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## Physico-chemical characterization of wastewater from a fish breeding station installed next the lagoon Ebrie (Côte d'Ivoire)

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Danielle Aboua, Nahoua Issa Ouattara and Essetchi Paul Kouamelan**

### Abstract

Sewage from aquaculture farms can cause, like domestic and industrial wastewater, surface water pollution. This study aims to characterize, on a physicochemical level, the wastewater emitted by a fish station installed near the Ebrié lagoon. Four seasonal sampling campaigns were conducted between August 2016 and July 2017. Temperature, pH and dissolved oxygen were measured, in-situ, using a multiparameter. Then, a 1 liter glass flask was used to take a sample of water and effluents at the entrance of the station and at the exit of the station, respectively. Analyzes in the laboratory determined the concentrations of nutrient salts, BOD5 and SS. The results reveal that the discharged water is acidic ( $\text{pH}=5.8 \pm 0.32$ ), poor in oxygen ( $2.2 \pm 0.13 \text{ mg O}_2/\text{l}$ ), has a very high organic matter load (OPI between 1.5 and 2) and a high rate of SS ( $273.25 \pm 57.75 \text{ mg/l}$ ). This fish wastewater is inadequate to be discharged into the Ebrié lagoon and must therefore be treated before discharge or reuse.

**Keywords:** Fish breeding effluents, Organic pollution, Ebrié lagoon, Environmental risk

### 1. Introduction

Fish farming is the most popular aquaculture activity in Côte d'Ivoire<sup>[1]</sup>. It raises a lot of hope for food self-sufficiency, food security, the fight against unemployment, hunger and poverty<sup>[1]</sup>. The exploitation of fish ponds, with a contribution of more than 60% to the national fish production, are the most productive fish breeding system<sup>[2]</sup>. They are found throughout the country but with a high concentration in the southern forest zone<sup>[2]</sup>, especially around the Ebrié lagoon<sup>[3]</sup>. The way in which these fish ponds are exploited implies environmental concerns with regard to untreated wastewater emissions that can have damaging consequences in nearby lakes and rivers. According to IUCN<sup>[4]</sup>, aquaculture has the challenge of relieving overfishing, meeting the growing demand for fish products without causing environmental problems. Discards from fish farms such as ponds are loaded with organic matter consisting mainly of food debris and metabolic compounds (feces, urea and mucus) from fish activity<sup>[5]</sup>. These compounds, when they reach the surface waters, are able to alter the quality of the water and cause eutrophication conditions<sup>[6, 7]</sup>.

The lagoon Ebrié is much requested for the fish production<sup>[8]</sup>. It has on its shores many fish farms exploiting ponds<sup>[9, 3]</sup>. Unfortunately, these farms emit their untreated effluent into the waters of the Ebrié lagoon. This raises concerns about the organic debris contained in these fish farms emissions. This study aims to characterize waste water emitted by a fish farm installed at the edge of the lagoon Ebrie.

