

Specific diversity of fish ponds in the Haut-Sassandra and risks of contamination by potential pathogens among *Oreochromis niloticus* (Tilapia)

Abstract

Fishing and aquaculture products constitute a significant part of the nutrient intake in the human diet and a real source of income. However, the fish farming activity is even less known by the Ivorian population and still does not benefit from technical assistance. This could impact the quality of aquaculture resources. This study was therefore carried out to first take stock of fish farming in the Haut-Sassandra region and then assess contamination by potential bacterial pathogens in Tilapia fish from fish ponds in this region. For this reason, a survey was carried out from June to December 2022 using questionnaires. The survey consisted of direct interviews and farm visits to collect data. Then the Tilapia fish were sampled and analyzed. It appears that fish farming is a popular activity in the Haut-Sassandra Region but practiced in a related way and organized in a cooperative society. It is mainly practiced by people aged between 35 and 50, with a majority of primary education. Women are represented at 2.66%. The dominant system is extensive, practiced in dammed and diversion ponds where several activities coexist. In this region we find 100% Tilapia fish (*Oreochromis niloticus*), 21% from Cameroon (*Heterotis niloticus*) and 48% catfish (*Clarias gariepinus*) on all farms. Of the two types of ponds, dam ponds have the best characteristics. This is justified by the low load of microorganisms in these ponds compared to diversion ponds. Fish farming is an activity of the future, however special attention must be given to it to meet the needs of the Ivorian population.

Keywords: Fish farming, ponds, fish, fish farms

1. INTRODUCTION

Meeting the needs for aquaculture resources has become a major challenge throughout the world, particularly in developing countries. Aquaculture production in sub-Saharan Africa remains low despite many years of practice. Despite the immense human, geographical, natural and agricultural potential available to Côte d'Ivoire, fish production remains very low [1]. The country has over 1000 number of fish farms is a little over 4000 from a total exploited area of 750 hectares [2]. Indeed, in 2020, the total annual national aquaculture production was estimated at 3750 tonnes in 2020 and this remains very insignificant not enough for the national annual consumption, which was estimated at 286,000 tonnes [3,4]. Currently, Ivorian fish farming only provides nearly 5% of national fish production [5].

To increase the production and cover its needs, Côte d'Ivoire through the FAO's "FISH4ACP" initiative, wants to increase investments in fish farms to increase tilapia production (*Oreochromis niloticus*) to 68,000 tonnes by 2031 compared to the current 3,500 tonnes currently [6]. The Haut-Sassandra region, although being a large agricultural production area, is also known for its potential in fish production [7]. Fish production in the Haut-Sassandra region was 236.72 tonnes in 2013 [2]. However, this fish production only covers 6.32% of local consumption estimated at nearly 4000 tonnes [1]. The

Comment [T1]: I suggest the topic to be: 'Microbial prevalence in Tilapia (*Oreochromis niloticus*) fish farming practiced in Haut-Sassandra Fish Ponds in Cote D'ivoire'

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Comment [T3]: Revise this statement

Comment [T4]: Is this per year or what and how does this compare to the previous fish catch?

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main species produced in fish ponds are Nile tilapia (*Oreochromis niloticus*), catfish (*Clarias gariepinus*) and Cameroon (*Heterotis niloticus*).

