Water quality in fee-fishing ponds located in the metropolitan region of São Paulo city, Brazil: an analysis of the eutrophication process.

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ABSTRACT: Water quality in fee-fishing ponds located in the Metropolitan region São Paulo city, Brazil: an analysis of the eutrophication process. **This study intended to evaluate the eutrophication process of fee-fishing ponds located in the Metropolitan region of São Paulo city. Samples from 30 of such fishing ponds were taken during the dry (winter) and rainy (summer) seasons in order to measure the following variables: phosphorous, water transparency and chlorophyll-*a*. The modified Carlson trophic state index was applied to evaluate the "trophic status". Considering both seasons, the total phosphorous concentrations ranged from 0.03 to 0.35 mg/L, and were 10 times higher than the recommendated values of the National Council of Environment (CONAMA, 1986). Reactive soluble phosphorus varied from 0.01 to 0.05 mg/L; chlorophyll-*a* from 0.001 to 0.43 mg/L and water transparency from 0.10 to 0.80 m. The analysis of variance showed that there were no significant differences between the two seasons for the variables, suggesting that management strategies have more influence on the system dynamics rather than seasonal variations. In general, the high phosphorous load derived from ration distribution increased the phytoplankton biomass, indicating an intense eutrophication process in these sites. Concerning the Trophic State Index, the fee-fishing ponds were classified as eutrophic or hyper-eutrophic environments. Nitrogen and phosphorus intake control by means of the preliminary knowledge of the quantity and quality of the introduced ration, bait intake, as well as water flow are necessary for maintaining water quality. The control of fish densities, especially the smaller ones may contribute to reduce the internal phosphorus release. Finally, from the water quality point of view, the fee-fishing ponds shall be seen through an approach different from the pisciculture management practices. It means that this activity deals neither with fish production nor with their reproduction, thus invalidating some management practices, such as plankton production increase and high protein content ration.**

Key-words: **fee-fishing; eutrophication; Modified Trophic State Index; water quality; freshwater.**

RESUMO: Qualidade da água em pesque-pagues da Região Metropolitana de São Paulo, Brasil: avaliação do processo de eutrofização. **Avaliou-se o processo de eutrofização de pesque-pagues localizados na região metropolitana da cidade de São Paulo, o qual constou da amostragem de 30 pesqueiros no período seco (inverno) e chuvoso (verão) das variáveis fósforo, transparência da água e clorofila *a*. Aos resultados aplicou-se o Índice de Estado Trófico de Carlson modificado. Considerando-se ambos os períodos, as concentrações de fósforo total variaram entre 0,03 a 0,35 mg.L^{-1}, valores que se encontram na ordem de até 10 vezes acima do recomendado pela Resolução CONAMA (1986). O fósforo solúvel reativo variou entre 0,01 a 0,05 mg.L^{-1}; a clorofila *a* entre 0,001 a 0,43 mg.L^{-1} e a transparência da água de 0,10 a 0,80 m. A análise de variância não mostrou diferenças significativas entre as duas épocas do ano, sugerindo que as estratégias de manejo exercem maior influência sobre a dinâmica dos sistemas do que propriamente as variações sazonais. De maneira geral, a elevada carga de fósforo advinda do arraçoamento aumentou a biomassa fitoplanctônica, evidênciando intenso processo de eutrofização. O Índice de Estado Trófico, classificou os ambientes como eutróficos a hiper-eutróficos. Um controle da entrada de nitrogênio e fósforo através do conhecimento prévio da quantidade e qualidade da ração intoduzida, da entrada de ceva, bem como do fluxo de água são fundamentais para a manutenção da qualidade da água. O controle da densidade de peixes principalmente de menor tamanho poderia contribuir para a diminuição do aporte**

interno de fósforo. Do ponto de vista da qualidade da água os pesque-pague devem ser vistos através de um enfoque distinto das práticas de manejo empregadas na piscicultura.
Palavras-chave: **pesque-pague; eutrofização; Índice de Estado Trófico Modificado; qualidade da água; água doce.**

Introduction

Following the current trends observed on first world countries, the Brazilian rural space, especially on the Central-South region, which features a higher demographic concentration and intensive agriculture, has been experiencing important changes that go beyond agriculture. Such rural space began featuring non-agricultural activities, among them sporting fishing (fish-and-pay and pay-and-fish) (Graziano-Silva, 1999).