### 2. Material And Methods

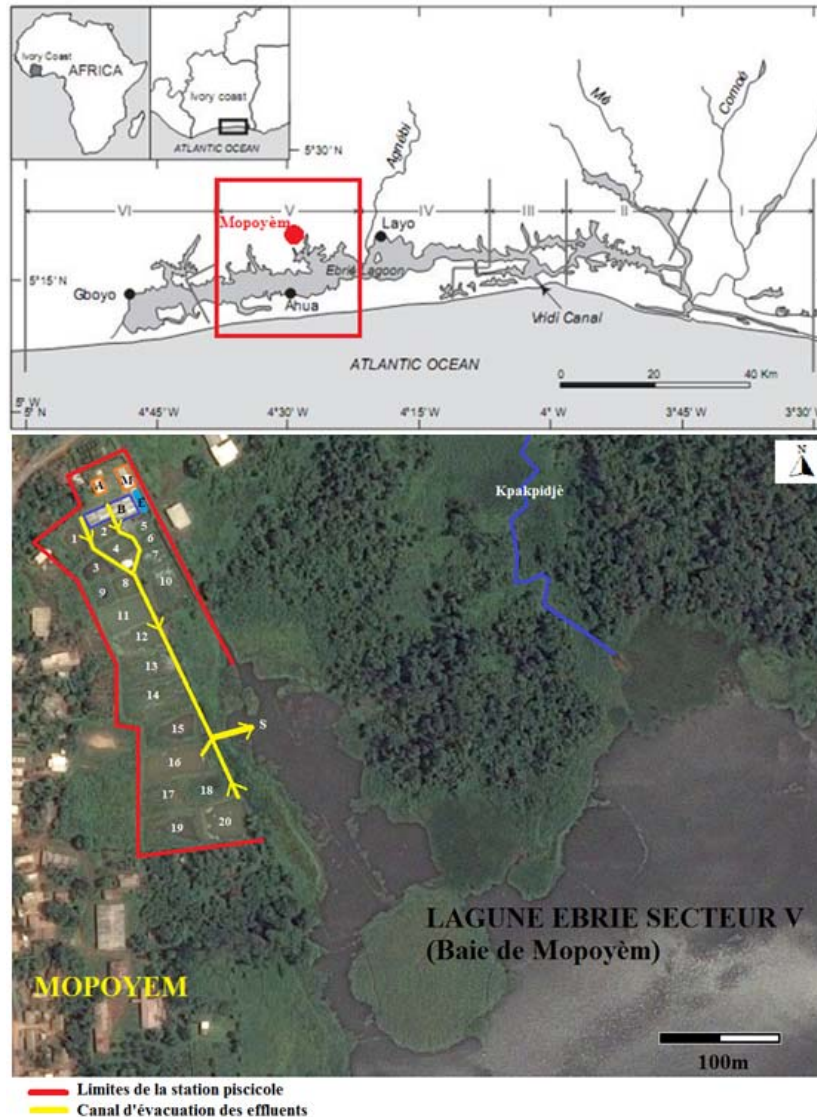
#### 2.1 Presentation of the study area and the fish station

The sampling station is located in Dabou at the bay of Mopoyèm in sector V of the Ebrié lagoon at coordinates  $5^{\circ}318 \text{ N}$  and  $4^{\circ}464 \text{ W}$ . It is located in a locality influenced by Attiean climate, a humid equatorial climate with four seasons including two dry seasons (short dry season: SDS and long dry season: LDS) and two rainy seasons (short rainy season: SRS and long rainy season: LRS).

This fish farming station (Figure 1) has for main activities the production and the marketing of fingerlings *Oreochromis niloticus* to supply the private fish farmers all over the Ivorian

territory or in the countries of the sub-region. It has 13 concrete ponds (B) for the reproduction and rearing of fish and about twenty ponds for pre-growing and growing phases. Ponds receive water from a reservoir erected on a tower (E) which also being supplied by the waters from a small river

(Kpakpidje) located 500 meters from the station. A pipeline network collects effluents from different basins and ponds and before discharging through a main channel (S) into the bay. The production of this farm is about 100.000 fingerlings/year.



**Fig 1:** Satellite view of the Mopoyèm fish breeding station (sector V, Ebré lagoon); A: administration, M : store, B: concrete ponds for breeding and rearing, E: water supply tower for ponds and concrete ponds, (1 to 20): ponds for the pre-growth and growing phases, S: discharge outlet. (Source : Dufour *et al.* <sup>[10]</sup> et Google map 2017)

## 2.2 Determination of physicochemical parameters

Four sampling campaigns were carried out between August 2016 and July 2017 precisely in August, November, February and July. During each sampling campaign, the physicochemical parameters such as temperature, pH and dissolved oxygen (DO) were measured, in-situ, using a HANA type multiparameter model HI98194. Transparency was measured with a Secchi disk. Then, a water sample was taken at the entrance of the ponds at the feeder tower (E) and another sample of liquid effluents was taken at the outlet of the station in the evacuation channel (S). Samples were taken using 1 liter glass bottles. The samples taken are packed with aluminum foil, placed in a cooler containing cold accumulators and sent immediately to the Pasteur Institute of Côte d'Ivoire.