In Côte d'Ivoire, if agricultural activity benefits from supervision for its producers, the fish production sector does not always benefit from qualified assistance. Indeed, whatever the type of water supply, fish ponds are strongly influenced by the anthropogenic activities of local populations. They misuse pesticides in agricultural activities [8]. The World Health Organization also indicates that there are nearly 250,000 deaths each year worldwide from pesticide poisoning [9]. In addition, in breeding ponds, uneaten food intake and releases of metabolites from captive fish accumulate in the sediments, thus providing a good source of nutrients for the various bacteria found there. Furthermore, the penetration of rain and the transport of soil particles and organic matter into ponds by runoff could lead to biological pollution of the water, which would contaminate the fish [10]. Agricultural effluents, waste and urban discharges contaminate the aquatic environment with pathogenic bacteria resistant to antibiotics which contaminate fish resources [11]. The presence of bacteria pathogenic bacteria to humans in fish resources can lead to foodborne infections and cause serious health problems to humans. In 2016, in Europe, 13.4% of foodborne illnesses originated from aquatic products. The main bacterial agents responsible for these TIAs were *Salmonella* And *Vibrio parahaemolyticus* [12]. Several studies in sub-Saharan Africa have noted microbial contamination of aquaculture resources in Zimbabwe, the Democratic Republic of Congo and Mali [13,14]. This work showed contamination by bacterial pathogens and the risks of infection of populations. In Côte d'Ivoire, studies have also shown the contamination of aquaculture resources by pathogenic bacterial strains of aquaculture resources [15,16]. The main-most fish species heavily incriminated were, affected are *Oreochromis niloticus*, *Sarotherodon melanoheron*, *Sardinella maderensis*, And *Chrysichthys nigrodigitatus*. The potentially pathogenic bacteria responsible for contaminating bacterial species the aquatic fish s- were *Escherichia coli*, *Vibrio parahemolyticus*, *Salmonella* And *Pseudomonas*. Despite the risks-prevalence of contamination of various kinds in fish ponds following agricultural and other anthropogenic activities, the problem of health quality of the resources from these ponds, very little scientific data exists on these ponds and their production in Côte d'Ivoire. This observation allows us to justify this study, the general objective of which is to evaluate the contamination by potential bacterial pathogens of fish resources in the Haut-Sassandra Region.

2. MATERIAL AND METHODS

2.1. Collection of data from fish farmers

A survey was carried out among fish farmers to collect data on fish production. It consisted of direct interviews and farm visits. Fish farms and fish farmers were selected with the help of cooperatives in Haut-Sassandra to carry out this study.

2.2. Sampling

Tilapia fish (*Oreochromis niloticus*) collected from a few fish farms were used to carry out this study. Approximately twenty (20) tilapia fish samples were collected in the Haut Sassandra region. These are

Comment [T10]: revise this sentence and your sentence started midway in instead of from the margin

Comment [T11]: this word does not stand well

Comment [T12]: death of who? Fish or humans

Comment [T13]: where? Mention it

Comment [T14]: use carried away or deposition

Comment [T15]: avoid redundancy; use contaminate once in this sentence

Comment [T16]: In 2016, 13.4% of brah ...brah... brah... from aquatic products in Europe.

Comment [T17]: What is this?

Comment [T18]: No capitalization

Comment [T19]: Avoid generalizing; use some studies or remove several

Comment [T20]: When did you do this?

In the introduction section, you don't report what you did rather you introduce the topic to the readers

Comment [T21]: This number is for what?

Comment [T22]: This is too broad and be specific on what you want to say. So delete that

Comment [T23]: Check my earlier comment

Comment [T24]: revise

Comment [T25]: can you come out clear, what is the problem at hand that prompted you to initiate the study?

Bring the justification to the problem and why do you think it is worth researched?

Of what significance is this study going bring to the aquaculture industry and to the consumers in general

So the last paragraph or statement of the introduction must be strong be and probably with scientific facts

And what are the objectives of the study...to help sharpen the direction and flow off the research design

Comment [T26]: How many fish farms? How many fish farmers?

four (4) samples in the Issia area, twelve (12) in Daloa and four (4) in Zoukougbeu. Once collected, the samples are stored in carefully labeled stomacher bags. They are stored in coolers containing ice and sent directly to the microbiology laboratory for analysis.

2.3. Microbiological analysis of fish samples

2.3.1. Preparation of samples for analysis

Once in the laboratory, the fish samples ~~undergo-were~~ pre-treatment, then they ~~we~~ are dissected aseptically. The gills and viscera which will be used for the various analyzes are separated from the other parts. A quantity of 25 g of each part to analyze (gills and viscera) is homogenized in 225 ml of sterile buffered Peptone water (EPT) previously prepared according to standard NF V08-010. Decimal dilutions will be carried out according to standard [17]

2.3.2. Counting germs in samples Microbial enumeration

A quantity of 0.1 mL of each decimal dilution retained ~~is-was~~ placed in ~~p~~Petri dishes containing 20 mL of each agar previously prepared and poured. These are Rapid *E. coli* 2, BEA and Rapid Staph agars. This quantity is spread on the surface of each agar using a sterile spreader. The inoculated plates are incubated at 37°C for 24 to 48 hours for the enumeration of *Staphylococcus aureus* on Rapid Staph, *Enterococcus* on BEA medium and *E. coli* on Rapid medium *E.coli* 2. The enumeration of microbial was done using the formula in Equation 1.

