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Water characterization of Igarapés used in fish farming in Manaus and Iranduba, Amazonas, Brazil

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ABSTRACT
The objective was to study the impacts of the implementation of fish farming projects (fish breeding), the quality of water effluents from these enterprises, in upland streams on properties in the municipalities of Manaus and Iranduba. We chose to monitor some physical-chemical attributes such as turbidity, dissolved oxygen, chlorophyll-a, ammonia, nitrite, nitrate and phosphorus because they are able to establish a relationship between fish farming and the loss of environmental quality of water. For this study, 16 sample units were analyzed, with two collection points each, upstream and downstream in the fish farming enterprises in uplands of continuous land (continuous flow), in two different periods in the year 2016 and 2017. The main variables studied in the analysis stage of an aquatic ecosystem, including fishing grounds, they can be: water temperature, pH, turbidity, concentration of nutrients (nitrite, nitrate and ammonia, total phosphorus), dissolved oxygen, chlorophyll. There was no significant difference in temperature, dissolved oxygen, ammonia and nitrate. There was a significant difference for the depth, turbidity and nitrite parameters. There was a significant difference for phosphorus and pH and no difference was observed for chlorophyll-a. The analyzed parameters were sufficient to demonstrate that the fish farming activity in Igarapé alters turbidity, nitrite and phosphorus and pH. Based on these parameters, better control of water quality in fish farming in Igarapé is suggested as water flow and better quality of the feed offered to fish.

INTRODUCTION

In recent years, due to population growth combined with urban development, there has been a diversification of water uses in the Amazon region, generating an increase in the discharge of effluents and solid waste and the destruction of riparian forests, producing inadequate environmental conditions (SIQUEIRA, 2012). The population in the Amazon uses the water from streams for human consumption, animal feed, domestic use and mainly bathing in streams, in addition to streams the population frequents places close to rivers, waterfalls and even dams to enjoy primary contact recreation.

In the State of Amazonas, the use of water from rivers and streams for recreation of primary contact associated with the development of tourist activity is quite significant. Thus, knowing the water quality of a given water body to adapt it to its most varied uses, whether consumptive or non-consumptive, is an important task. Igarapés have an underestimated ecological, economic and cultural importance and are not included in most water resources and biodiversity management policies. In addition, igarapés provide vital resources for human populations, such as drinking water for their own consumption and for the livestock, irrigation of high-value crops, such as fruits and vegetables, fish for consumption and ornamental trade, and recreation areas (NUNES FILHO, 2018).

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According to Waltrick (2007), the Amazon region has fundamental characteristics for fish farming: the large extension of the Brazilian Amazon Basin; the warm climate all year round, with an amplitude of 3 to 4 ºC in the water bodies; and the wide variety of fish species in it, with highlights to the creation of the tambaqui (*Colossoma macropomum*), the matrinxã (*Brycon amazonicus*) and the pirarucu (*Arapaima gigas*).

The objective was to analyze the impact and the quality of the water upstream and downstream of the fish farming enterprises in Igarapés in Manaus and Iranduba, Amazonas.

MATERIAL AND METHOD

Characterization of Study Areas

16 properties were selected to assess the impact of fish farming in different locations in the rural area of the municipality of Manaus and Iranduba, both belonging to the State of Amazonas.

The studied areas are characterized, as they are located in the equatorial region and have a hot and humid climate, in addition to seasonal thermal amplitude of the order of 1-2 ºC, with average values of 27.9 ºC in September and 25.8 ºC in April, with an average rainfall of approximately 2300 mm per year in Manaus (FISCH et al., 1998).

The 16 (sixteen) selected properties/developments use the fish farming system in uplands of uplands, classified as being black waters, according to State Law No. 3785 of July 24, 2012, in addition to being called continuous flow systems by the fact that the areas have a sand substrate, black colored water with a depth varying between 50 cm and a maximum width of 3 m, where the first row of nurseries is supplied with water taken directly from the spring, whose outgoing water supplies the other nurseries.

Each enterprise carries out fish farming in igarapés channels using galvanized or plastic plastic screens, and wooden structure of the ripe rap type. The most cultivated species are tambaqui (*Colossoma macropodium*) and matrinxã (*Brycon amazonic*us), due to their high commercial value and also the ease in their creation as described by Waltrick (2007).

