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Water quality in six sequentially disposed fishponds with continuous water flow

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ABSTRACT. This study evaluated selected limnological variables in inlet water in six sequentially distributed semi-intensive fishponds. Data were collected during 15 consecutive days in three distinct grow-out periods (May, October and January). Only phosphorus and pH varied among sites and periods ($p < 0.01$); the opposite ($p > 0.05$) occurred in the cases of nitrite and dissolved oxygen. No variation was reported with regard to dissolved oxygen, conductivity, alkalinity, free CO_2, bicarbonate, chlorophyll-*a*, nitrite and ammonia did not vary throughout the period ($p > 0.05$). In May, or rather, the final grow-out period, the fishponds displayed high concentrations, mainly in nitrogen compounds. As from fishpond 3, the inlet water contained high levels of nutrients. The water is passed from pond to pond, evidencing the need for management practices adequate to the specific conditions of each pond. Water quality should be monitored more frequently during high grow-out period when food addition is more intense. Thereafter, more care should be taken, as highest phosphorus concentrations occurred in May.

Key words: water flow, water quality, fishpond, sequential distribution.

RESUMO. Qualidade da água em seis viveiros de piscicultura com fluxo contínuo de água em disposição seqüencial. Este estudo verificou algumas variáveis limnológicas na água de entrada em seis viveiros de criação semi-intensiva de peixes com distribuição sequencial de água em três períodos distintos de engorda de peixes (maio, outubro e janeiro), durante 15 dias consecutivos em cada período. Somente o fósforo e pH variaram entre os pontos e períodos de coleta ($p < 0,01$) e o oposto ($p > 0,05$) ocorreu com nitrito e oxigênio dissolvido. Ao longo do período não foram significativas ($p > 0,05$) as variáveis como oxigênio dissolvido, condutividade, alcalinidade, CO_2 livre, bicarbonato, clorofila-*a*, nitrito e amônia. No mês de maio, correspondente ao final do período de engorda de peixes, os viveiros apresentaram em geral maiores concentrações, principalmente, em relação aos compostos nitrogenados. A partir do viveiro 3 a água de entrada apresentou teores mais elevados de nutrientes em função da passagem direta de água de um viveiro para o outro, evidenciando a necessidade de práticas de manejo voltadas para as condições específicas de cada viveiro. A qualidade da água dos viveiros deve ser monitorada mais frequentemente, durante o período de engorda dos peixes, porém, após este período cuidados devem ser tomados visto que em maio foram observadas as maiores concentrações de fósforo na água.

Palavras-chave: fluxo de água, qualidade de água, viveiros, distribuição sequencial.

Introduction

Fishponds and fish breeding tanks are dynamic ecosystems, characterized by shallowness and continuous water flow, which directly affect the limnological variables throughout the day. Water flow is extremely important due to its transport of nutrients, microorganisms, addition of oxygen to the medium and organic material. In fact, ration is added daily to the water as fish feed and thus the fertilization of the water medium increases. Further, accumulated detritus on the bottom of the fishpond may be removed and relocated to the next pond. Introduced nutrients and those produced in the fishponds are used for organic production whilst others remain in solution or suspended in the water or even absorbed by the soil (BOYD, 2003).

Since the ponds receive a daily load of ration plus the ration originating from the previous pond, this fact may promote an increase in the water nutrient load. However, depending on flow rate and pond depth, continuous water flow may present a concentrating or diluting effect on the materials contained in the water (SIPAÚBA-TAVARES et al., 2003).

The grow-out period in the southeast region of Brazil extends during the summer season, from November to March, when temperatures fluctuate with subsequent higher growth rates and yield. During this period, the amount of feed supplied as well as stock density per pond may exceed the capacity of such systems, which causes deterioration of water quality (MACEDO; SIPAÚBA-TAVARES, 2005).

Appropriate management, knowledge and control of the ecological, biological and socio-economical aspects of aquaculture are important to obtain and maintain proper water quality that guarantees high biomass production. The above is mandatory to clarify issues related to water quality and minimize the negative impact caused by this activity. In fact, environmental concerns and limitation in water availability are some of the most important factors in aquaculture (METAXA et al., 2006).

