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Studies of the physicochemical parameters of fish farm water in Antsirabe I, Vakinankaratra, Madagascar

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Abstract:

This study examines the quality of water used to farm tilapia and carp in Antsirabe, Madagascar. The physicochemical parameters of 95 farm sites were analyzed to determine and assess their compliance with the quality standards required for sustainable aquaculture. Samples taken at several farm sites revealed an average pH of 6.92, an average conductivity of 105µS/cm, an average oxygen level of 6mg/l, a temperature of 22°C, and an average salinity of 0.054/00. These results highlight the importance of water quality management in aquaculture practices in Antsirabe, helping to ensure the economic and environmental viability of fish farming in this region.

Keywords:

Aquaculture; environmental monitoring; hydrochemistry; sustainable fish farming; water quality

I. Introduction

Aquaculture plays an increasingly important role in global food security, particularly in countries like Madagascar, where natural fishery resources are under pressure (Tucker & Hargreaves, 2008). The island, rich in freshwater resources, offers considerable potential for the farming of fish species such as tilapia (Oreochromis spp.) and common carp (Cyprinus carpio). Still, water quality remains a critical factor for the success of these activities (Boyd, 1998). The physicochemical parameters of water, such as temperature, dissolved oxygen, pH, and conductivity, directly influence the health, growth, and survival of farmed fish (Stone & Thomforde, 2004). Consequently, a thorough assessment of water quality in Antsirabe's aquaculture environments is essential to identify potential risks and offer recommendations for improving aquaculture practices (Rakotondrabe et al., 2018; Rasoloariniaina et al., 2015). Therefore, the central issue of this study is to understand the physicochemical characteristics of aquaculture waters in Antsirabe, with a focus on parameter levels and their compliance with the quality standards required for tilapia and carp farming. Development is a systematic and continuous effort made to realize something that is aspired. Development is a change towards improvement. Changes towards improvement require the mobilization of all human resources and reason to realize what is aspired. By better understanding these parameters, this research will contribute to strengthening the scientific foundation necessary to promote sustainable and resilient aquaculture in the region. The objective is to determine these parameters for sustainable aquaculture development and to identify strategies adapted to the environmental and socio-economic realities of the country (Tucker & Robinson, 1990; Zhu et al., 1999).

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II. Reserach Methods

Data was collected from 19 livestock farmers in the communes of Antsirabe I within a 10km radius. Several instruments and materials were used to collect data on livestock water quality in Antsirabe in order to ensure accurate and reliable measurements. A digital thermometer was used to measure water temperature. A portable multifunction pH meter was used to measure pH, salinity, and conductivity. Chemical analysis kits were used to determine nitrites and nitrates, providing a simple method. The samples were taken from the same depth to ensure a representative representation of the conditions in the farming environment. This equipment enabled a complete and rigorous analysis of water quality parameters, which are crucial to the health and productivity of the aquatic species farmed.

2.1 Statistical analysis

For the statistical analysis of the results, the biometric data for each repetition are considered as an observation. These results are compared statistically by means of a one-character analysis of variance (ANOVA) using the EXCEL software procedure after prior verification of the homogeneity of the variances and the normality of the data to be analyzed. When the ANOVA was significant, the TUKEY test was used to compare the means. A significance level of 5% was used for these comparisons.

III. Results and Discussion

The readings taken in Antsirabe show a pH ranging from 6.85 to 7.05, which is within a suitable range for aquaculture activities, albeit slightly acidic. The conductivity values provided for different areas around Antsirabe (North: 106 µS/cm; Centre: 104.89 µS/cm; East: 105.84 µS/cm; West: 106.32 µS/cm; South: 103.95 µS/cm) average between 103 and 106 µS/cm. Dissolved oxygen levels measured in different areas of Antsirabe ranged from 6 mg/L to 6.05 mg/L. The temperatures obtained in the different areas of Antsirabe are between 22.65 and 23°C. According to the measurements, the average salinity in the different areas of Antsirabe varies between 0.053/00 and 0.54/00 µS/cm. Nitrate levels were all below 25 mg during data collection, and nitrite levels were almost equal to 0 mg. According to ANOVA, the values obtained are all significantly different ($p > 0.05$).

Table 1. Average value of samples taken

Parameter	Location				
	Antsirabe north	**Antsirabe center**	**Antsirabe east**	**Antsirabe south**	**Antsirabe west**
pH	$6,85^{a} \pm 0,38$	$6,94^{b} \pm 0,33$	$6,93^{c} \pm 0,39$	$7,05^{d} \pm 0,30$	$6,85^{e} \pm 0,25$
Conductivity (µS/cm)	$105,84^{a} \pm 4,10$	$105,58^{b} \pm 3,85$	$105,63^{c} \pm 4,34$	$104,63^{d} \pm 3,67$	$106,11^{e} \pm 4,24$
Dissolved oxygen (mg/l)	$6,05^{a} \pm 0,54$	$6,04^{b} \pm 0,70$	$6,02^{c} \pm 0,49$	$6^{d} \pm 0,46$	$6,03^{e} \pm 0,43$
Temperature (°C)	$22,88^{a} \pm 0,70$	$22,85^{b} \pm 0,66$	$23^{c} \pm 0,59$	$22,99^{d} \pm 0,99$	$22,65^{e} \pm 0,65$