[\[bring the Equation here\]](#)

2.3.3. ~~Research and characterization~~ Detection and isolation of *Salmonella ssp.*

The ~~research-detection~~ of *Salmonella ssp.* was carried out according to stipulated standard procedure [18] ~~which involved in-4 steps namely- This involves~~ pre-enrichment in Buffered Peptone Water broth, selective enrichment in Vassiliadis Rappaport broth, isolation on Héктоen medium and identification using the Leminor Reduced Rack.

2.3.4. Expression of enumeration results

The number N (estimate of the microbial population) was calculated according to the following equation:

$$N \text{ (UFC/g)} = \frac{\sum C_i}{(n_1 + 0,1n_2) d.V} \quad \text{Equation 1.}$$

N (CFU/g): Number of germs per gram of product;

$\sum C_i$: Sum of colonies counted on all plates retained from successive dilutions;

V: Volume of inoculum applied to each plate (in ml);

n_1 : Number of boxes retained at the first dilution considered;

n_2 : Number of boxes retained at the second dilution considered;

d : Dilution factor corresponding to the first dilution retained.

Comment [T27]: In the introduction you mentioned three different fish species one of it being catfish. Why did you study tilapia only?

You collected from few fish farms. Why few? Just say tilapia was collected fromthen mention the farms

Say twenty (20) tilapia fish was collect. Kindly delete Approximately. But was the sample size enough to generate all the data and give a true representation?

In what condition of the tilapia did you collect (fresh, dried, smoked or fried). So you have to indicate here.

Why the collection of the samples is different; 4, 12 and 4? Why not taking equal number of tilapia fish samples?

The samples were collected carefully; how carefully? Were the aseptic techniques implord? And how long were the samples on transit to the lab. This is important because bacteria population doubles every 15 minutes also.

In general, this part needs to be reworked thoroughly.

Include the pictures of the tilapia that you collected

Comment [T28]: How did you pre-treat and why?

Comment [T29]: Kindly, remember when writing a report; use past tense

Show the readers how did you dissected the tilapia for sampling by including the picture on how you did it. When were these samples analyzed? Was it upon arrival? So may you kindly come out clear.

What is EPT stands for?

This part as well needs to be reworked

Comment [T30]: You didn't tell us that you prepared this. So show us

Comment [T31]: Write in full before you abbreviate. This part as well needs to be written clearly on what you did.

So kindly, revise it.

Comment [T32]: Delete this

Comment [T33]: Bring this formula up

2.3.5. Statistical analysis

The data collected during the survey were entered with the SPHINX-LEXICA software then processed and analyzed with the SPHINX-LEXICA software. The results were analyzed by Excel 2016 software for descriptive analyses. Analysis of variance (ANOVA) has a factor at the threshold of $\alpha=0.05$ and Tukey's HSD test were used for calculation and classification of means, respectively.

Comment [T34]: Mention the software's name once

Comment [T35]: This is not a software, rather a package or components of the Microsoft office software

Comment [T36]: You cannot mention ANOVA if you didn't indicate or mentioned the study design, how many dependent and independent factors the study encompassed of.

The study design gives the direction of the results visualization.

Comment [T37]: Revise this section and check how it is written

3. RESULTS

3.1. Sociodemographic Profile of fish farmers

Fish farming is practiced as a related activity in Haut-Sassandra. The study found that out of 150 fish farmers surveyed, only two (2) were practicing fish farming as their main activity. The remaining while the rest (148) were are mostly crop farmers, planters, civil servants and business persons, men as shown in Table 1. The dominant age group is 35-50 years old followed by the elderly (over 50 years old) and mostly having a primary school level. The female gender is less represented with 2.67%. These farms are generally privately owned. However, family farms are often observed (Table I).

Comment [T38]: Use past tense

Now my question is: you said you surveyed fish farms and fish farmers. And yet the results are showing that 148 were not fish farmers. Are you not contradicting yourself?

Or maybe the you wanted to say; 150 fish farmers interviewed, two (2) were only practicing fish farming while the rest apart from fish farming, they were also engaged in other economic activities such as crop farming, civil servants and cetera. Is that so?