The present work was conducted to monitor the physical and chemical parameters in the inlet water of six semi-intensive fishponds with continuous water flow, distributed sequentially during three distinct grow-out periods, before (October), during (January) and after (May) the grow-out fish period.

Material and methods

Study area and fish management

The current investigation was carried out at Aquaculture Center (21°15'S; 48°18'W), 'Universidade Estadual Paulista', Jaboticabal, São Paulo State, Brazil, in the inlet water of six ponds, with continuous water flow, provided 5% daily rate of rearing volume, during the months of May, October, and January. The six fishponds (P_1 – P_6) were laid out sequentially, or rather water from one fishpond flowed directly into another, while it received water from other tanks and smaller parallel fishponds, (with exception of P_1 - water supply), used by the nutrition, frog culture, fish breeding and shrimp culture sectors. The surface areas of the six ponds are 3,800 m^2 (P_1); 2,306 m^2 (P_2); 9,231 m^2 (P_3); 4,351 m^2 (P_4); 5,671 m^2 (P_5); and 2,507 m^2 (P_6). The ponds presented average depth varying from 1.41 m (P_1) to 1.87 m (P_3) (SIPAÚBA-TAVARES et al., 1991).

The first pond (P_1) receives water directly from a well (W), and actually functions as a water supply for the other ponds. Food management of P_2, P_4, P_5, and P_6, comprises 10 to 12 kg of commercial ration containing corn, soybean and meal fish with a daily addition of 28% of crude protein. However, the largest pond, P_3, receives 20 kg day^{-1} of the same ration. In addition to the water outlet for the subsequent ponds, P_2, P_3 and P_4 have another outlet. Pond P_2 has pipes to directly dispose of water into the frog culture ponds, while water is pumped in pond P_3 to irrigate the agricultural fields belonging to the University. In the case of pond P_4, the water is distributed by pipes to irrigate hydroponic systems and into three more fishponds outside the area.

The first pond (P_1) is totally covered by floating, emergent, and sub-emergent aquatic macrophyte, represented mainly by *Eichhornia crassipes*, *Typha* sp., *Egeria* sp., *Ludwigia elegan*, *Myriophyllum aquaticum* and *Alternanthera philoxeroides*. The second pond (P_2) is covered by floating aquatic macrophyte (just the first 30 m), represented by *Eichhornia crassipes* and *Salvinia* sp., and populated with adult *Brycon amazonicus* (matrinxã), *Pseudoplatystoma corruscans* (pintado), and *Piaractus mesopotamicus* (pacu), a total of 1 fish m^{-2}. The third pond (P_3) acts as grow-out pond populated with species such as *Oreochromis niloticus* (tilapia), *Brycon amazonicus*, *Piaractus mesopotamicus*, and *Colossoma macropomum* (tambaqui), a total of 4 adult fish m^{-2}. The fourth pond (P_4) has a total of 20 fish m^{-2}, populated with *Oreochromis niloticus*, *Colossoma macropomum*, *Cyprinus carpio* (carpa) and *Pseudoplatystoma corruscans*. The fifth pond (P_5) is a sports fish pond for the recreation of University employees. It is populated with *Oreochromis niloticus*, *Piaractus mesopotamicus*, *Cyprinus carpio*, *Cichla ocelaris* (tucunaré), and *Leporinus obtusidens* (piauçu), a total of 12 adult fish m^{-2}. Finally, P_6 acts as a grow-out pond populated with *Cyprinus carpio*, *Colossoma macropomum*, *Oreochromis niloticus* and *Brycon orbignyanus* (piracanjuba), totaling 6 adult fish m^{-2}.

Physical and chemical parameters

Water was always measured at 9:00 am, during 15 consecutive days on each month (May, October and January) at the inlet water, with a Van Dorn bottle (5 L). A total of seven sampling sites were assigned: W = well, and P_1 to P_6 = ponds 1 to 6. Temperature, pH, electrical conductivity and dissolved oxygen were measured 'in situ' by a Horiba U 10 water quality checker. The nutrients were determined by spectrometer, according to Golterman et al. (1978) and Koroleff (1976) for nitrite, nitrate, total-phosphorus, and ammonia. The wind speed was measured by an anemometer Lutron AM-4201, whereas chlorophyll-*a* was measured according to Nush (1980). The alkalinity and inorganic carbon were determined according to Mackereth et al. (1978).