The study area is located in a region classified as humid tropical forest, with an average annual rainfall of around 2,200 mm, ranging from 1,900 to 2,500 mm, being formed by: Plateau Alto Forests, located at the highest levels; Plateau Low Forest with Campinaranas, found in slope regions, this being the most representative phytophysiognomy (GALUCH, 2007).

Water Sample Collection and Analysis

To assess the impacts of fish farming on the water quality of the streams, visits were made to 16 (sixteen) sample units, where collections were made in two different periods: August/2016 and July/2017. Each collection carried out in each sample unit was made approximately 10 meters upstream from the fish farming enterprises in streams and 10 meters downstream (after) the enterprise.

The water was collected at 50 cm depth in 2l polyethylene bottles, previously sterile and later conditioned in thermal containers until storage in a conventional refrigerator at 4ºC.

The concentrations of dissolved oxygen, temperature, and pH of the water were determined at the collection site as described below. Temperature (Temp.) - Performed with a thermometer inserted from the free surface of the water in the stream at a depth of 30 cm. Dissolved Oxygen (DO) - Dissolved oxygen was measured through on-site tests using a dissolved oxygen measurement kit (UNIKIT). Hydrogenionic Potential - The pH was obtained in the pH Test of the brand "Universal Indicator of Decisive Test Paper 1-14". Turbidity - A secchi disk was used using the centimeter scale. The concentrations of ammonia, nitrite, nitrate, chlorophyll-a and total phosphorus were determined at the EMBRAPA Pisciculture Laboratory in the Western Amazon. Ammonia - Total ammonia concentrations (NH_3^+ and NH_4^+) were determined by colorimetric method according to the Protocol for the determination of total ammonia Apha, 1998. The absorbances were obtained using a spectrophotometer by Amersham Pharmacia Biotech, model Novaspec II.

Nitrite and Nitrate - The determination of the concentration of nitrite (NO_2^-) by means of the Protocol (APHA, 1998), using a spectrophotometer from Amersham Pharmacia Biotech, model Novaspec II. Total Phosphorus - It was determined using two large steps: (1st) conversion of the phosphorus-containing compounds to the form of interest of dissolved orthophosphate and (2nd) colorimetric determination of that dissolved orthophosphate. By filtering the sample through a 0.45μm filtering membrane, the suspended and dissolved phosphorus forms can be separated; thus generating the forms of Soluble and Total Phosphorus, using the FIA star 5000 (Flow injection analysis) device from the FOSS Tecator brand. Chlorophyll-a - The methodology for the protocol for determining chlorophyll-a according to the NUSCH protocol, 1980.

The normality of the data was tested according to Kolmogorov-Smirnov, and when necessary transformed, using Neperian logarithm (Ln). Subsequently, the Students t test (5% significance) was used using the PAST program (HAMMER; HAPER, 2001) to assess water quality parameters (dependent variable) between upstream and downstream (categorical variable).

RESULTS AND DISCUSSION

The main variables studied in the analysis phase of an aquatic ecosystem, including fishing grounds, can be: water temperature, pH, turbidity, concentration of nutrients (nitrite, nitrate and ammonia, total phosphorus), dissolved oxygen, chlorophyll. There was no significant difference in temperature, dissolved oxygen, ammonia and nitrate. However, there was a significant difference for the depth, turbidity and nitrite parameters. In the present study, there were no differences in the average water temperatures between the sampling points. We conclude that in the two points collected upstream and downstream, fish farming did not change the temperature (Table 1). Leonardo et al. (2011) that the increase in temperature caused mortality in tilapia raised in reservoirs. This variable is directly related to vegetation cover, and more shaded environments, such as small water courses and springs tend to have lower temperatures than large rivers, lakes or dams, where a large part of the water surface is exposed to solar radiation (WALTRICK, 2007).

