum* (0.999*); the pH at *G. intestinalis* (0.999*) and at *H. nana* (0.9970*); the conductivity to *C. parvum* (0.999*) and to *E. hominis* (0.998); turbidity at *I. butchili* (0.998*), *Ascaris* sp. (1.00**), *E. vermicularis* (0.998*) and *E. coli* (0.998*); nitrites are correlated with *E. hartmanni* (0.998*) and *H. nana* (0.999*); potassium correlates with *T. trichiura* eggs (0.998*); NaOCl is correlated with *H. nana* (1.00**). Total hardness is correlated with *C. parvum* (1.00*).

Negatively significant correlations were observed. Thus, alkalinity is correlated with *E. hartmanni* (-1.00*), *C. mesnili* (-1.00**) and *C. cayetanensis* (-1.00*); nitrates are correlated with *E. nana* (-0.999*) and *G. intestinalis* (-1.00**); nitrogen correlates with *Trychostrongylus* sp. (-0.999*); hardness is correlated with *E. hominis* (-1.00*).

Table 2: Correlations between some physico-chemical and biological variables. The significant values bear * or ** at 5 % or 1 % respectively

Genera	T	O ₂	pH	Cond	Turb	Nitrates	Nitrites	Amm	Alkali	T.hard	Pota	NaClO
<i>E. hartmanni</i>	0.992	-0.033	0.983	0.982	0.944	-0.969	0.998*	0.288	-1.00*	-0.988	0.699	0.995
<i>I. butchili</i>	0.920	-0.302	0.896	0.996	0.998*	-0.866	0.945	0.536	-0.971	-0.993	0.866	0.931
<i>E. nana</i>	0.985	0.264	0.994	0.883	0.804	-0.999*	0.971	-0.008	-0.946	-0.897	0.456	0.980
<i>C. parvum</i>	0.962	-0.181	0.945	0.999*	0.982	-0.922	0.978	0.427	-0.993	-1.00**	0.797	0.969
<i>C. cayetanensis</i>	0.991	-0.041	0.981	0.984	0.946	-0.967	0.998*	0.296	-1.00*	-0.989	0.704	0.994
<i>C. mesnili</i>	0.986	-0.070	0.975	0.989	0.955	-0.959	0.995	0.323	-1.00**	-0.993	0.725	0.991
<i>E. hominis</i>	0.967	-0.162	0.951	0.998*	0.978	-0.929	0.982	0.410	-0.995	-1.00*	0.785	0.974
<i>G. intestinalis</i>	0.994	0.203	0.999*	0.911	0.839	-1.00**	0.984	0.055	-0.964	-0.923	0.511	0.990
<i>Ascaris</i> sp.	0.900	-0.349	0.873	0.991	1.00**	-0.840	0.927	0.578	-0.957	-0.986	0.890	0.912
<i>T. trichiura</i>	0.549	-0.780	0.500	0.782	0.866	-0.444	0.605	0.914	-0.675	-0.763	0.998*	0.573
<i>E. vermicularis</i>	0.920	-0.302	0.896	0.996	0.998*	-0.866	0.945	0.536	-0.971	-0.993	0.866	0.931
<i>Trychostrongylus</i> sp.	-0.122	0.977	-0.064	-0.425	-0.554	0.000	-0.189	-0.999*	0.277	0.397	-0.866	-0.150
<i>D. latrum</i>	0.054	0.999*	0.111	-0.260	-0.400	-0.175	-0.015	-0.976	0.105	0.231	-0.765	0.025
<i>H. nana</i>	1.00*	0.077	0.997*	0.956	0.902	-0.990	0.999*	0.181	-0.990	-0.964	0.616	1.00**
<i>E. coli</i>	0.920	-0.302	0.896	0.996	0.998*	-0.866	0.945	0.536	-0.971	-0.993	0.866	0.931

II.2. Discussion

Physico-chemical characterization of water

During this study, the physicochemical quality of the water did not vary significantly between the sampling stations. The recorded water and air temperature values decreased slightly from the outfall to the outfall as did the light intensity at the water surface. To this end, Garner et al. (2014) state that there is a linear relationship between water temperature and air temperature. Moreover, a positive and significant correlation ($r = 0.999$; $p = 0.05$) was obtained between water temperature and light.

