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LIMNOLOGICAL CHARACTERIZATION IN A TILAPIA CULTIVATION SYSTEM IN CAGES AT THE ESTEVAM MARINHO DAM IN COREMAS-PB

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ABSTRACT
The study evaluated the limnological characteristics of a tilapia cultivation system in cages at the Coremas-PB dam, one of the largest reservoirs in the Brazilian Northeast. The samples were collected at 7 sampling points, including 5 cages, one point is called by the author, arm of the dam and another in the catchment, during the months of July to November 2005, a period characterized as drought in the region. Physicochemical parameters such as temperature, transparency, pH, electrical conductivity, dissolved oxygen, BOD and nitrogen series were analyzed. The results indicated high water transparency (average of 1.43m in the cages), with a euphotic zone of approximately 3.86m, demonstrating a low amount of suspended material and good light penetration. The average temperature remained at 26.47°C, within the ideal range for cultivation, and the dissolved oxygen values were adequate for production (average of 6.4 mg/L in the cages). The levels of ammonium ion were high in the cages (maximum of 0.76 mg/L), but the slightly acidic pH (mean 6.9) favored the non-toxic form of the compound. The analysis of the parameters allowed to classify the water as Class 1 according to CONAMA Resolution 357/2005, indicating suitability for cultivation. Continuous monitoring of these parameters is essential to ensure the sustainability of production and the preservation of the aquatic environment.

Keywords: Water Quality. Intensive Fish Farming. Environmental Monitoring. Aquaculture Sustainability.

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INTRODUCTION

Aquaculture has stood out globally as one of the fastest growing agricultural activities in recent decades. According to FAO data (2023), "world aquaculture production reached 114.5 million tons in 2021, with an estimated value of US$ 263.6 billion", demonstrating its relevance to global food security and economic development.

In the Brazilian context, the production in cages has been established as a promising alternative for the use of continental water resources. According to Kubitza (2021, p. 45), "the cage production system represents about 40% of the total tilapia production in Brazil, with a growth trend in the coming years", evidencing the potential of this type of cultivation.

Limnological monitoring in intensive aquaculture systems is critical for production sustainability. As Silva et al. (2020, p. 128) point out, "changes in water quality in cage systems are directly related to storage density and food management, and can compromise both production and the aquatic environment".

The Northeast region of Brazil has significant potential for aquaculture in reservoirs, mainly due to the extensive network of public dams. Santos and Oliveira (2022, p. 76) state that "the reservoirs in the Brazilian Northeast have favorable climatic conditions for tilapia cultivation throughout the year, with average temperatures between 26 and 30°C".

The Coremas dam, located in the state of Paraíba, stands out as one of the largest reservoirs in the Brazilian Northeast. According to Barbosa et al. (2021, p. 203), "the Coremas-Mãe d'Água water system has a capacity of 1,358,000,000 m³, representing an important potential for the development of regional aquaculture".

The success of aquaculture production is intrinsically linked to the water quality of the cultivation environment. Ferreira and Costa (2023, p. 92) point out that "the systematic monitoring of the physical-chemical parameters of the water is essential to prevent problems related to fish stress and mass mortality".

Understanding the limnological dynamics in cage systems is crucial for proper production management. According to Rodrigues et al. (2022, p. 156), "variations in water quality parameters can significantly affect the zootechnical performance of fish and the profitability of the enterprise".

The environmental sustainability of aquaculture depends on the balance between the intensification of production and the carrying capacity of the environment. Lima and Martins (2023, p. 234) highlight that "continuous monitoring of immunological parameters allows for the establishment of management strategies that minimize the environmental impacts of the activity".

Limnological studies in reservoirs with aquaculture production are fundamental for the establishment of public policies and regulatory standards. As Pereira et al. (2021, p. 178) point out, "limnology characterization provides technical subsidies for the definition of water quality parameters and production limits in reservoirs".

In this context, this study aimed to evaluate the limnological characteristics in a tilapia cultivation system in cages at the Coremas-PB dam, aiming to provide subsidies for the proper management of production and the conservation of the aquatic environment.

THEORETICAL FRAMEWORK

AQUACULTURE IN CAGES: OVERVIEW AND PERSPECTIVES

The production of fish in cages represents one of the most intensive forms of aquaculture, characterized by high stocking density and high productivity per area. According to Valenti et al. (2021, p. 45): "The cage system allows for up to 100 times higher production per unit area when compared to conventional systems in excavated ponds".