From the early 90s, the Brazilian aquaculture began featuring a faster development rhythm than the one observed till then. The fee-fishing ponds quickly spread, enabling that cultivated fishes were sold on a faster, efficient and feasible way for the producer (Proença, 1998). Today, the fee-fishing ponds constitute a fishing possibility closer to large urban areas and metropolitan regions. According to Kitamura et al. (1999) the few information available enable to infer that the highest potential demand regarding sporting fishing in Brazil is located on the Southeastern and Southern regions, especially close to urban centers. Such demand is related to several factors, such as the search for leisure and tourism services in natural environments, the capture pressure over the aquatic fauna, and the reduction of its stocks on locations traditionally visited by fishermen. The appearance and the expansion of fee-fishing ponds in the State of São Paulo have been occurring together with the growing development of pisciculture in Brazil. Kitamura et al. (1999) have made an economical and environmental assessment of sporting fishing on the Piracicaba River Basin, SP and noticed that most of the enterprises started during the 90s. Venturieri (2002) working on the São Paulo Metropolitan Region and 14 administrative regions registered 1000 fee-fishing ponds on a database, out of which 250 locations were visited.

The maintenance of water quality in pisciculture crawls is a basic requirement for the economical success of the productive system. This quality can be affected by several factors, such as the water supply spring and the feeding management (Eler et al. 2001). Even today, the concern about maintaining a good water quality in pisciculture-related activities is almost non-existent. This quality can be considered through different aspects, such as assuring a better production efficiency and better fish and water sanitary conditions; assuring the users' health and the environment preservation.

Today, the eutrophication process is one of the major questions to be dealt when water quality is considered (Tundisi, 2003). Nutrient enrichment (especially nitrogen and phosphorous) leads to the uncontrolled growth of algae which may result in several problems, such as lack of oxygen in water, and consequently fish mortality. The urgent need of monitoring the fish production and sporting fishing systems was highlighted by Eler et al. (2001), which warned that fishes from such systems may work as a new route of human intoxication due to direct and cumulative action toxins, such as the microcystins, produced by cyanobacteria.

The site chosen for the development of the present study was the Alto Tietê hydrographic basin region, which comprises an area around 5,900 km^2, with wide urbanization on the hydrographic network formed by 35 cities. It encompasses the City of São Paulo and most of the cities belonging to the São Paulo Metropolitan Region, resulting in the large urban and social-economical dynamics complexity (FUSP, 2000). Such complexity justified the choice of the location because the unordered growth of this activity could bring serious environmental damages to the sub-basins which serve several cities, besides financial losses to the owners. Therefore, an eutrophication process assessment of the pisciculture activity, comprising the sporting fishing in the São Paulo Metropolitan Region, contributes for the proposal of an adequate management of such enterprises, thus assuring a better hydraulic resource management and a sustainable growth.

Material and methods

Study area and limnological characteristics:

The Alto Tietê hydrographic basin is formed mainly by the Tietê, Pinheiros and Tamanduateí rivers, and comprises the reservoirs of Ribeirão do Carmo, Ponte Nova, Paraitinga, Biritiba, Jundiaí, Taiaçupeba, Billings, Edgard de Souza, Paiva Castro, Pirapora, Rio das Pedras and Guarapiranga (FUSP, 2000).

The fishing ponds were located primarily in the Alto Tietê basin, including the cities of Santa Isabel, Arujá, Mairiporã, Santana do Parnaíba, São Lourenço da Serra, Itapecerica da Serra, São Paulo (district of Santo Amaro), Mauá, Suzano, Ribeirão Pires, São Bernardo, Cotia, Mogi das Cruzes and Vargem Grande Paulista.

Thirty fishing ponds were sampled during the dry (September / 2001) and rainy seasons (February / 2002). A questionnaire-based inquiry showed that most of such fishing ponds didn't have information about the stock density, which generally ranged from 0.5 to 1.0 kg/m² (Fapesp, 2002). Tilapia (*Oreochromis niloticus* and *Tilapia rendalli*) were the most abundant species in the fishing ponds (Esteves et al., 2003).

Water samples from each establishment were collected using a Van Dorn bottle (5L) in surface of water column.

The phosphorus was determined in the laboratory according to the techniques described in Strickland & Parsons (1960); the chlorophyll-*a* and phaeophytin were determined by ethanol according Wetzel & Likens (1991) and Marker et al. (1980); water transparency was determined using a Secchi disk. The Modified Carlson Index (MCI), described in Toledo Jr. et al. (1983), and recommended by Mercante & Tucci-Moura (1999) was applied to the results obtained for phosphorus, chlorophyll-*a* and water transparency, in order to assess the trophic levels of the studied environments.