Statistical analysis

Two-way nested ANOVA was applied to physical and chemical parameters in order to compare sites (P_1 – P_6 and W) and periods (May, October and January) (SOKAL; ROHLF, 1981). Significance level was $p < 0.05$.

Results and discussion

The limnological variables tended to fluctuate during the period under analysis. Actually they depended on the water flow and the management employed. Since the water goes directly from one pond to another without prior treatment, a tendency exists to accumulate certain elements in the medium. However, the system dynamics and the management practiced in pond 4 (P_4), or rather, where the water is partially conducted to the plantation nearby, somewhat decreased the organic and inorganic material carried to the next sequential ponds (P_5 and P_6).

A two-level nested Anova demonstrated variation in the limnological variables analyzed comparing the sites (spatial variation) and periods (temporal variation). Limnological variables pH and total phosphorus varied ($p < 0.01$) among sites (W, P_1-P_6) and periods (months); the opposite was reported for dissolved oxygen and nitrite ($p > 0.01$).

Although temperature did not vary among sites owing to their being geographically very close to one another, it varied according to the period ($p < 0.01$). Actually, the season affected variations; the same occurred with the wind ($p < 0.05$) variable, since it is highly associated with the climate (Table 1). Daily variation in water temperature that did not exceed 4°C provided good conditions for freshwater culture. The wind varying from 1.31 to 4.32, 2.15 to 4.8, and 1.45 to 2.56 km h^{-1}, respectively in May, October and January (Figures 1 and 2).

The inlet water in the ponds was well oxygenated and revealed average concentrations above 4.6 mg L^{-1}. The highest dissolved oxygen concentrations were observed at P_3, during May, with 10.3 mg L^{-1}. The inlet water in site P_3 presented adequate oxygenation, varying from 5.6 to 10.3 mg L^{-1} during the period under analysis. Water flow from P_2 to P_3 was a sharp inclination, thus causing high water oxygenation. Actually it is a good way of introducing more oxygenated water into the fishponds when water flows from one pond to another without previous treatment (Figure 1).

Table 1. Results of two-way nested Anova.

Variables	F (Spatial variation)	F (Temporal variation)
Temperature	0.50ns	35.90**
pH	37.70**	26.70**
Dissolved oxygen	1.03ns	1.90ns
Conductivity	14.70**	2.80ns
Alkalinity	12.96**	0.31ns
Free CO_2	3.60*	1.90ns
Bicarbonate	12.37**	0.23ns
Wind speed	2.50ns	10.32*
Chlorophyll-*a*	13.10**	1.90ns
Total phosphorus	221.70**	37.90**
Nitrite	1.10ns	2.20ns
Nitrate	0.76ns	5.39*
Ammonia	6.10**	1.80ns

*p < 0.05; **p < 0.01; ns - not significant.