Table 1. Average values with standard deviation of the variable of water quality and depth parameters, evaluated in the waters collected downstream and upstream of fish farming located in the rural area of the municipality of Manaus and Iranduba, State of Amazonas, Brazil

	Temperature (°C)	Depth (cm)	Turbidity (cm)	OD (mg/L)	Ammonia (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)
Amount	27.87±0.95	81.25±14.80a	61.87±24.00a	10.25±1.34	0.22±0.14	9.87±2.50a	0.20±0.68
Downstream	27.87±0.95	88.75±16.68b	35.00±8.16b	10.25±1.34	0.21±0.11	12.12±3.00b	0.51±0.62
	P>0.05	P<0.05	P<0.05	P>0.05	P>0.05	P<0.05	P>0.05

In the column, values with the same letter do not differ from each other by the t test (P> 0.05).

Regarding the depth, a significant difference was observed in the depth upstream of the fish farming compared to the downstream. This greater depth upstream is due to the volume of water impounded that causes the bottom upstream to be removed

The water turbidity parameter was statistically significant at the collection point upstream than at the collection point downstream of fish farming. This greater turbidity is due to the remains of feed, feces and also suspended phytoplankton. The main responsible for water turbidity are suspended particles (biogenic and abiogenic) and to a lesser extent, dissolved compounds (ARRUDA et al., 2015). The turbidity of water in nurseries is associated with the presence of phytoplankton and, consequently, there is a great absorption of heat by the presence of this particulate material (TAVARES, 1995). According to Queiroz and Silveira (2006) the visibility of Secchi's disc from 40 to 80 cm is desirable in nurseries stocked with tambaqui and surubins.

Dissolved Oxygen in the present study, there were no significant differences in the means, when comparing the sampling points. The normal Dissolved Oxygen values are justified by the absence of organic matter and the low density of fish storage in the igarapé channel during the periods. According to CONAMA (2005), it establishes OD values between ≥ 5 mg/L O_2 as normal for Class 2, from Água Doce, therefore all sample units presented normal, stable results, consistent with the parameters indicated by the resolution. Adequate concentrations of dissolved oxygen are essential for maintaining aquatic life (ARRUDA, 2014).

The amount of Ammonia measured did not show any significant difference between the two points collected. Ammonia values are within CONAMA (2005), which establishes a value of 3.7 mg/L for total ammonia. Comparing the results with the works carried out by Waltrick (2007), the data presented by Amônia are similar to other studies and analyzes, also suggesting that fish farming activities in streams are not compromising the aquatic environment with high nutrient loads, of nitrogen origin. The largest source of ammonia in ponds is directly related to fish excreta, although they can result from the decomposition of organic matter. The degree of toxicity of ammonia is related to the chemical processes of water, which depends on pH and temperature (TAVARES, 1995).

There was a significant difference for phosphorus and pH and no difference was observed for chlorophyll-a (Table 2). The nitrate values were not statically significant and are in accordance with CONAMA (2005) establishes the value of 10 mg/L for Nitrate, a value far below those found in the two points studied. In comparison to another study by Waltrick (2007), they presented values below the resolution in fish farming in streams.

Nitrite averages were statistically significant at the downstream point compared to the upstream point. Nitrite is related to the biological activity in the decomposition of proteins contained in organic matter, and comes from the oxidation of NH_4^+ ammonium by Nitrosomonas bacteria and anaerobic reduction of non-ionized ammonia (NH_3). CONAMA (2005) establishes the value of 1.0 mg/L for Nitrite (NO_2^-), a value much higher than that found in all studied streams. One of the factors that may have caused the increase in the amount of Nitrite, may be the excess of feeding or the use of unbalanced rations in the listed period, since the reduction of the nutrients absorption of the fish can result in excess formation of organic matter and nutrients in production systems, with direct impacts on water quality, with an increase in phytoplankton, reduced water transparency and decreased dissolved oxygen at critical levels at dawn, thus compromising fish health (CYRINO et al., 2010) . Another factor that may have contributed to the increase in nitrite was the absence of a natural biological filter (HUNDLEY; NAVARRO, 2013).