Comment [T39]: Delete

Comment [T40]: We normally use male and female as gender terms

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Then re-analyze it

Table I: Sociodemographic profile of fish farmers in Haut-Sassandra

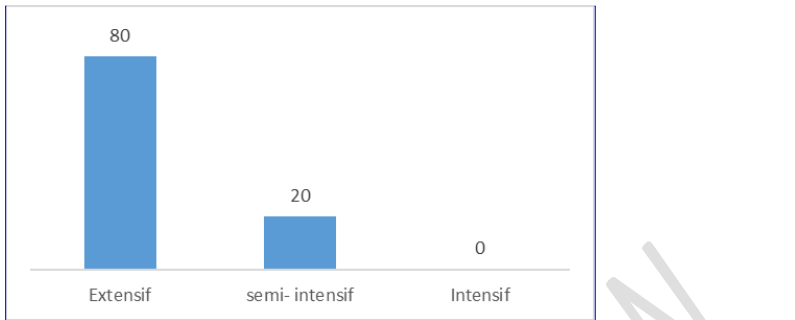
	Settings	Number	Percentage (%)
Sex	Mean	146	97,33
	Women	4	2,67
Ages (years)	≤ 18 years old	0	0
	18-35 years old	9	6
	35-50 years old	81	54
	≥ 50 years old	60	40
Level study	Unschooling	48	32
	Primary	63	42
	Secondary	25	16,66
	University	14	9,33
Activity main	Fish farming	2	1,33
	Agriculture/ Planter	117	78
	Official	4	2,66
	Trade	14	9,33
	Household	4	2,66
	Employee	9	6

3.2. Production systems

Two fish production systems were observed in Haut-Sassandra. This is the extensive system observed on 80% of the farms surveyed and semi-intensive on the remaining 20% (figure 1). These systems are practiced in two types of ponds : dam ponds and diversion ponds. Of these two systems,

Comment [T43]: Where is this coming from because you never mentioned this anywhere in the methodology

the extensive system is the most practiced in dam ponds and in rural areas. As for the semi-intensive system, it is exclusively observed in diversion ponds and particularly in urban and peri-urban areas.



Comment [T44]: What does extensif, intensif means? And what language is this?

Figure 1 : Fish production systems in Haut-Sassandra

3.3. Distribution of ponds in the Haut-Sassandra Region

Dam ponds and diversion ponds are observed throughout the Haut-Sassandra region. Of the 150 fish farms visited, 132 contain diversion ponds and 45 contain dam ponds. However, diversion ponds are more observed in peri-urban and urban areas (59%) than in rural areas (41%). On the other hand, dam ponds are more observed in rural areas (80%) than in peri-urban and urban areas (20%). We often note the presence of these two types of ponds on the same farm (figure 2).

Comment [T45]: The generation of this data was never mentioned in the methodology and one wonders what is this for?

May you clear out in the methodology and probably summarize these results. Not everything is worthy reporting.



A : Distribution of dam ponds

B : Distribution of diversion ponds

Figure 2: Distribution of ponds in the Haut-Sassandra Region

3.4. Activities associated with fish farming

Ponds are sometimes the place where several activities coexist. Indeed, fish farming is sometimes associated with rice farming, giving it the name rice-fish farming. This activity is encountered in dammed ponds. The rare dam ponds using this system are only found in rural areas (Bediala, Iuenoufla). In fact, out of 45 dam ponds visited and surveyed, only 6 practice rice-fish farming, or 13% (Figure 3). However, the diversion ponds do not have any associative activities but the fish farmers are considering rice farming.

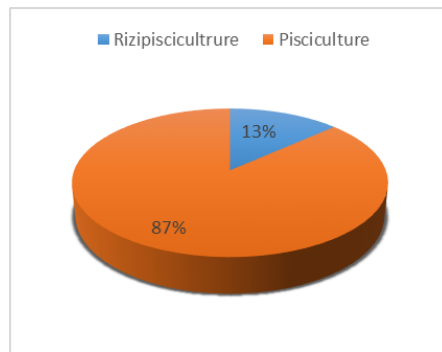


Figure 3: Activities associated with fish farming in dam ponds

3.5. Surrounding activities

Various activities are practiced around the ponds of the upper Sassandra region. These include rice growing, cash crops and sometimes market gardening. Of all these activities, cashew plantations are closest to dam ponds, followed by rice growing and rubber growing. Cocoa cultivation occupies last place with a rate of 11%. Unlike dammed ponds, rice cultivation occupies first place in diversion ponds followed by rubber cultivation and market gardening. We also note the habitats in peri-urban areas which, if classified as an activity, would occupy first place with rice growing. (Table II)