The determination of the nitrite, ammonium and phosphate ions was carried out according to the colorimetric method

using a spectrophotometer and reagents as described by Murphy and Riley. <sup>[11]</sup> BOD<sub>5</sub> was measured by the respirometric method using OxItop manometric heads <sup>[12]</sup>. The concentration of suspended solids (SS) is determined according to the fiberglass filter filtration method described by Rodier *et al.* <sup>[13]</sup>.

## 2.3 Evaluation of the organic load of fish farm effluents

The evaluation of the organic load of the effluents is based on the calculation of the organic pollution index (OPI) proposed by Leclercq <sup>[14]</sup>. The method consists of using the values obtained for the phosphates, nitrites, ammonium ions and BOD<sub>5</sub> to find the class corresponding to the average value of each parameter. The OPI is obtained by calculating the average of the 4 classes. The value of the index makes it possible to appreciate the organic load of the effluents collected (Table 1).

**Table 1:** Quality Grid (OPI) <sup>[14]</sup>

Class number	DBO5 (mg/l)	NH4+ (mg/l)	NO2- (µg/l)	PO43- (µg/l)	OPI	Organic load
5	< 2	< 0.1	≤ 5	≤ 15	5.0 - 4.6	No
4	2 - 5	0.1 - 0.9	6 - 10	16 - 75	4.5 - 4.0	weak
3	5.1 - 10	1 - 2.4	11 - 50	76 - 250	3.9 - 3.0	Moderate
2	10.1 - 15	2.5 - 6	51 - 150	251 - 900	2.9 - 2.0	High
1	> 15	> 6	> 150	> 900	1.9 - 1.0	Very High

**3. Results**

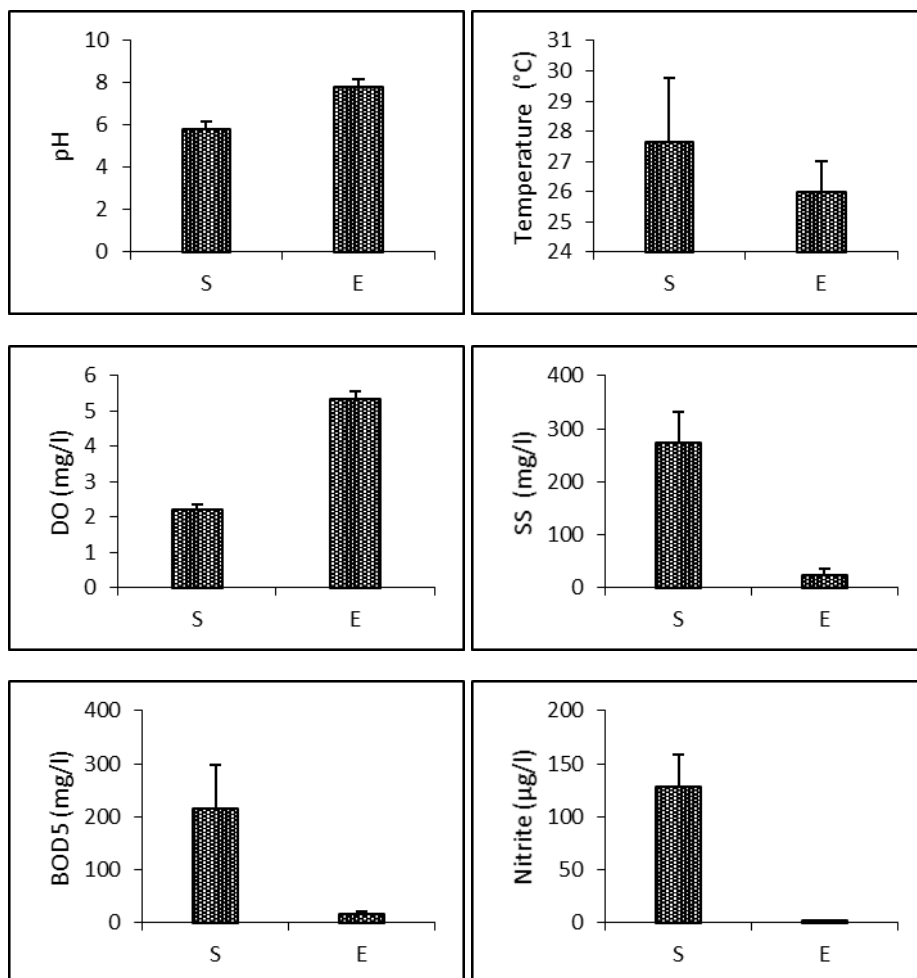
**3.1 Physicochemical quality of samples**