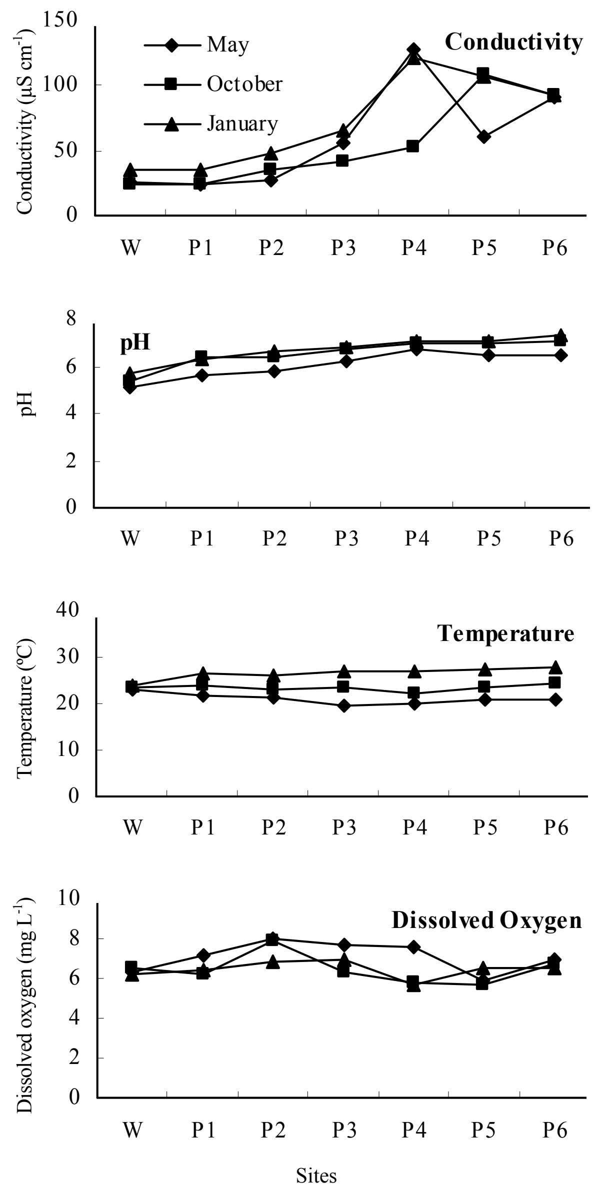

Figure 1. Mean variation (15 consecutive collection days) of conductivity (µS cm^{-1}), pH, temperature (°C), and dissolved oxygen (mg L^{-1}), in fishponds during the period, where: W = well, and P_1-P_6 = ponds 1 to 6.

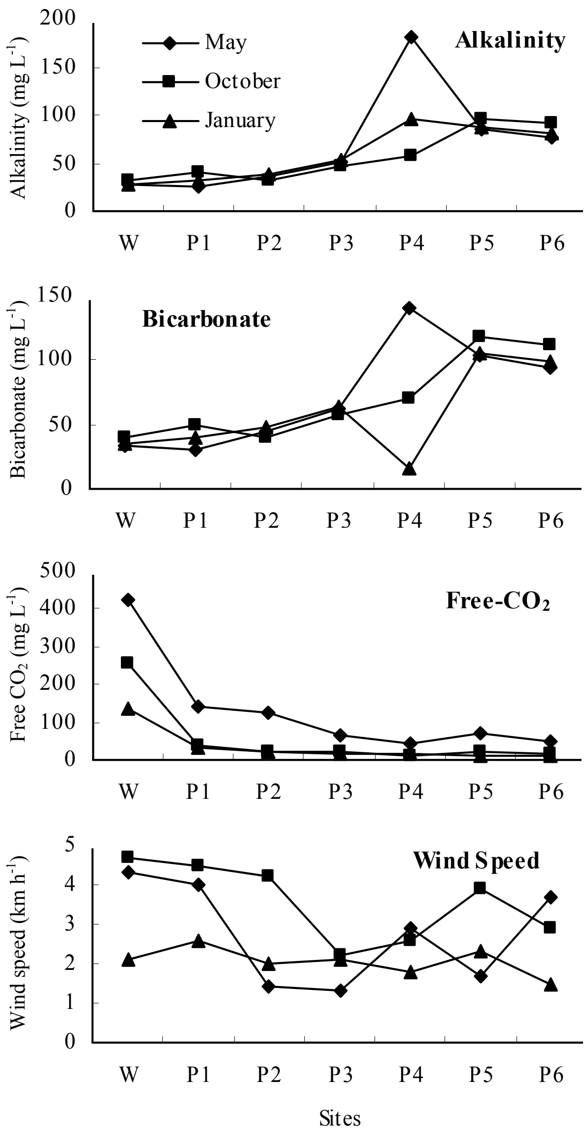

Figure 2. Mean variation (15 consecutive collection days) of alkalinity (mg L^{-1}), bicarbonate (mg L^{-1}), free CO_2 (mg L^{-1}) and wind speed (km h^{-1}) in the fishponds during the period under analysis, where P_1 = well, and P_2-P_6= ponds 1 to 6.