Table 2. Average values with standard deviation of the variable phosphorus, Chlorophyll-a and pH in the evaluated samples of the waters collected downstream and upstream of fish farming located in the rural area of the municipality of Manaus and Iranduba, State of Amazonas, Brazil

	Phosphor (mg/L)	Chlorophyll -a (ug/l)	pH
Amount	0.13±0.32a	1.38±1.74	6.125±0.80a
Downstream	0.38±0.37b	1.39±1.48	6.375±0.71b
	P<0.07	P>0.05	P<0.05

In the column, values with the same letter do not differ by the t test (P> 0.05)

The phosphorus values were statistically higher for the collection point. CONAMA (2005) establishes for the Total Phosphorus parameter the maximum value in this water class of 0.05 mg/L.

Only in unit P4 the parameter Phosphorus would be in accordance with what was established in the CONAMA (2005). This increase in phosphorus is due to the increase in the rest of feed and feces in the fish farm (Table 2).

Information presented in the literature reports that only 25 to 30% of the nitrogen and phosphorus supplied in diets and fertilizers will be used to form the biomass of fish and shrimp, with the rest of the nitrogen and phosphorus being retained in the sediment of the ponds or eliminated. by the effluent (CASILLAS-HERNÁNDEZ et al., 2006).

There was no significant difference between the points, in all the streams studied, the values of Chlorophyll-a were below CONAMA (2005).

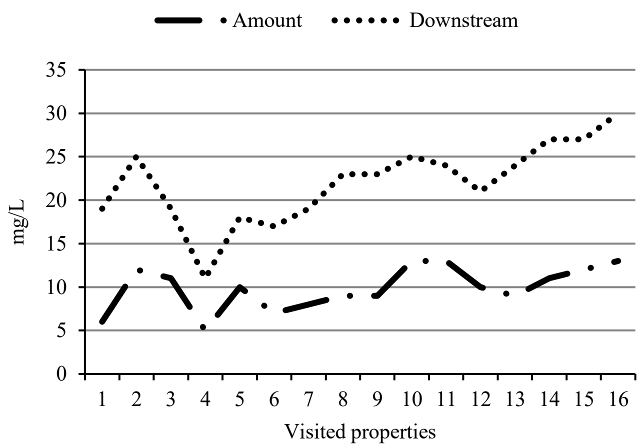

Figure 1. Amount of nitrite (mg/l) downstream and upstream of streams in the sixteen properties visited located in the rural area of the municipality of Manaus and Iranduba, State of Amazonas, Brazil.

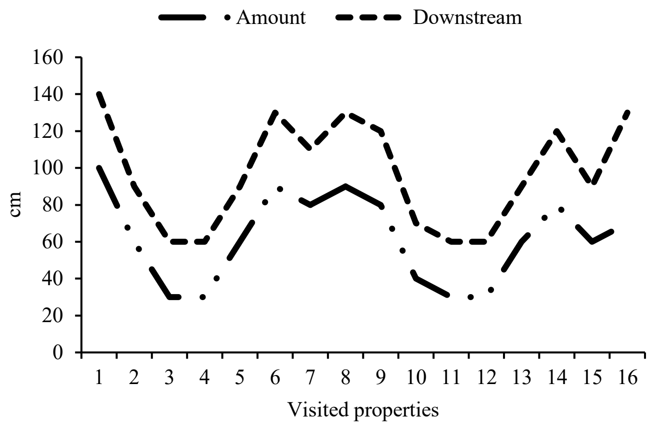

Figure 2. Amount of turbidity (cm) downstream and upstream of streams in the sixteen properties visited located in the rural area of the municipality of Manaus and Iranduba, State of Amazonas, Brazil.

Despite the values above the recommendation of CONAMA (2005), it establishes pH values between 6.0 to 9.0 as normal for Class 2, of Água Doce. The downstream collection point obtained significantly higher pH values than the upstream collection point, mainly due to the deposited organic matter and also to the use of carbon dioxide by photosynthesis. Mercante et al. (2007), also noted that the pH increases during the day due to the removal of carbon dioxide by use in photosynthesis.

Other studies like de Ribeiro et al. (2005), in which they measured the quality of water and sediment in fish farms in the state of Paraná, the results show that the pH value was the characteristic of less variation. It is important to emphasize that pH is a variable that changes depending on the primary productivity of the ecosystem (ARRUDA, 2014).

CONCLUSION

The parameters demonstrate that the fish farming activity in Igarapé alters turbidity, nitrite and phosphorus and pH. Based on these parameters, better control of water quality in fish farming in Igarapé is suggested as water flow and better quality of the feed offered to fish.