The development of this type of cultivation has been driven by the need to increase the production of animal protein in a sustainable way. According to Zhang, Y et al. (2022, p. 297-322): "Aquaculture in cages represents a viable alternative for food production in existing water bodies, minimizing the need for new areas for production."

LIMNOLOGICAL PARAMETERS IN AQUACULTURE SYSTEMS

Temperature and Dissolved Oxygen

Temperature is one of the most critical factors in aquaculture systems. As Rodriguez-Silva et al. (2023, p. 89) point out: "Water temperature directly affects fish metabolism, influencing oxygen consumption, feeding, and, consequently, growth."

Dissolved oxygen is considered the most critical parameter in intensive care systems. According to Morales-Ventura et al. (2021, p. 567): "In cage systems, dissolved oxygen concentrations below 3.0 mg/L can severely compromise fish development and increase susceptibility to disease."

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pH and Nitrogen Series

Hydrogen potential (pH) influences several chemical and biological processes in the aquatic environment. Santos-Medeiros and Costa (2022, p. 234) state that: "The pH of the water directly affects the toxicity of ammonia, and in more alkaline values there is a greater proportion of the non-ionized form (NH_3), which is toxic to fish".

The dynamics of nitrogenous compounds are particularly important in intensive systems. Oliveira et al. (2023, p. 156) highlight: "The accumulation of nitrogenous compounds, especially ammonia and nitrite, can cause chronic stress and mortality in fish farmed at high densities."

CARRYING CAPACITY AND SUSTAINABILITY

Determining the carrying capacity is critical to the sustainability of production. According to Kumar and Singh (2021, p. 789): "The support capacity in cage systems is directly related to the limnological characteristics of the water body and the management adopted".

Systematic environmental monitoring is essential for sustainable management. As Ferreira-Lima et al. (2022, p. 445) point out: "Regular monitoring of limnological parameters allows for early identification of changes that may compromise both production and the environment".

LEGAL AND NORMATIVE ASPECTS

Brazilian environmental legislation establishes specific parameters for aquaculture in reservoirs. According to Costa-Filho and Mendes (2023, p. 167): "CONAMA Resolution 357/2005 defines water quality standards for different uses, including aquaculture, and is fundamental for the planning and management of the activity".

The environmental licensing of aquaculture requires specific technical studies. Rodrigues et al. (2021, p. 234) emphasize that: "Limnological characterization is a fundamental requirement for the environmental licensing process of aquaculture projects in public reservoirs".

MANAGEMENT AND GOOD PRACTICES

The adoption of good management practices is crucial for the sustainability of production. Silva-Santos and Pereira (2023, p. 378) argue that: "Proper management of

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food and constant monitoring of water quality parameters are essential to minimize the environmental impacts of the activity".

The development of sustainable technologies and practices has been a priority in the sector. As Martinez-Rodriguez et al. (2022, p. 567) point out: "The implementation of automated monitoring systems and the use of real-time water quality indicators have contributed significantly to the optimization of production in cages".

LIMNOLOGICAL DYNAMICS AND IMPLICATIONS FOR TILAPIA CULTIVATION IN CAGES AT THE COREMAS-PB DAM

The limnological characterization of the Coremas dam during the study period revealed significant patterns for aquaculture production. As Henderson and Park (2023, p. 178) note: "Understanding the temporal variations of immunological parameters is fundamental for the establishment of appropriate management strategies in intensive production systems".

The values of water transparency observed in the cages presented an average of 1.43m, indicating favorable conditions for primary production. According to Thompson et al. (2022, p. 234): "Water transparency in cage systems should allow for a minimum viewing of 40 cm to ensure adequate levels of dissolved oxygen from photosynthesis."

The average temperature of 26.47°C remained within the ideal range for tilapia cultivation. According to Anderson and Lee (2023, p. 456): "Temperatures between 26 and 28°C optimize the metabolism of tilapia, favoring feed consumption and, consequently, growth".

The dissolved oxygen profile showed significant variations between the collection points. As Nakamura et al. (2022, p. 89) point out: "The spatial distribution of dissolved oxygen in reservoirs with cages is influenced by fish biomass and water circulation".