Salinity (/$_{00}$)	54,32^{a} ± 2,33	53,58^{b} ± 2,48	54^{c} ± 1,63	52,84^{d} ± 1,54	54,42^{e} ± 1,87

3.1 Discussions

Readings taken at Antsirabe show a pH ranging from 6.85 to 7.05, which is within a suitable range for aquaculture activities, albeit slightly acidic. According to McClanahan (1992), this pH level could be affected by local factors such as geology, the chemical composition of the soil, or pollutants. A pH of around 6 is acceptable for many species. However, if the pH falls below 6, this can cause physiological problems in certain more sensitive species. According to Boyd (1990) and Lawrence (2014), pH levels below six can affect osmotic balance and cause respiratory problems.

On the other hand, a pH that is too high (above 9) can cause gill and eye irritation in fish. Water quality standards for aquaculture generally recommend a pH between 6.5 and 8.5 to maintain optimum growth and limit fish stress. The readings at Antsirabe are, therefore, slightly below this optimum range but do not represent a critical condition (Chervinski, 1982).

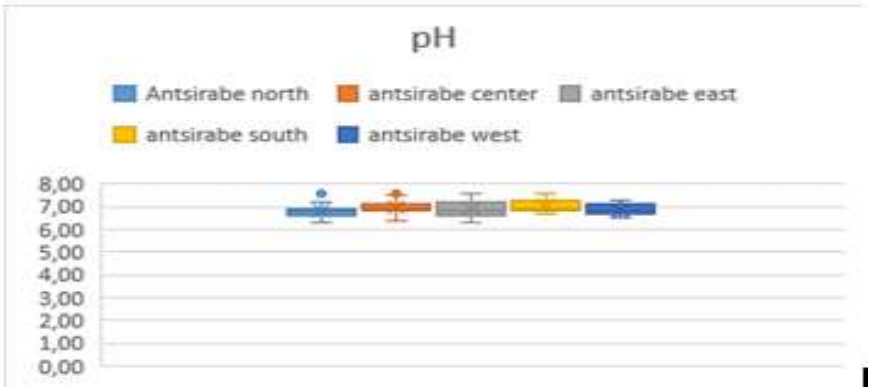

Figure 1. *pH of sampling sites*

According to Rodier et al. (2009), measuring conductivity provides a rapid but very approximate assessment of the water's overall mineralization and enables its evolution to be monitored. The conductivity level measured varies from 104 µS /cm to 107 µS /cm. According to Rodier et al. (2009), a conductivity of 100 to 150 µS/cm indicates very low mineralization, which is characteristic of freshwater.

According to Alcántar-Vázquez et al. (2014), salinity corresponds mainly to the concentration of dissolved mineral salts in water. According to March (1999), water salinity in ponds is normal as all tilapia are sensitive to salty water. Tilapia grow most efficiently when salinity is close to fresh or slightly brackish. Common carp is also a species that tolerates a wide range of environmental conditions but prefers freshwater. According to the measurements, the average salinity in the different areas of Antsirabe corresponds to extremely low levels (freshwater). Consequently, salinity levels in these waters are far from critical thresholds for tilapia and carp farming and should be adequate to maintain the health and productivity of these fish (El-Sayed 2006, FAO 2021).

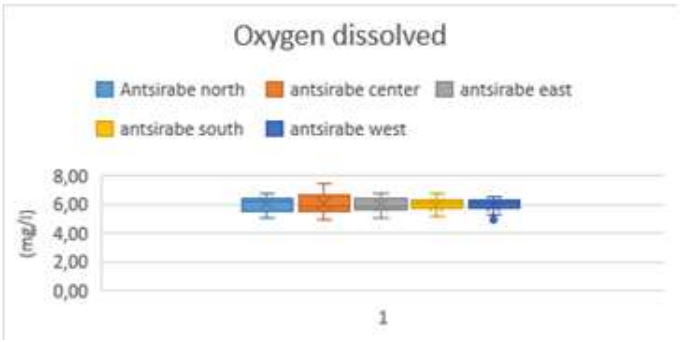

Figure 2. *Dissolved oxygen at sampling sites*

Dissolved oxygen (DO) concentrations in aquaculture-growing waters play a crucial role in the health and growth of aquatic organisms. The dissolved oxygen levels you measured in different areas of Antsirabe (ranging from 6 mg/L to 6.05 mg/L) seem close to the general recommendations for aquaculture systems (Welcomme, 1967).