Table II: Activities surrounding fish ponds

Activities surrounding	% in dammed ponds	% in diversion ponds
Cashew Rice	33	10
farming	30	25
Heveaculture	26	22
Cacao-culture	11	8
Habitats	0	25
Vegetable grower	0	18

3.6. Farmed fish species

Three species of fish are found on fish farms. These are the species *Oreochromis niloticus* (Tilapia) commonly called carp, *Heterotis niloticus* (Cameroon) and *Clarias gariepinus* (Catfish). Tilapia fish occupies first place because it is present on all farms, followed by catfish and finally Cameroon fish which comes in third position (Table III). Catfish owe their second place to nature because their presence is not at the whim of fish farmers.

Table III : Different species of fish raised in the ponds of Haut-Sassandra

Name scientist	Name vernacular	% in dammed ponds	% in diversion ponds
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<i>Oreochromis niloticus</i>	Tilapia	100%	100%
<i>Heterotis niloticus</i>	Cameroun	5%	25%
<i>Clarias gariepinus</i>	Catfish	57%	29%

3.7. Evaluation of microbial pathogens in the viscera and gills of fish from some ponds in the Haut-Sassandra Region

3.7.1. Diversion ponds

The microbiological analysis carried out on the fish (Tilapia) from the diversion ponds revealed the presence of the various pathogens sought. These pathogens are present at loads lower than the standards for those of health 2 (*E. Coli* And *S. aureus*). Of the two parts analyzed, the gills are the most loaded. However, *enterococcus* are more present in the gills than the viscera. Out of 12 samples analyzed, only 2 viscera contain *E. coli* against 5 gills. It is the same for the *S. aureus* (Table IV).

Comment [T46]: check

Table IV: Contaminants of tilapia from diversion ponds in the Haut-Sassandra Region

Ech	<i>Escherichia coli</i>		<i>S. aureus</i>		<i>Enterococcus</i>		<i>Salmonella</i>	
	Viscera	Gill	Viscera	Gill	Viscera	Gill	Viscera	Gill
1	70±14,14	80±56,56	20±28,28	0±0	Abs	prés	Abs	Prés
2	130±0	20±0	25±35,35	15±21,21	prés	prés	prés	Abs
3	0±0	0±0	5±7,07	10±14,14	Abs	prés	Abs	Abs
4	0±0	0±0	10±14,14	30±0	Abs	prés	Abs	Prés
5	0±0	70±42,42	10±0	0±0	Abs	prés	Abs	Abs
6	0±0	25±35,35	25±0	35±49,49	prés	prés	Abs	Abs
7	0±0	0±0	20±14,14	0±0	Abs	Abs	Abs	Abs
8	0±0	5±7,07	0±0	0±0	Abs	prés	Abs	Abs
9	0±0	0±0	0±0	10±14,14	prés	Abs	prés	Prés
10	0±0	0±0	0±0	25±7,07	Abs	prés	Abs	Abs
11	0±0	0±0	0±0	5±7,07	Abs	prés	prés	Abs
12	0±0	0±0	55±77,78	70±14,14	Abs	Abs	Abs	Abs
Avg	6,91±1,16	16,6±11,7	12±	16,6 ± 10	-	-	-	-
Criteria								
microbiologie	10 ² UFC/g		10 ² UFC/g		Abs/25g		Abs/25g	

Comment [T47]: in statistical data we do not use a comma. Kindly revise. The data is making it not easy to follow

3.7.2. Dam ponds

The analysis of the viscera and gills of fish from dam ponds showed a total absence of *E. Coli*. The presence of *S aureus* in the viscera and gills is a reality that this study has just revealed. However, they are present with loads lower than the standard. As for *salmonella*, an absence is observed in the viscera and gill (Table V).