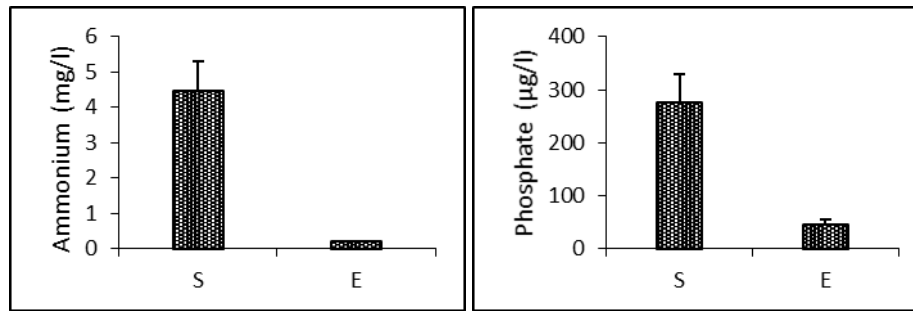
The diagrams in Figure 2 summarize results concerning physicochemical parameters. The average values of the physicochemical parameters measured in the waste water emitted by the fish farm station are 5.83 ± 0.33 for the pH, 27.63 ± 2.13 °C for the temperature, 2.20 ± 0.13 mg O2/l for dissolved oxygen, 273.30 ± 57.75 mg/l for SS, 215.4 ± 82.6 mg/l for BOD5, 128.10 ± 30.70 µg/l for Nitrite, 4.50 ± 0.80 mg/l for Ammonium and 266.00 ± 64.00 µg/l for Phosphate. On the other hand, the average values of these same parameters in the waters used to feed the ponds of the fish breeding station are 7.82 ± 0.38 for the pH, 26.00 ± 1.00 °C for the temperature, 5.35 ± 0.22 mg O2/l for dissolved oxygen, 24.30 ± 11.25 mg/l for SS, 15.70 ± 4.50 mg/l for BOD5, 2.00 ± 0.00 µg/l for Nitrite, 0.20 ± 0.00 mg/l for Ammonium and finally 45.80 ± 10.00 µg/l for Phosphate.

With the exception of temperature, pH and dissolved oxygen, the environmental variables measured are relatively very high in waste water compared to the water used to feed the ponds of the fish station. pH and dissolved oxygen are rather low in wastewater compared to pond feedwaters.

**3.2 Organic pollution**

Results for seasonal variations in water quality at the entrance and at the outlet of the farm are presented in Table 2. The organic matter load of the effluents at the exit of the fish station is very high in dry seasons (LDS : OPI=1.50 and SDS : OPI=1.75) and high in rainy seasons (LRS : OPI=2.00 and SRS : OPI=2.00). The waters used to feed the ponds are, on the other hand, moderately charged with organic matter in dry seasons (LDS : OPI=3.50 et SDS : OPI=3.75) and weakly loaded with organic matter in the rainy season (LRS : OPI=4.00 et SRS : OPI=4.00).





**Fig 2:** Average and standard deviation of the physicochemical parameters of the water measured at the entrance (E) and at the outlet (S) of the fish breeding station

**Table 2:** Seasonal variation of the organic pollution index of waste water emitted by the fish station installed at the edge of Ebrié lagoon in sector V.