Concentration of dissolved oxygen should be kept above 4 to 5 mg L^{-1} (SIPAÚBA-TAVARES, 1995) for excellent fish growth. In fact, such pattern has been reported in the fishpond under analysis (Figure 1).

In general, during May the pH was acidic, ranging from 4.92 to 6.80. During the study period the well (W) was acidic, ranging from 4.92 to 5.90. In October and in January, pH was slightly acidic in ponds 1 to 3, ranging from 5.25 to 7.04. However, pH varied from 6.77 to 7.46 in P_4 (Figure 1).

Rise in pH is generally caused by the photosynthesis process which, through CO_2 consumption, causes an increase in pH rates. As a rule, shallow artificial systems with a continuous water flow may occasionally cause small variations in pH and alkalinity rates (SIPAÚBA-TAVARES et al., 1998). In fishponds, CO_2 and H^+ from nitrifying bacteria and other acids produced by the organism decrease pH rate (SIPAÚBA-TAVARES et al., 2003).

Although conductivity tended to increase from P_4 to P_5, in general the highest conductivity was reported in P_4 in May (126.6 μS cm^{-1}) and January (121.7 μS cm^{-1}). In October, P_5 showed higher rates (109.3 μS cm^{-1}) (Figure 1).

Fishponds with continuous water flow receive large amounts of allochthonous material, such as rations and manure, and, consequently, have rates above 100 μS cm^{-1}. The fishponds are environments with great management requirements. In fact, such conductivity is associated with accumulative effect of the current caused by the water's continuous flow and consequently to the short residence time (SIPAÚBA-TAVARES et al., 2007). Currently higher rates of conductivity were reported in fishponds (P_4-P_5) which are directly affected by organic and inorganic, as occurred in the case of P_4 which receives water originating from ponds P_1, P_2, and P_3 and from the frog culture, whose daily wash causes a great amount of organic matter being introduced into the pond. Pond P_5 receives water from the shrimp culture from which it receives a large amount of nutrients (Figure 1).

Water from the well (W) was acid and free CO_2 concentrations were higher than rates of the other sites (P_1 and P_6), which varied from 137.6 to 426.4 mg L^{-1}. In the sites P_1 to P_6, bicarbonate rates were generally highest than those of free CO_2, with the exception of those in May at sites P_1, P_2, and P_3 (Figure 2).

Alkalinity was higher from site P_4 and the highest mean concentration was observed during May at site P_4, with 181.67 mg L^{-1}. Alkalinity and bicarbonate rates were significantly different ($p < 0.01$) only between sites (Table 1, Figure 2).

Although alkalinity rates are above those recommended for fish culture (20 to 40 mg L^{-1} of Ca CO_3), the continuous water flow may have affected oscillations since higher concentration have been reported in the last ponds (P_4-P_6).

Nutrients concentrations and conductivity rates may have been affected by fish stock and species density in the fishponds since these factors directly affected the limnology of shallow artificial systems (SIPAÚBA-TAVARES et al., 1998).

Only nitrite was not significant ($p > 0.05$) either during the periods and at the sites. On the other hand, nitrate and ammonia behaved differently, or rather, the former was different ($p < 0.05$) only for the period; the latter was different ($p < 0.01$) only for sites (Table 1).

The nitrification is not inhibited at high dissolved oxygen concentrations leading to complete nitrification with decrease nitrite concentration in the water (MA et al., 2008). In our study, high concentration of dissolved oxygen (> 4.6 mg L^{-1}), favored nitrate predominance and nitrite decrease in the ponds under analysis.

In general, the lowest concentrations of nitrogen compounds were observed in January, or rather, during the rainy period and at the highest effect of water current. Nitrate and ammonia were predominant and varied between 87.2 and 1,243.7µg L^{-1}, and between 9.8 and 416.7 µg L^{-1}, respectively, during the experiment period (Figure 3).

Continuous water flow in ponds contributed to the loss of part of the nitrogenous compounds, whereas the movement caused by the entrance and exit of water caused a higher nitrification of the system with less nitrite concentrations when compared with nitrate rates. As a rule, highest ammonia and nitrate accumulation was reported in the last fishponds (P_4-P_6) (Figure 3).