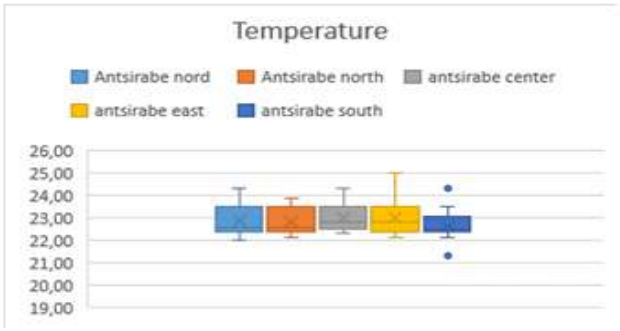

Figure 3. *Temperature at sampling sites*

Oxygen levels of 5 to 8 mg/L are often considered ideal for most aquatic species. Levels above six mg/L ensure good oxygenation and promote optimal growth. Dissolved oxygen readings are above the range of 2 mg/l to 4 mg/l and are compatible with the survival of aquatic life, especially fish. The required threshold is 2-3 mg/l (Desprez, 2004), which means that the water used by the station is suitable for fish farming.

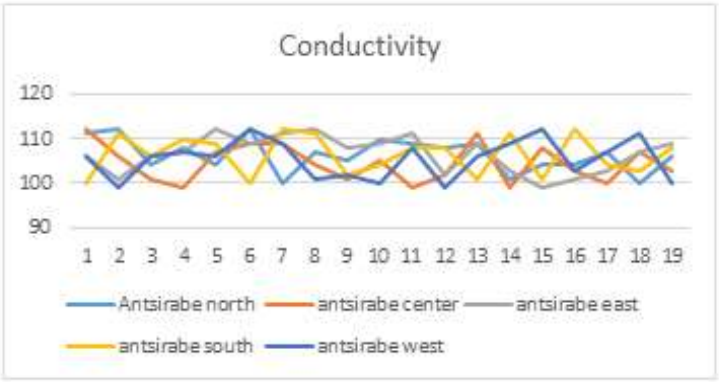

Figure 4. *Conductivity of sampling sites*

Farm water temperatures play a crucial role in the growth, health, and reproduction of fish such as tilapia and carp. By comparing the temperatures for the different regions of

Antsirabe (22.65 to 23°C) with the thermal requirements of the species, we can determine whether they are within optimum norms. (Colt, 2006).

The thermal tolerance limit for farmed fish species is 6.7°C to 41°C, the so-called extreme acclimatization values (Denzer, 1967 and Lee, 1979). These temperature values are, therefore, not lethal for the fish. Growth depends on temperature; the higher the water temperature, the faster the fish grow, and they often grow faster if the average daily water temperature is between 25 and 30°C (Lietar, 1984).

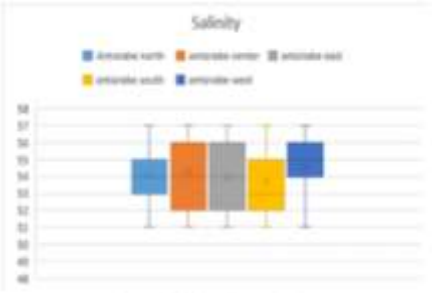

Figure 5. *Salinity of sampling sites*

For tilapia and carp, recommended aquaculture standards suggest that nitrate concentrations should ideally be below 50 mg/ L to maintain good fish health. However, one study has shown that tilapia can tolerate nitrate levels up to around 200 mg/L without serious effects on survival, but lower concentrations are still preferable to avoid stress (Graham, 2010; Svobodová, 1993). In the Antsirabe areas, an average nitrate concentration of less than 50 mg/L is very low and well below the critical thresholds for farmed fish. This indicates that the waters in these areas are free from nitrate pollution and comply with standards for tilapia and carp farming.

Table 2. Sample values

Parameter	**Location**				
	Antsirabe north	**Antsirabe center**	**Antsirabe east**	**Antsirabe south**	**Antsirabe west**
Nitrite (mg/l)	< 0,5				
Nitrate (mg/l)	< 25				

According to water quality standards for aquaculture, nitrite levels should ideally be below 1 mg/L. Nitrite toxicity varies according to fish species and other environmental factors such as temperature and pH. For tilapia, nitrite concentrations above 0.5 mg/L can already start to affect fish health (Murray et al., 2016). The nitrite concentration is 0 mg/L at the various sites in Antsirabe. This indicates that nitrite levels in tilapia and carp farm water in Antsirabe are within water quality standards and should not pose a risk to fish health. This is a positive result that suggests good control of the farming environment.

IV. Conclusion

This study on the quality of farming waters in Antsirabe revealed levels that comply with safety standards. These results indicate a healthy aquatic environment conducive to tilapia and carp farming. Maintaining such water quality levels is crucial to ensuring the health of the fish and optimizing aquaculture production. This will allow for the rapid identification of any potential changes in the aquatic ecosystem and the implementation of corrective measures if necessary. Adhering to best management practices and monitoring farming waters is essential to ensuring the sustainability of aquaculture in Antsirabe. These results provide a solid foundation for potential future research on the impacts of farming conditions on the productivity and health of aquatic species in this region.

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