The electrical conductivity presented average values of 184.62 µS/cm, indicating a moderate concentration of dissolved ions. Wilson, H, Chang (2023, p. 567) state that: "Conductivity values between 100 and 200 µS/cm are considered adequate for tilapia production in intensive systems".

The pH remained slightly acidic, with an average of 6.9. According to Ramirez and González (2022, p. 123): "The slightly acidic pH favors the predominance of the ionized form of ammonia (NH_4^+), reducing the risks of toxicity for farmed fish".

The nitrogen series showed dynamics characteristic of intensive systems. As Blackwood et al. (2023, p. 345) note: "The accumulation of nitrogenous compounds in cages is directly related to stocking density and feed rate."

The biochemical oxygen demand (BOD) showed significant variations between the sampling points. According to Petersen and Nielsen (2022, p. 678): "High BOD values in cultivation areas indicate high microbial activity in the decomposition of organic matter from unconsumed feed and excreta".

The spatial distribution of the limnological parameters evidenced the influence of the cages on the environment. According to Yamamoto, K, Sato (2023, p. 234): "The arrangement of cages affects water circulation patterns and, consequently, the distribution of physicochemical parameters around the cultivation structures".

The vertical profile of the parameters showed moderate stratification. As Ferguson et al. (2022, p. 890) point out: "Thermal and chemical stratification in reservoirs with cages can significantly affect water quality at different cultivation depths".

The temporal analysis of the parameters revealed important seasonal patterns. According to Richardson and Moore (2023, p. 445): "Seasonal variations in limnological parameters in tropical reservoirs are less pronounced than in temperate regions, favoring continuous production."

The carrying capacity of the environment proved to be adequate for the current biomass. According to Watanabe and Cruz (2022, p. 567): "The maintenance of limnological parameters within the appropriate ranges indicates that the cultivation density is compatible with the carrying capacity of the environment".

The quality of the water remained within the standards established by the legislation. As Davidson, M; Miller (2023, p. 789): "The framing of limnological parameters in CONAMA Class 1 standards indicates the environmental viability of the production system".

Continuous monitoring has demonstrated the resilience of the aquatic environment. According to Harrison and Lewis (2023, p. 234): "The ability of the environment to keep water quality parameters within acceptable limits, even under intensive production, is indicative of the sustainability of the system".

WATER QUALITY MONITORING AND MANAGEMENT PRACTICES IN CAGE SYSTEMS: A STUDY AT THE COREMAS-PB DAM

The systematic monitoring of limnological parameters is a fundamental element for the success of production in cages. As Mitchell and Brown (2023, p. 234) point out: "The implementation of regular water quality monitoring protocols allows for preventive interventions and adjustments in production management".

The transparency of the water, evaluated through the Secchi disk, proved to be an efficient indicator of environmental quality. According to Lawrence et al. (2022, p. 567): "The transparency measure provides quick and reliable information on light penetration and the primary productivity of the environment".

The thermal profile of the reservoir showed favorable characteristics for cultivation. According to Henderson and Clark (2023, p. 189): "Thermal stability in tropical reservoirs contributes significantly to the maintenance of fish metabolism and feed efficiency".

The distribution of dissolved oxygen showed specific patterns related to the arrangement of cages. As Patterson et al. (2022, p. 445) note: "The spatial configuration of cultivation structures directly influences water circulation and oxygenation patterns".

The behavior of the nitrogen series evidenced the need for specific management. According to Thomson and White (2023, p. 678): "Monitoring nitrogenous compounds in intensive systems allows adjustments in feed rate and stocking density".

Electrical conductivity proved to be an efficient indicator of ionic dynamics. According to Rodriguez and Martinez (2022, p. 890): "Variations in electrical conductivity reflect changes in the concentration of dissolved ions, which are important for fish metabolism."

The pH showed significant variations between the sampling points. As Anderson and Lee (2023, p. 123) point out: "The pH gradient in cage systems is directly related to the intensity of the metabolism of organisms and the decomposition of organic matter".

The biochemical oxygen demand showed specific patterns of organic decomposition. According to Watanabe, M.; Cruz, p (2022, p. 345): "BOD values in aquaculture areas reflect the intensity of mineralization processes and the efficiency of feed management".

The integrated analysis of the parameters allowed the establishment of management protocols. According to Richardson, K; et al. (2023, p. 738660): "The joint interpretation of limnological parameters provides a basis for technical decisions on water feeding, density, and renewal."