The average SS value (104 ± 2 mg / L) was higher than that recommended (25-75 mg / L) by Rodier et al. (2009) for water used in fish farming. This could be explained by domestic and urban discharges in the Olezoa watershed that feeds the Obili Pond. In this regard, Hébert and Légaré (2000) point out that the excess SS in water generally comes from municipal discharges. Moreover, the turbidity and the color show a similar variation profile from the entry to the

exit of the pond as the SS.

The pH values recorded at the different stations (5.41-5.5 UC) show that the water in the pond is slightly acidic. This pH indicates that the water is more acidic than the pH of the water recommended by the Ministère du Développement durable, de l'Environnement et de la Lutte contre les Changements Climatiques (2014) for fish water (6-9 UC). Acidification is believed to be linked to the fermentation processes of decaying organic matter in the Pond. According to Gaudreau (1991), the acidity of a body of water can be caused by the presence of organic acids released during the decomposition process of vegetation and by the presence of carbon dioxide dissolved in water.

The percentage of dissolved oxygen saturation ($45.5 \pm 21.8\%$) is lower than the interval recommended by Schlumberger and Bouretz (2002) for aquaculture water (50 to 62.5%). This shows that the medium is weakly oxygenated. This could be explained by the

high solids content of the water, which would lead to a decrease in the penetration of light into the water, in turn leading to a decrease in primary production and consequently a decrease in the production of dissolved oxygen for plants using chlorophyll. Rodier et al. (2009) point out in this regard that the variation in dissolved oxygen in water is a function of the presence of plants and photosynthesis phenomena. The high ammoniacal nitrogen content of water ($0.67 \pm 0.30 \text{ mg / L of NH}_4$) would be linked to the inputs of water laden with organic substances discharged either directly into the watercourse or simply carried by runoff water. This value is within the acute toxicity range ($0.6 - 1.5 \text{ mg / L NH}_4^+$) defined by Fontaine (1994) for fish life. The average value of the electrical conductivity ($1592.6 \pm 17.6 \text{ } \mu\text{S / Cm}$) recorded in the pond would reflect according to the classification of Rodier et al. (2009) high mineralization. This is believed to be due to the transformation of organic matter in the pond. The conductivity of water can be considered as an indicator of its salt content (Melaku Zigde and Endale Tsegaye, 2019). The conductivity of fresh water should be between 300 and 1200 $\mu\text{S / cm}$. The waters of the Obili Pond have an average conductivity greater than 1,200 $\mu\text{S / cm}$ and are highly ionized. This could in long term interrupt the development of freshwater fish (Arab and Arab, 2017; Stieglitz et al., 2000).

Biological characterization

The presence of biological pathogens (bacteria and forms of dissemination of protozoa and helminths) in the fish pond of Obili is believed to be due to the quality of the water used to supply the pond. Indeed, the water that supply this Pond is subject to contamination of wastewater from the discharges of homes and the University Hospital of Yaoundé located upstream of the pond. If the water used has sufficient phosphate and nitrate contents to increase fish yield, it can nevertheless constitute a risk factor for enormous bacteriological and parasitic contamination (Youssef and Driss, 2007).

Parasitic contamination of wastewater has been highlighted by several authors (El Shazly et al., 2003; Gantzer et al., 2001). Spatially, the higher density observed at the entrance to the Pond could be due to the fact that most of the intestinal parasites in the pond come from the wastewater that feeds the Pond. Specifically, *Ascaris* sp. (helminth) and *C. parvum* (protozoan) presented the greatest densities. These high densities could be due to the cosmopolitan character and the wide distribution of *Ascaris* eggs (Okoa Amougou et al., 2021). In addition, *Ascaris* eggs have a triple membrane that allows them to resist environmental stresses for a long time (Bouhoum et al., 1995; Dssouli et al., 2001).

The wide distribution of *Cryosporidium* oocysts is favored not only by their small size which allows them to disseminate quickly but also by their double wall allowing them to resist disinfection techniques. Similar observations were made by Tsomene Namekong and Ajeagah Aghaindum (2020). *D. latrum* has the highest density of parasites found in the pond. This high density could be explained by the fact that this species has fish as an intermediate host and the piscicultural activity is generally more intense in the center of the pond (Dakwen et al., 2019, 2015; Towa et al., 2019). Pathogens that concentrate in the viscera of fish or infest their tissues can survive and in some cases reproduce until the fish are harvested and consumed (World Health Organization, 1994).