Ponds with water renewal tend to have nitrite concentrations above 37 µg L^{-1}; in non-renewal water concentrations are very low and show the absorption of this element by the phytoplankton and the activities of nitrifying bacteria in the environment (SIPAÚBA-TAVARES et al., 2000). Nitrite has generally remained below 20 µg L^{-1} in fishponds, with the exception of peaks during May at P_5 and P_6 (93.7 and 73.4 µg L^{-1}, respectively). Total phosphorus was significantly different ($p < 0.01$) between spatial (sites) and temporal (periods) variations (Table 1). Highest total phosphorus concentrations were observed in May with highest peak in P_3 (245.5 µg L^{-1}), keeping concentration above 138 µg L^{-1} (Figure 3). Lowest concentration of this nutrient during January and October, generally, bellow 100 µg L^{-1}, may be due to the fact that nutrient is easily chelated in the sediment. Discharge controls phosphorus dynamics in the environment with regard to its absorption in the sediment (AVNIMELECH, 1998).

There are physical, chemical and biological forces influencing the different total phosphorus components (SINDILARIU et al., 2008). Total phosphorus is removed primarily by cation exchange reactions with the substrate and algae community, even though climate factors such as heavy rainfall (January) may affect the availability of this nutrient in the water (SIPAÚBA-TAVARES et al., 2007).

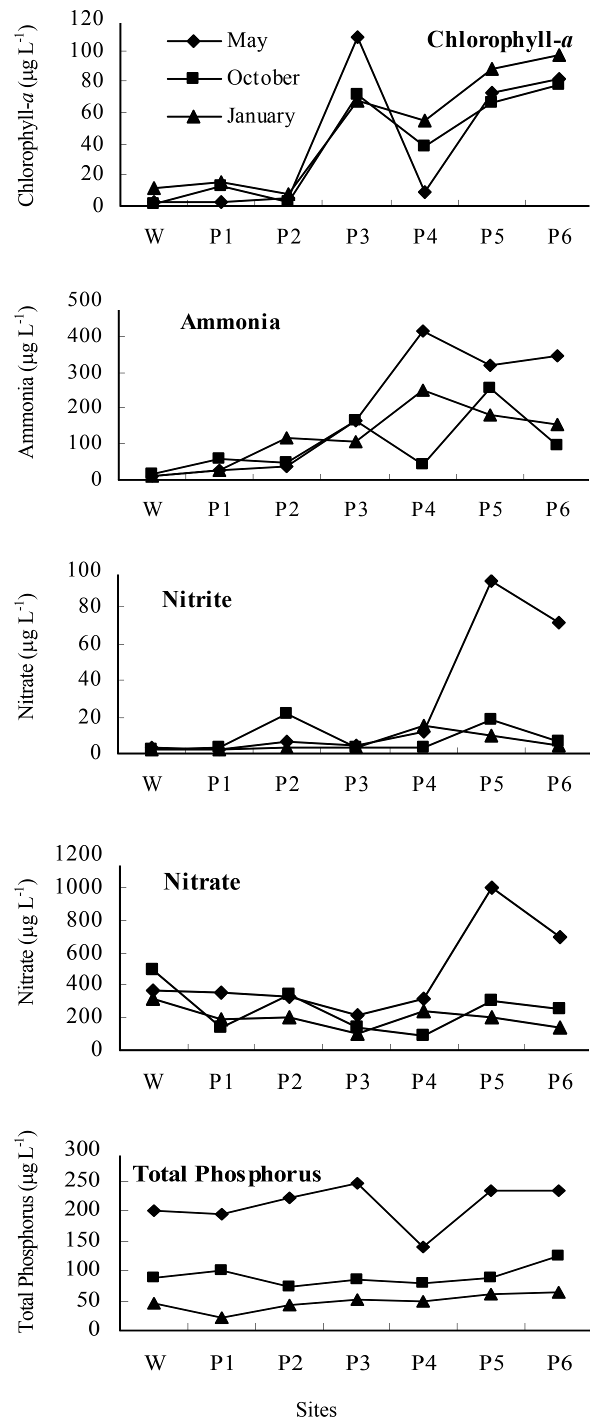

Figure 3. Mean variations (15 consecutive collection days) of chlorophyll-*a*, ammonia, nitrite, nitrate, and total phosphorus, (µg L^{-1}) in fishponds during the period, where W = well, and P_1-P_6 = ponds 1 to 6.