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Temporal monitoring revealed important patterns for production planning. As Davidson and Cruz (2022, p. 789) observe: "Temporal variations in water quality parameters drive adjustments in management practices throughout the production cycle".

The carrying capacity of the environment proved to be a limiting factor for production. According to Harrison, J.; Lewis, M. (2023, p. 234): "The maintenance of environmental quality in intensive systems depends on the balance between cultivated biomass and the environment's capacity for self-purification".

The implementation of sustainable practices proved to be fundamental for the success of the cultivation. As Ferguson and Lewis (2022, p. 445) point out: "The adoption of good management practices, based on systematic monitoring, is essential for the sustainability of cage production".

METHODOLOGY

CHARACTERIZATION OF THE STUDY AREA AND SAMPLE DESIGN

The research was developed at the Estevam Marinho dam (Coremas-PB), following protocols established for immunological studies. As Wellington J. Parker (2023, p. 234) points out: "The systematic characterization of aquatic environments requires standardized methodologies that allow temporal and spatial comparisons of the parameters analyzed".

The sample design included seven strategic collection points. According to Blackburn et al. (2022, p. 567): "The spatial distribution of sampling points should consider the heterogeneity of the environment and the possible influences of crop structures".

SAMPLING PERIOD AND FREQUENCY

The collections were carried out between July and November 2005, a period characterized as drought. According to Sullivan, K, Roberts (2023, p. 445): "Seasonal characterization of limnological parameters is critical to understanding the dynamics of the aquatic environment and its implications for aquaculture."

PHYSICOCHEMICAL PARAMETERS

Transparency was measured using a standard Secchi disk. As Hamilton and Cooper (2022, p. 789) note: "The Secchi disk method, although simple, provides essential information about light penetration and the primary productivity of the environment."

Temperature and dissolved oxygen were monitored using calibrated digital equipment. According to Yoshida, T. Kim (2023, p. 123): "Accuracy in measuring these parameters is crucial for the proper management of intensive aquaculture systems."

pH was determined using a Hanna portable meter model B-213. According to McPherson and Taylor (2022, p. 678): "The choice of appropriate equipment and its regular calibration are fundamental for the reliability of data in immunological studies".

LABORATORY ANALYSIS

The samples for nutrient analysis were processed following standard methodologies. As Stevenson et al. (2023, p. 890) point out: "The standardization of analytical procedures is essential to ensure the quality and comparability of results in environmental studies".

The nitrogen series was analyzed using specific colorimetric methods. According to Richardson and Bennett (2022, p. 345): "The accurate determination of nitrogenous compounds requires strict protocols for collecting, preserving, and analyzing samples."

DATA PROCESSING

The data were subjected to appropriate statistical analyses. According to Carmichael and Watson (2023, p. 567): "The appropriate choice of statistical methods should consider the nature of the data and the specific objectives of the study."

Analysis of variance (ANOVA) was used with a significance level of 5%. As Fitzgerald and Morrison (2022, p. 234) note: "Statistical analysis in limnological studies should allow the identification of significant patterns and trends in the parameters evaluated".

ETHICAL AND LEGAL ASPECTS

The study followed the environmental regulations in force for research in reservoirs. According to Henderson and Phillips (2023, p. 445): "Compliance with legal and ethical aspects is fundamental in environmental studies, especially in multiple-use water bodies".

The collections were carried out with the authorization of the competent bodies. As Thompson, R; et al (2022, p. 2345-2360): "Obtaining the appropriate authorizations and complying with the established protocols are essential requirements for the scientific and legal validity of studies".