Parameters	Water at the entrance (E)				Effluents at the outlet (S)			
	LDS	LRS	SDS	SRS	LDS	LRS	SDS	SRS
OPI	3.50	4.00	3.75	4.00	1.5	2	1.75	1.75
Organic pollution	Moderate	Weak	Moderate	Weak	Very High	High	Very High	Very High

#### 4. Discussion

The physicochemical characteristics of the effluents from the fish farm station show that the wastewaters of this station are not suitable for being discharged, without treatment, in lagoon environments. With the exception of dissolved oxygen ( $2.20 \pm 0.13$  mg O<sub>2</sub>/l), the values of the organic pollution indicators such as pH ( $5.83 \pm 0.33$ ), ammonium ( $4.50 \pm 0.80$  mg/l), BOD<sub>5</sub> ( $215.4 \pm 82.6$  mg/l) and SS ( $273.30 \pm 57.75$  mg/l) exceed the standards set by the WHO for the safe discharge of wastewater into the environment. The emission of these effluents from fish farms into the Ebrié lagoon is therefore an environmental problem because they can affect the quality of the water and disrupt the ecological balance of the aquatic environment at the local level. Indeed, the process of decomposition of organic compounds (non-ingested food debris, feces and mucus) the process of decomposition causes nutrient enrichment of the waters [15, 16], the reduction of dissolved oxygen [17] the increasing of suspended particles level [18]. According to the MDDEFP [19], Zirirane *et al.* [20], Hamdani *et al.* [21], Bengherbia *et al.* [22] et Dongo *et al.* [23], wastewater with high concentrations of nutrients and suspended solids is responsible for increasing nutrients and suspended solids in the receiving water environment. The transparency at the discharge point in lagoon can be affected and photic zone reduced. The consequences of such modifications in the receiving environment are numerous, some of which are irreversible. The most important changes are the eutrophication of the aquatic environment with nutrients accumulation [24], the advent of anoxic condition following the decrease of oxygen produced by phytoplankton organisms [25], the silting up of lagoon bottoms by the process of sedimentation of suspended particles [26, 27] and the redistribution of aquatic organisms with the disappearance of sensitive species and the proliferation of resistant species [28]. The organic loads of the effluents emitted by the fish farm which are very high in dry seasons and high in the rainy seasons represent a threat for the lagoon environment and in particular for the ecological balance of Mopoyèm bay. The decrease in organic load during the rainy season is due to the dilution of the effluents by the inflow of rainwater and the slowing down of microbiological activities following the lowering of temperatures in this period [29]. This influence of rainwater on the physicochemical characteristics of natural waters is a phenomenon which has been observed by Zinsou

*et al.* [30] et Amon *et al.* [31] in the waters of the Oueme delta in Benin and in the Aghein lagoon in Côte d'Ivoire, respectively. Indeed, the character of the wastewater discharged by the fish breeding station is similar to that of the raw waste of the city of Oujda [32] with regard to BOD and the SS. However, the values of these two pollution parameters are lower than those obtained by Hamdani *et al.* [21] in the effluents of a dairy located in the city of El Jadida. these effluents are less loaded with suspended matter than those emitted by Katanga feeding farm (ELAKAT) in RD Congo [33]. Wastewater from human activities is one of the main causes of pollution of water resources [34-36] and disruption of the ecological balance of aquatic ecosystems [37]. although the development of fish farming represents an important socio-economic issue for the Ivorian state, although the development of fish farming represents an important socio-economic issue for the Ivorian state, it is important, however, that a guideline be established to guide the various actors in the sector towards a responsible and sustainable fish farming with respect to environment.

#### 5. Conclusion

The waste water discharged by the Mopoyèm fish station in the Ebrié lagoon has an acidic pH, a very high organic matter load and a relatively high rate of suspended solids. The emission of these untreated fish farm effluents in the Ebrié lagoon, specifically in the Bay of Mopoyèm, can affect the water quality in the long term and disrupt the local ecological balance. The establishment of a treatment process for these effluents is therefore necessary before they are discharged into the Ebrié lagoon or possibly before their reuse.

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