Although no significant differences were observed ($p > 0.05$) between periods with regard to chlorophyll-*a*, it tended to increase as from pond P_3 ($p < 0.05$). The highest and lowest concentrations of chlorophyll-*a* were 252.96 µg L^{-1} (P_3) and 0.28 µg L^{-1} (W) (Figure 3).

Chlorophyll-*a* concentration is directly related to continuous water flow and management (feed) which determine higher or less availability of nutrients in the water which, in turn, may cause or not an increase in algae biomass (SIPAÚBA-TAVARES, 1995).

May (final grow-out period) presented in general, the highest values for limnological variables. Nutrients, inorganic carbon compounds and alkalinity showed higher concentrations in the water column due to the accumulation of rations added to the fishponds during grow-out fish period (November – March) (Figures 2 and 3).

Whereas water quality is the key to a successful aquaculture activity, water supply is of paramount importance to maintain good farming conditions. In the current study, the well (W) that supplied water to pond P_1 contained a reasonable nutrient concentration, which indicated a possible contribution to the subsequent fishponds. This was probably due to the fact that around the area there were different agricultural crops which integrated the University's experimental research.

When compared to other sites (P_2-P_6), the inlet water in P_1 generally had low concentrations of analyzed variables. It received water directly from well (W), which supplies the other fishponds (P_2 to P_6). Pond P_1 has a water surface rich in floating, emergent and sub-emergent aquatic macrophytes, acting as a natural biofilter and, consequently, improving the quality of the water flowing to pond P_2.

Sipaúba-Tavares et al. (2003) verified that the inlet water, after passing through the floating macrophyte located in the first 30 meters, presented reduced nitrite, total-phosphorus, orthophosphate, conductivity, alkalinity, and inorganic carbon.

The sequential distribution of the ponds and high allochthonous materials from pond P_4 influenced some limnological variables in pond P_5. The tendency to increase limnological variable concentrations from pond P_4 onwards showed the need to treat the water before pond P_4 and P_5. Another management practice employed in these ponds was the emptying of the ponds for harvesting. This procedure is not appropriate since it releases a great part of the nutrients on the sediment into the water column. Emptying and filling pond P_5 for harvesting prior to the start of current investigation may have contributed towards the re-suspension of the sediment, since nutrients, chlorophyll-a and conductivity rates were higher in this pond.

When water is drained directly from one pond to another, it may affect the characteristics of subsequent fishponds. It is thus recommended that partial emptying of the fishpond, with approximate 10% of water left in the system (BOYD; QUEIROZ, 2001).

The grow-out fish period (January) did not present serious problems. In fact, the heavy rains that occurred during January diluted the material contained in the ponds. Since fishponds are shallow, the rain and the wind homogenized the water by favoring aeration in the ponds (SIPAÚBA-TAVARES et al., 2007).

The maintenance of good water quality boils down to a good product on the market. Since the water is passed from one pond to another without previous treatment, the need for adequate management practices to the specific conditions of each pond is evident. Thus the inlet water in each fishpond should either have a inclination similar to that in pond P_2 to P_3 or the wetland should be set in an appropriate place. Emptying the ponds for harvesting should be reevaluated, since it disturbs the sediments and damages the water quality. Therefore, the technique of maintaining about 10% of the water volume and emptying slowly the pond may be adopted. Water quality should be monitored more frequently, not merely during the fish grow-out period when food addition is more intense, but also just after this period, owing to the high nutrient concentration reported during May.

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References

AVINIMELECH, Y. Minimal discharge from intensive fishponds. **World Aquaculture**, v. 29, n. 1, p. 32-33, 1998.

BOYD, C. E. Guidelines for aquaculture effluent management at the farm-level. **Aquaculture**, v. 226, n. 1-4, p. 101-112, 2003.