The evaluation of water quality in the studied ponds was based on the recommendations of the National Council of Environment (CONAMA, 1986) for class 2, that classifies the water that will be used in the natural and/or intensive rearing (aquaculture) of aquatic organisms bred for human consumption. In case parameters were not included in the CONAMA Resolution (1986), specialized studies were used as reference.

Data analysis

A one way ANOVA was used to compare data among seasons of the year.

Results

Tab. I and Fig. 1 to 5 present total phosphorus, orthophosphate, chlorophyll-*a*, phaeophytin, water transparency and Carlson Index obtained at each pond. Considering the periods of winter and summer, the concentrations of total phosphorus ranged from 0.040 to 0.300mg/L and from 0.030 to 0.350mg/L respectively, results that are up to 10 times higher than the ones suggested by CONAMA Resolution for class 2. The concentrations of soluble reactive phosphate phosphorus varied between 0.007 and 0.032mg/L (winter) and 0.002 and 0.050mg/L (summer). Phytoplanktonic biomass varied from 0.001 to 0.430mg/L of chlorophyll-*a* in summer and 0.001 to 0.170mg/L in winter. The concentrations of phaeophytin fluctuated between 0.015 and 0.400mg/L (winter) and between 0.016 and 0.260mg/L (summer). Water transparency ranged from 0.10 to 0.60m (winter) and from 0.10 to 0.80m (summer). Based on the recommendations of the CONAMA Resolution, 100% of the establishments showed figures above the proposed ones for orthophosphate and total phosphorus; 67% for chlorophyll-*a* and 40% for water transparency in winter. In summer, 57% of the ponds exceeded the suggested values for soluble reactive phosphate phosphorus; 100% for total phosphorus; 53% for chlorophyll-*a* and 50% for water transparency. According to the Modified Carlson Index (MCI) 100% of the ponds were classified as eutrophic or hyper-eutrophic in both periods. The statistical analysis (ANOVA), showed that the variables studied did not show meaningful differences between the two periods.

Table I: **$P\text{-}PO_4^{-3}$ Phosphorus ($P\text{-}PO4^{3}$ and TP; $mg.L^{-1}$) and chlorophyll *a* (CHL; $mg.L^{-1}$) concentrations, water transparency (SD; m) and modified Carlson trophic state index (MCI) in 30 recreational fisheries of the metropolitan area of São Paulo (Winter 2001 - W and Summer 2002 - S).**

Variables	$P\text{-}PO_4^{-3}$	$P\text{-}PO_4$	PT	PT	CHL	CHL	SD	SD	MCI	MCI
Seasons / Fisheries	W	S	W	S	W	S	W	S	W	S
1	0.01	0.00	0.06	0.05	0.05	0.01	0.40	0.50	57	57
2	0.01	0.00	0.06	0.06	0.04	0.01	0.50	0.70	68	56
3	0.01	0.01	0.07	0.06	0.04	0.00	0.10	0.35	63	50
4	0.01	0.01	0.06	0.05	0.04	0.01	0.40	0.20	57	59
5	0.02	0.00	0.19	0.10	0.09	0.01	0.40	0.40	68	61
6	0.01	0.00	0.06	0.06	0.02	0.00	0.60	0.30	55	54
7	0.01	0.00	0.11	0.11	0.01	0.06	0.30	0.30	58	68
8	0.01	0.00	0.09	0.08	0.03	0.02	0.40	0.50	60	60
9	0.01	0.01	0.09	0.08	0.01	0.10	0.50	0.50	56	67
10	0.03	0.01	0.17	0.35	0.04	0.01	0.25	0.20	69	70
11	0.01	0.00	0.12	0.08	0.03	0.02	0.60	0.80	59	59
12	0.01	0.00	0.07	0.08	0.01	0.04	0.50	0.40	53	64
13	0.02	0.00	0.15	0.13	0.07	0.06	0.40	0.25	65	69
14	0.01	0.00	0.18	0.18	0.05	0.01	0.50	0.25	63	66
15	0.02	0.02	0.09	0.05	0.04	0.00	0.50	0.55	44	52
16	0.03	0.01	0.12	0.17	0.11	0.04	0.20	0.20	70	70
17	0.01	0.01	0.04	0.07	0.00	0.01	0.50	0.60	62	57
18	0.01	0.01	0.06	0.03	0.03	0.02	0.40	0.40	57	55
19	0.01	0.02	0.06	0.07	0.00	0.05	0.30	0.40	49	64
20	0.02	0.01	0.16	0.10	0.04	0.07	0.40	0.40	65	67
21	0.02	0.02	0.14	0.14	0.03	0.02	0.30	0.40	65	65
22	0.01	0.00	0.04	0.05	0.01	0.13	0.50	0.50	49	66
23	0.01	0.02	0.12	0.17	0.02	0.04	0.10	0.15	63	71
24	0.01	0.05	0.17	0.13	0.10	0.00	0.40	0.20	66	59
25	0.01	0.01	0.12	0.08	0.07	0.05	0.30	0.40	63	65
26	0.03	0.01	0.16	0.16	0.07	0.03	0.20	0.20	69	69
27	0.01	0.01	0.12	0.14	0.05	0.05	0.40	0.30	61	69
28	0.02	0.02	0.23	0.19	0.17	0.09	0.30	0.30	71	73
29	0.02	0.01	0.12	0.09	0.05	0.02	0.30	0.30	64	63
30	0.01	0.01	0.28	0.23	0.13	0.43	0.30	0.25	67	81
maximum	0.01	0.00	0.04	0.03	0.00	0.00	0.10	0.15	71	81
mean	0.01	0.01	0.12	0.11	0.05	0.05	0.38	0.37	61	64
minimum	0.03	0.05	0.28	0.35	0.17	0.43	0.60	0.80	44	50