REFERENCE

ARRUDA, N. M. B.; RIZZI, N. E.; MIRANDA, T. L. G. Análise multivariada na avaliação da qualidade de água do reservatório de Foz do Areia, estado do Paraná. Revista Brasileira de Ciências Ambientais, 26-37. 2014. 10.5327/Z2176-947820159514 .

CONAMA, Conselho Nacional do Meio Ambiente. RESOLUÇÃO CONAMA Nº 357, DE 17 DE MARÇO DE 2005**.** Brasília. Disponível: <http://www.mma.gov.br/port/conama/index.cfm> Acesso: 01 Set. 2016.

CYRINO, J. E. P.; BICUDO, A. J. A.; SADO, R. Y.; BORGHESI, R.; DAIRIKI, J. K. A Piscicultura e o ambiente: o uso de alimentos ambientalmente corretos em piscicultura. Revista Brasileira Zootecnia, 39:68-87. 2010. 10.1590/S1516-35982010001300009

FISCH, G.; MARENGO, J. A.; NOBRE, C. A. Uma revisão geral sobre o clima da Amazônia**.** Revista Acta Amazônica, 28(2):101-101,1998. 10.1590/1809-43921998282126.

GALUCH, A. V. Adaptação de um Índice de Integridade Biótica para Igarapés da Amazônia Central, com Base em Atributos Ecológicos da Comunidade de Peixe**.** Dissertação, Universidade Federal do Amazonas, 2007.

HAMMER, Ø.; HARPER, D. A. T. Past: Paleontological statistics software package for education and data analysis. Palaeontologia Electronica. 4(1):9 pp. 2001.

LEONARDO, A. F.; CORRÊA, C. F.; BACCARIN, A. E. Qualidade da água de um reservatório submetido à criação de tilápias em tanques-rede, no sul de São Paulo, Brasil. Boletim Instituto de Pesca, 37(4): 341-354, 2011.

MERCANTE, C. T. J.; MARTINS, Y. K.; CARMO, C.; OSTI J. S.; PINTO, C. S. R.; TUCCI, M. A. Qualidade da água em viveiro de Tilápia do Nilo (*Oreochromis niloticus*): caracterização diurna de variáveis físicas, químicas e biológicas, Bioikos, 21(2):79-88. 2007.

NUNES FILHO, M. S. Caracterização da água de Igarapés utilizados na piscicultura em Manaus e Iranduba-AM. Dissertação de Mestrado em Ciências Ambientais, Universidade de Brasília. 2018. 47 p.

QUEIROZ, J. F.; SILVEIRA, M. P. Recomendações Práticas para Melhorar a Qualidade da Água e dos Efluentes dos Viveiros de Aquicultura. EMBRAPA: Jaguariúna, 2006.

RIBEIRO, R. P.; SENGIK, E.; BARRERO, N. M. L.; CIOLA, A. L.; MOREIRA, H. L. M.; SUSSEL, F. R.; JUNIOR, E. L.; BENITES, C. Coleta de amostras de sedimentos em viveiros de piscicultura. Acta Science Animal Science, 27, (3),399-403. 2005.

SILVA, T. C. S. E.; BOAS, J. Q. V. A nova natureza jurídica da água e suas consequências em face da outorga de direito de uso de recursos hídricos. Revista Eletrônica do Curso de Direito da UFSM. 8, 1. 2013. 10.5902/198136948853

SIQUEIRA, G. W.; APRILE, F.; MIGUÉIS, A. M. Diagnóstico da qualidade da água do rio parauapebas (Pará – Brasil). Revista Acta Amazonica 42(3): 413–422. 2012. 10.1590/S0044-59672012000300014

TAVARES, L. H. S. Influencia da luz, manejo e tempo de residencia sobre algumas varia veis limnologicas em um viveiro de piscicultura. Biotemas, 8, 1, 61-71. 1995. 10.5007/%25x.

WALTRICK, V. P. Avaliação ambiental de igarapés influenciados pela criação de matrinxã (*Brycon amazonicus*) e por peixes ornamentais em Manaus–AM. Dissertação, Universidade Federal do Amazonas: Manaus, 2007.