Table V: Contaminants of tilapia from dam ponds in the Haut-Sassandra Region

Ech	<i>E. coli</i>		<i>S. aureus</i>		<i>Enterococcus</i>		<i>Salmonelle</i>	
	Viscera	Gill	Viscera	Gill	Viscera	Gill	Viscera e	Gill
1	0±0	0±0	30±14,14	15±21,21	Pres	Abs	Abs	Abs
2	0±0	0±0	60±84,85	25±35,35	Pres	Pres	Abs	Abs
3	0±0	0±0	0±0	10±14,14	Abs	Pres	Abs	Abs
4	0±0	0±0	5±7,07	5±7,07	Abs	Abs	Abs	Abs
5	0±0	0±0	0±0	10±14,14	Abs	Pres	Abs	Abs
6	0±0	0±0	5±7,07	0±0	Abs	Abs	Abs	Abs
7	0±0	5±7,07	0±0	0±0	Pres	Abs	Abs	Abs
8	0±0	0±0	0±0	0±0	Pres	Abs	Abs	Abs
Avg	0±0	0,62±	12.5±	5,41±				
Criteria								
microbiol	10² UFC/g		10² UFC/g		Abs/25g		Abs/25g	
ogi								

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Comment [T48]: the digits are difficult to read. Is that a comma? And where is the decimal point

4. DISCUSSION

Fish farming is a popular activity in the Haut-Sassandra region. It is practiced in the departments of Daloa, Issia and Zoukougbeu. However, no farm has been identified in Vavoua. This activity owes its existence to its favorable environment [19]. To make this activity more successful, fish farmers have grouped themselves into cooperative societies. A total of six (06) cooperative societies were identified. Indeed, this organization allows clearer visibility on fish farming activity both by fish farmers and by partners. These are mainly APDRA and ANADER (technical partners) and MIRAH (financial partner). Added to these are the FAO and the World Bank. Despite this support, fish farming is practiced as an additive activity to other activities and by people whose age is between 35 and 50 years old. There is an absolute absence of young people under the age of 18 in this activity. This could be explained by the lack of resources (financial and technical), difficult access to spaces and above all the desire of young people for bureaucracy. These observations are similar to those of [20,21].

According to the latter, this situation is due to the fact that access to the fish farming profession remains more open to people who have land, a certain financial autonomy and a workforce. In the city of Brazzaville (Republic of Congo), this activity is mainly practiced by men (95%) aged 50 [22]. Thus, fish farming is an exclusively male activity. This study showed that the female gender was represented at 2.67%. These results corroborate those of [23,24] who observed 2.89% and 2.6% respectively.

Comment [T49]: check

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Comment [T51]: don't you think that this is obvious because someone below the age of 18 is not old enough to run a fish farm. This is where a study design and sampling technique I mentioned was to come out clear in your methodology. So study was supposed to stratify the target population

According to these authors, the non-involvement of women is explained by the arduousness of the tasks, societal constraints (inaccessibility of land by women, lack of time) and economic constraints. The rare women who practice this activity generally do so through inheritance [25]. Furthermore, for these same authors, the majority of these fish farmers have a primary level. These results are close to ours with a rate of 42%. These results differ from those of [20]. Indeed, these authors showed that in the city of Abidjan, the majority of fish farmers have a higher level of education. In Congo, [26] on the other hand, showed that the majority of fish farmers have a secondary level (55%). If fish farming is constantly emerging in Haut-Sassandra, it must be emphasized that it remains a related activity. Indeed, the survey showed that fish farmers are 78% planters and farmers. This dominance by planters and farmers could be explained by land ownership and a modest financial state. Similar results were observed in Cameroon by [27]. On the other hand, in Benin, [28] affirm that fish farming is a main activity for 32,5.

In Haut-Sassandra, two production systems were observed. This is the extensive system used on 80% of farms (mainly in rural areas) and the semi-intensive system (mainly in urban and peri-urban areas). The dominance of the extensive system could be explained by the lack of industrial feed, fry and especially the financial problems hence the use of agricultural by-products (rice bran, corn, cassava skin, rice stalks, etc.) for fish feeding. In Gontougo, east of the Ivory Coast [29] showed the dominance of this system in fish farming. Similar results were observed in Oued Righ, an Algerian region by [30]. However, the south of Côte d'Ivoire is dominated by an intensive system [31]. The different 10 systems are used in two types of ponds including dam ponds more present in rural areas and diversion ponds in urban and peri-urban areas. According to [23], these two structures are the most encountered in Côte d'Ivoire. However, we observe a fish farming system integrated into agriculture and this only in the dam ponds taking the name of rice-fish farming. This system is, according to fish farmers, less expensive because the stems of the rice plants will be used to feed the fish, reducing thermal shock caused by the sun. Similar results were observed by [1], which shows the presence of this system in Haut-Sassandra. We also note activities such as cashew nut growing, rice growing, rubber growing, cocoa growing around these farms regardless of the structure. In the Menoua department of Cameroon, the surrounding crops are, in order of importance, beans, banana-plantain, macabo/taro, peanuts, soybeans, yams, potatoes and finally cassava. [32].