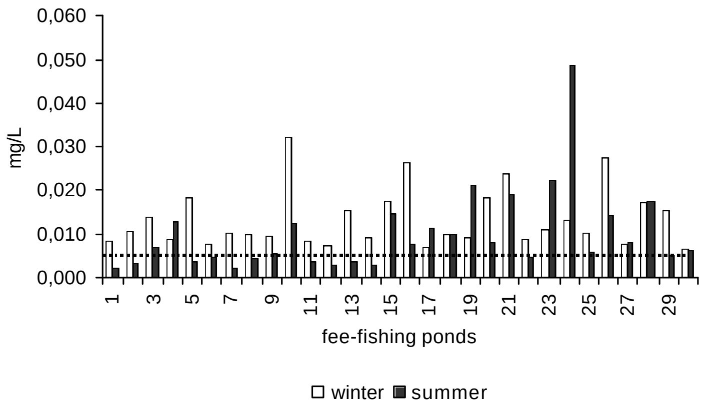

Figure 1: Soluble reactive phosphate phosphorus ($mg.L^{-1}$) in 30 fee-fishing ponds (winter and summer) located in the metropolitan region of São Paulo, SP - Brazil. The line shows the limits recommended in literature (£ 0.0004 $mg.L^{-1}$ $P\text{-}PO_4^{-3}$) .

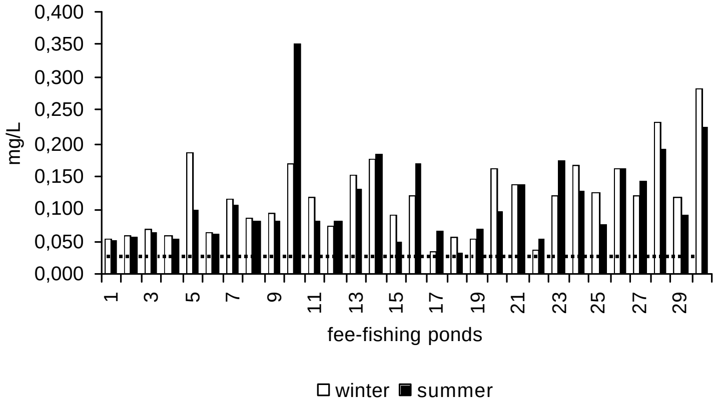

Figure 2: Total phosphorus (mg.L-1) in 30 fee-fishing ponds (winter and summer) located in the metropolitan region of São Paulo, SP - Brazil. The line shows the limits recommended in CONAMA 20/86 (£ 0.025 mg.L-1PT).

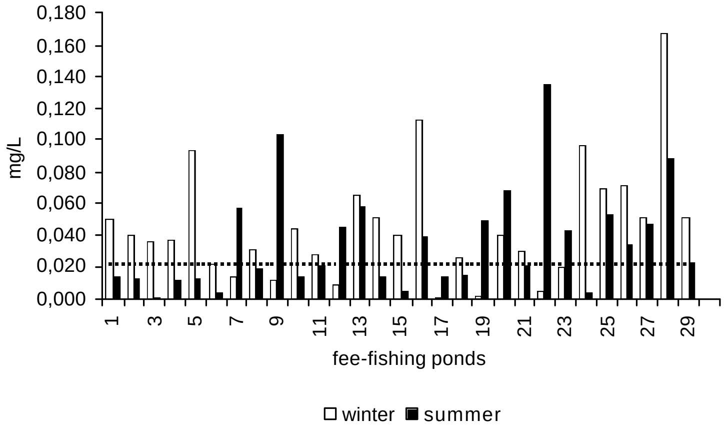

Figure 3: Chlorophyll a (mg.L-1) in 30 fee-fishing ponds (winter and summer) located in the metropolitan region of São Paulo, SP - Brazil. The line shows the limits recommended in literature (£ 0.025 mg.L-1).