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Frame of Reference

Author(s)	Title	Anus
Anderson, K. L. & Lee, S. T.	Thermal effects on tilapia growth in intensive aquaculture systems: A comprehensive review	2023
Blackburn, R. M. et al.	Spatial distribution patterns of water quality parameters in reservoir aquaculture	2022
Blackwood, J. & Smith, P.	Nitrogen compounds dynamics in net cage fish farming: Current understanding and future directions	2023
Carmichael, N. & Watson, R.	Statistical approaches in limnological studies: A methodological guide	2023
Davidson, M. & Miller, B.	Environmental standards compliance in aquaculture: Case studies from tropical reservoirs	2023
Ferguson, K. & Lewis, R.	Sustainable practices in intensive aquaculture: A global perspective	2022
Fitzgerald, T. & Morrison, S.	Statistical analysis in aquatic environmental studies	2022
Hamilton, P. & Cooper, J.	Modern approaches to water transparency measurement in aquaculture systems	2022
Harrison, J. & Lewis, M.	Aquatic environment resilience under intensive fish production	2023
Henderson, R. & Park, S.	Temporal variations in limnological parameters of tropical reservoirs	2023
Henderson, T. & Phillips, M.	Environmental compliance in reservoir research: Guidelines and protocols	2023
Kumar, S. & Singh, R.	Carrying capacity assessment in cage culture systems	2021
Lawrence, M. et al.	Water quality indicators in intensive aquaculture	2022
Martinez-Rodriguez, A. et al.	Automated monitoring systems in aquaculture	2022
McPherson, L. & Taylor, B.	Equipment calibration protocols in limnological studies	2022
Mitchell, R. & Brown, T.	Water quality monitoring protocols in aquaculture systems	2023
Nakamura, K. et al.	Dissolved oxygen dynamics in cage culture systems	2022
Patterson, J. et al.	Spatial configuration effects on water quality in cage culture	2022
Petersen, M. & Nielsen, O.	Biochemical oxygen demand in intensive aquaculture environments	2022
Ramirez, C. & González, M.	pH dynamics and ammonia toxicity in fish culture systems	2022
Richardson, K. & Bennett, P.	Analytical methods for nitrogen compounds in aquaculture	2022
Rodriguez, A. & Martinez, B.	Ionic dynamics in intensive aquaculture systems	2022
Silva-Santos, M. & Pereira, N.	Best management practices in cage culture systems	2023
Stevenson, R. et al.	Standard methods for nutrient analysis in aquatic environments	2023
Sullivan, K. & Roberts, M.	Seasonal characterization of aquaculture environments	2023
Thompson, R. et al.	Water transparency effects on primary productivity in aquaculture	2022
Watanabe, M. & Cruz, P.	Environmental carrying capacity in tropical reservoirs	2022

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Wellington, J. & Parker, A.	Standardized methods for limnological characterization	2023
Wilson, H. & Chang, T.	Electrical conductivity patterns in intensive tilapia culture	2023
Yamamoto, K. & Sato, T.	Spatial distribution of physicochemical parameters in cage culture	2023
Yoshida, T. & Kim, S.	Digital monitoring systems in aquaculture: Precision and reliability	2023

Source: authorship

The table above presents the references selected for the literature review. Each of these works contributes significantly to the understanding of limnological parameters in tilapia production, offering diverse perspectives and approaches on the subject. The references were chosen based on criteria of relevance and topicality, ensuring that the analysis covers the main studies and discussions present in the academic literature.

CHALLENGES IN THE IMPLEMENTATION OF CAGE CULTIVATION SYSTEMS IN THE COREMAS-PB DAM: A CRITICAL ANALYSIS

The implementation of cage cultivation systems at the Coremas dam faces several challenges that need to be carefully considered to ensure the success and sustainability of the activity. Among the main obstacles, the need for significant initial investment in infrastructure stands out, including the net tanks themselves, monitoring equipment and feeding systems.

The technical training of producers represents another significant challenge. Proper system management requires specific knowledge about water quality, animal nutrition, health, and production management. The lack of specialized and continuous technical assistance can compromise the productive performance and economic viability of the enterprise.

Systematic monitoring of water quality parameters is a major operational challenge. The need for specific equipment and the regularity of the analyzes demand financial and human resources that are not always available to producers, especially smaller ones.

The management of fish feed represents a critical point of the system. The high cost of commercial feed, associated with the need for adequate storage and strict control of supply, directly impacts production costs and the profitability of the activity.

The commercialization of production also presents significant challenges. The need to establish efficient distribution channels, maintain regularity in supply and meet market requirements regarding product quality and standardization requires planning and organization on the part of producers.

The legal and regulatory aspects constitute another challenging point. Obtaining and maintaining environmental licenses, complying with sanitary standards and meeting the requirements of inspection agencies require considerable time and resources from producers.

The sanitary management of fish represents a constant challenge. Disease prevention and control in intensive care systems require permanent surveillance, appropriate prophylactic measures, and rapid interventions when necessary, requiring specific technical knowledge and appropriate resources.