Aquaculture resources are tilapia fish (*Oreochromis niloticus*), catfish (*Clarias gariepinus*) and Cameroon (*Heterotis niloticus*). Of these three species, tilapia is the main one. This dominance is due to its ability to adapt to environmental conditions, its easier reproduction and above all its nutritional and organoleptic quality. The species *clarias* for it, owes its existence to nature because its cultivation is not done at the discretion of the fish farmer. But its presence in the pond is sometimes used to the benefit of the fish farmer to control activity by reducing unwanted fry. These results are close to those of Anounouet al., (2016) who recorded tilapia (100%), catfish (33.33%), Cameroon (9.09%) and swallowtail (5.56%). In the bandal in Senegal, more than 16 species are bred [33] thus showing a diversity of species and more in-depth knowledge of fish farming. The different fish foods found on farms are agricultural by-products and pellets. Agricultural by-products represent a source of fish food for the majority of fish farmers surveyed, i.e. 78% in this Zone. In fact, this represents less

expense for them, especially since this region has several surrounding cultures. The same is true in Congo where [24] recorded a rate of 43% of fish farmers using agricultural by-products.

In order to determine the level of contamination of fish by microbial pathogens, a microbiological analysis was carried out. Unfortunately the presence of the pathogens sought is a reality revealed by this study. This is *Escherichia coli*, *staphylococcus aureus*, *enterococcus* and *salmonella*. This presence could be due to contamination of anthropogenic origin or the nature of their environment (water). [33] confirm this result during their study on waterways in Yaoundé in Cameroon where they showed that these fish production waters present a high concentration of bio-pollution indicators (*E. coli*, *enterococcus*, total coliform). However for health germs 2 (*E. coli* And *S. aureus*), loads are almost below standards for all farms except. However, these charges differ depending on the ponds and the parts considered. The gills of fish in diversion ponds are heavier than those in dam ponds. This could be due to the filter function of the gills. As for the viscera, the opposite effect is observed.

Regarding the other germs sought, general dissatisfaction is observed due to their presence. Fish in diversion ponds are more loaded with germs 11 enterococcus than those of dam ponds with loads ranging from 5 ± 7.07 to 840 ± 339.41 and from 5 ± 7.07 to 60 ± 14.14 respectively. As for salmonella, a total absence was observed in the dam ponds.

5. CONCLUSION

The objective of this study was to evaluate the contamination by potential bacterial pathogens of fish resources in the Haut Sassandra region, an area with high fish production in Ivory Coast. For this, a good knowledge of the activity was necessary. This study therefore showed that fish farming is an important activity for the Haut-Sassandra Region. However, special consideration must be given to fish farming because those involved in this field are faced with enormous difficulties. This activity is practiced in a favorable environment. Operations are carried out in dam ponds and diversion ponds. Microbiological analyzes revealed the presence of potentially pathogenic species, notably *Escherichia coli*, *Staphylococcus aureus*, *Salmonella spp* and *Enterococcus* in the viscera and gills of tilapia (*Oreochromis niloticus*) ~~the emblematic fish of these fish ponds.~~ However, dammed ponds provide more assurance on the microbiological quality of the tilapia found there

6. REFERENCES

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Comment [T52]: discussion section discusses nothing but the results in the results section. Delve and shed more light for the prevalence of microbial in the fish pond. Provide scientific evidence as to why the results are like that.

Bring a balance discussion by comparing your results with those found by others. you also bring the studies who found similar results to your study

What does the microbial data means to you? Does the results mean that the fish is safe for consumption?

What take home message does it give to the fish farmers and to the community?

May you kindly revise

Comment [T53]: You conclude based on each and every objective and then provide recommendations

Comment [T54]: This should have been mentioned in the last part of the introduction

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Comment [T55]: Provide more reference on fish microbiology because this is very fundamental to the piece of work (food safety)

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