BOYD, C. E.; QUEIROZ, J. Feasibility of retention structure settling basins, and best management practices in effluent regulation for Alabama channel catfish farming. **Fisheries Science**, v. 9, n. 2, p. 43-67, 2001.

GOLTERMAN, H. L.; CLYMO, R. S.; OHNSTAD, M. A. M. **Methods for physical and chemical analysis of fresh water**. 2nd ed. Oxford: Blackwell Scientific Publication, 1978. (IBP Handbook, n. 8).

KOROLEFF, F. Determination of nutrients. In: GRASSHOF, E.; KREMLING, E. (Org.). **Methods of sea water analysis**. German: Verlag Chemie Wenhein, 1976. p. 117-181.

MA, W. K.; BEDARD-HAUGHN, A.; SICILIANO, S. D.; FARELL, R. E. Relationship between nitrifier and denitrifier community composition and abundance in predicting nitrous oxide emissions from ephemeral wetland soils. **Soil Biology and Biochemistry**, v. 40, n. 5, p. 1114-1123, 2008.

MACEDO, C. F.; SIPAÚBA-TAVARES, L. H. Variações de nutrientes e estado trófico em viveiros seqüenciais de criação de peixes. **Acta Scientarium. Animal Sciences**, v. 27, n. 3, p. 405-411, 2005.

MACKERETH, F. J. H.; HERON, J.; TALLING, F. J. **Water analysis**: some revision methods for limnologists. Oxford: Titus Wilson and Sons, 1978. (Scientific publication, n. 36).

METAXA, L.; DEVILLER, G.; PAGAND, P.; ALLIAUMEC, C.; CASELLAS, C.; BLANCHETON, J. P. High rate algal pond treatment for water reuse in a marine fish recirculation system: Water purification and fish health. **Aquaculture**, v. 252, n. 1, p. 92-101, 2006.

NUSH, E. A. Comparison of different methods for chlorophyll and phaeopigment determination. **Archiv für Hydrobiologie**, v. 14, n. 1, p. 14-36, 1980.

SINDILARIU, P. D.; WOLTER, C.; REITER, R. Constructed wetland as a treatment method for effluents from intensive trout farms. **Aquaculture**, v. 277, n. 3-4, p. 179-184, 2008.

SIPAÚBA-TAVARES, L. H. Influência da luz, manejo e tempo de residência sobre algumas variáveis limnológicas em um viveiro de piscicultura. **Biotemas**, v. 8, n. 4, p. 61-71, 1995.

SIPAÚBA-TAVARES, L. H.; OLIVEIRA, D. S.; CASTAGNOLLI, M. C.; BACHION, M. A.; DURIGAN, J. G. Estudo batimétrico e morfométrico em represas. **Ciência Zootécnica**, v. 6, n. 1, p. 10-12, 1991.

SIPAÚBA-TAVARES, L. H.; GOMIDE, F. B.; OLIVERA, A. Dynamic limnological variable studied in two fish ponds. **Brazilian Journal of Ecology**, v. 2, n. 1, p. 90-96, 1998.

SIPAÚBA-TAVARES, L. H.; YOSHIDA, C. E.; BRAGA, F. M. S. Tilapia Aquaculture. In: FITZGIMNOUS, S.; CARVALHO, J. (Org.). **Effects of continuous water exchange on the limnology of tilapia (Oreochromis niloticus) culture tanks**. Rio de Janeiro: SRG Gráfica e Editora, 2000. p. 279-287.

SIPAÚBA-TAVARES, L. H.; BARROS, A. F.; BRAGA, F. M. S. Effect of floating macrophyte cover on the water quality in fishpond. **Acta Scientarium. Animal Sciences**, v. 25, n. 1, p. 12-24, 2003.

SIPAÚBA-TAVARES, L. H.; GUARIGLIA, C. S. T.; BRAGA, F. M. S. Effects of rainfall on water quality in six sequentially disposed fishponds with continuous water flow. **Brazilian Journal of Biology**, v. 67, n. 4, p. 643-649, 2007.

SOKAL, R. R.; ROHLF, F. J. **Biometry**: the principles and practice of statistics in biological research. San Francisco: W. H. Freeman and Company, 1981.

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