The fluctuations observed in certain bacterial groups would be linked to environmental conditions. The absence of *E. coli* at stations S2 and S3 is thought to be the result of their passive adhesion to organic (fish skin and plant walls) and inorganic substrates (Boutaleb, 2007; Noah Ewoti et al., 2011). This result could be justified by the fact that enteropathogenic strains carry specific genes in their plasmids which code for virulence factors (type IV pili, adhesins, toxins) and which play an important role in the process cellular adhesion. They allow the interconnection of bacteria in micro-colonies favoring their stabilization (Trabulsi et al., 2002). In addition, the acidic pH and high SS are stressors for microorganisms. The abundance and omnipresence of MHAB would reflect the high load of organic matter and favorable conditions for development. The ratio $R = \text{FC} / \text{FS}$ (faecal coliforms on faecal streptococci) is used as a first order element to determine the origin of faecal pollution. The average FC / FS ratio of the Obili Pond indicates that the bacteriological pollution of this pond comes mainly from human sources following the evacuation of the gun latrines and the discharge of domestic wastewater upstream of the pond (Saab et al., 2007). Since FC and FS are conditioned by certain abiotic variables such as pH and temperature, the latter can also influence the abundances of these bacteria in the best (Chigbu et al., 2004).

The use of untreated wastewater in fish farming is not without consequences on the health of fish farmers and consumers. In fact, certain species such as *D. latrum* also called *Tænia* of fish, salmonella, TC and FC can infect fish and contaminate consumers (Gamane Kaffine et al., 2018). In fact, the WHO recommends the use of water containing less than one helminth egg per liter (Jimenez, 2007). However, the high densities observed constitute an enormous health risk for fish farmers who can be infected by transcutaneous penetration of *Ankylostoma* and *Strongyloides* larvae. Indeed, studies carried out on

the viability of helminths have been able to demonstrate that helminth eggs can maintain their viability even after exposure to very high temperatures or to biocides (Fotseu Kouam and Ajeagah Aghaïndum, 2020; Khalid and Fethi, 1995; Khalid et al., 2018). Similarly, Gamane Kaffine et al. (2018) demonstrated the presence of TC, CF and TS in the flesh of fish before and after smoking; because these germs can resist and even proliferate if the process of smoking and cooling the fish is not correctly applied.

The presence of these parasitic elements at high densities constitutes a real constraint linked to the reuse of this water in fish farming. The densities of bacterial and parasitic elements obtained are much higher than the standards recommended for the reuse of wastewater. Indeed, according to the Aquaculture and Organization (1989), Blumenthal et al. (2000) and World Health Organization (2006) for an optimal use of wastewater without risk of infections, the concentration of helminth eggs must be less than 1 egg / L, that of protozoa must be between 1 and 10 cysts / L and that of bacteria must be less than 10 CFU / mL, but the concentrations obtained in this study are much higher than those recommended. This constitutes a real danger for fish farmers and consumers. If wastewater heavily loaded with organic and faecal matter is continuously introduced into the Obili pond without prior treatment, this fish pond will become a source of contamination of the various species of fish reared and may constitute a factor in the resurgence of bacterial diseases and parasitic.

Conclusion

At the end of this study on the assessment of the health risks of the waters of the Obili piscicultural pond, it appears that the waters of this pond are slightly acidic, poorly oxygenated, but highly mineralized, rich in solid particles and nitrogen. ammoniacal. Microbiological analysis identified 83% of bacteria (MHAB, TC, FC, FS and *E. coli*) 9% of protozoa (*Cryptosporidium parvum*, *Cyclospora cayetanensis*, *Isospora belli*, *Entamoeba histolytica*, *Entamoeba hartmanni*, *Iodamoeba butchili*, *Endolimax nana*, *Chilomastix mesnili*, *Enteromonas hominis*, *Giardia intestinalis*) and 8% helminths (*Strongyloides* sp., *Ascaris* sp., *Ankylostoma duodenale*, *Trichuris trichiura*, *Enterobius vermicularis*, *Trychostrongylus* sp. *Diphylobothrium latrum*, *Hymenolepis nana*). These bacterial and parasitic concentrations are well above the values prescribed by the WHO. Thus the waters of the Obili fish pond are of poor physico-chemical and biological quality and therefore not very suitable for fish farming activities and therefore constitute a danger not only for the health of fish farmers and consumers, but also for fish surrounding populations who use them for multiple purposes. To limit the

spread of disease or any infection linked to the reuse of wastewater, it is essential to set up a treatment system for this water before it arrives in the pond.

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