The organization of producers in associations or cooperatives, although challenging, is fundamental to overcome many of the difficulties faced. Collective action can facilitate access to inputs, technologies, and markets, in addition to strengthening the sector's representativeness with public agencies and development institutions.

PROPOSALS FOR THE FUTURE OF AQUACULTURE IN CAGES AT THE COREMAS WEIR: PERSPECTIVES AND RECOMMENDATIONS

The sustainable development of aquaculture in cages at the Coremas dam requires the implementation of innovative strategies and technologies that can optimize production. The adoption of automated water quality monitoring systems, with real-time sensors and remote data transmission, will allow for more precise control of environmental parameters and faster responses to detected variations.

The implementation of continuous training programs for producers is fundamental for the future of the activity. The establishment of partnerships with research and extension institutions can provide the transfer of updated technologies and knowledge, contributing to the professionalization of the sector and improvement of production rates.

The development of specific rations for the cage system, with greater stability in the water and better use by fish, represents an important perspective for reducing production costs and minimizing environmental impacts. The use of alternative and local ingredients can contribute to the economic sustainability of the activity.

The organization of a structured production chain, including fish processing and processing units, will add value to the final product and expand the possibilities of commercialization. The development of differentiated products with greater added value can open new markets and improve the profitability of producers.

The implementation of specific environmental and quality certification programs for the production of cages can enhance the value of the product and ensure greater access to demanding markets. Production traceability and origin assurance are growing trends in the food market.

The establishment of an integrated production management system, including cost control, monitoring of zootechnical performance and analysis of economic indicators, will allow for a more professional and efficient management of enterprises. The use of specific software can facilitate this process.

The creation of a reference center in aquaculture in the region, with infrastructure for research, technological development and training, can boost the sustainable growth of the activity. This center could act as a hub for the dissemination of technologies and good production practices.

The development of a strategic plan for the sector, built in a participatory manner with all the actors involved, will establish clear guidelines for the orderly growth of the activity. This plan must contemplate technical, environmental, economic and social aspects, ensuring long-term sustainability.

FINAL CONSIDERATIONS

The study of the limnological characteristics of the tilapia cultivation system in cages at the Coremas-PB dam revealed predominantly favorable environmental conditions for aquaculture production. The physicochemical parameters analyzed were mostly within the ranges considered adequate for the development of the species, indicating the environmental viability of the production system.

The transparency of the water and the extension of the euphotic zone demonstrated favorable conditions for primary production and maintenance of adequate levels of dissolved oxygen. This aspect is particularly important in intensive systems, where water quality is directly related to the productive performance of fish.

The thermal profile of the reservoir was stable and within the optimal range for tilapia cultivation, favoring fish metabolism and feed efficiency. The thermal stability characteristic of tropical environments contributes significantly to the maintenance of adequate growing conditions throughout the year.

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The dynamics of nitrogen compounds, especially ammonium ion, revealed the need for special attention to feed management and stocking density. Continuous monitoring of these parameters is essential to prevent situations of stress and fish mortality.

The slightly acidic pH observed during the study favored the predominance of the non-toxic form of ammonia, reducing the risks of toxicity to fish. This aspect is particularly relevant in intensive systems, where the accumulation of nitrogenous compounds can compromise production.

The spatial analysis of the parameters evidenced the influence of the cages on the surrounding water quality, although without significantly compromising the characteristics of the aquatic environment. This result suggests that the carrying capacity of the reservoir is being respected at the current level of production.

The framing of the parameters analyzed in the standards established by CONAMA Resolution 357/2005 for Class 1 waters indicates the environmental sustainability of the activity. However, continuous monitoring is essential to maintain these conditions as production expands.

The implementation of adequate management practices, based on the systematic monitoring of water quality parameters, proved to be fundamental for the success of the crop. The adoption of these practices should be encouraged and disseminated among producers in the region.

The results obtained provide important subsidies for the planning and management of aquaculture activity in the reservoir. Establishing monitoring protocols and setting safe production limits are key to ensuring long-term sustainability.

Finally, it is recommended to continue the limnological studies in the reservoir, with an extension of the parameters analyzed and the monitoring period. The continuous generation of scientific data is essential to improve management practices and ensure the sustainable development of aquaculture in the region.

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