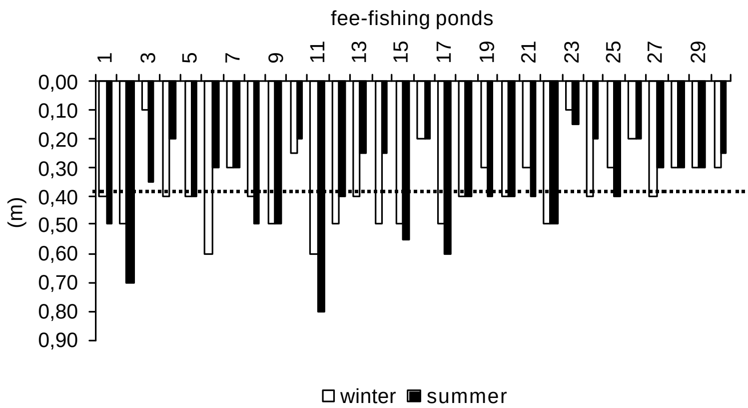

Figure 4: Secchi Disk in 30 fee-fishing ponds (winter and summer) located in the metropolitan region of São Paulo, SP - Brazil. The line shows the limits recommended in literature (³ 0.40 m).

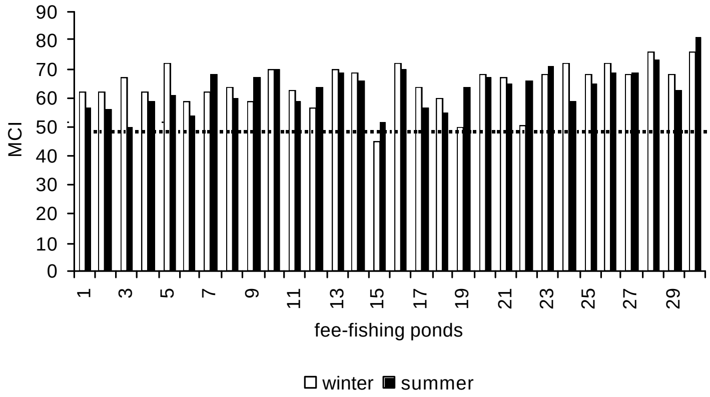

Figure 5: **Modified Carlson Index in 30 fee-fishing ponds (winter and summer) located in the metropolitan region of São Paulo, SP - Brazil. The line shows the limits recommended in literature (MCI £ 50)**

Discussion

In pisciculture, one of the main aspects to be considered refers to nitrogen and phosphorous input, coming from several autochthonous or allochthonous sources which results in an increase in the primary productivity causing, in many cases, the water quality deterioration of these systems. This process of artificial enrichment is called eutrophication, being anoxia one of its main effects, which causes death of fishes and invertebrate animals, the appearance of algae and the uncontrolled growth of other water plants and the release of toxic substances by certain species of cyanobacteria (UNEP, 2001). Therefore, the nutrient cycling and its relationship with biotic factors are extremely important for maintaining water quality in pisciculture as a basic requirement for the economical success of the productive system. On the present study, high concentrations of phosphorous and nitrogen as well as phytoplankton biomass were obtained. Such high concentration may be related to several factors, among them, the nitrogen and phosphorous intake from ration. Ration distribution was practiced by 76.7 % of fishing pond owners, and the ration amount ranged from 0 to 4 g/m^2/day (Fapesp, 2002). However, other factors should be considered, as follows: ration remains; fine powder released from pellets; bait intake and phosphorous excretion rate. According to Smith (1998) algae flourishing, especially cyanobacteria, is a result of nitrogen and phosphorous availability resulting from non-consumed ration remains. According to Kibria et al. (1998) the fine powder being released from ration pellets and falling directly into water column also contributes for increasing the nutrients. Drapcho & Brune (2000) also indicated that other factors may increase the nutrient concentration in water and, consequently, cooperate with the primary production increase; among them can be considered: non-consumed ration remains and the system carbon intake via zooplankton, bacteria and fish breathing. Some fish species, such as tilapia contribute for increasing nutrient cycling and maintaining the internal release. During laboratory tests Pereira & Ribeiro-Filho (2003) working with tilapias from Paranoá Lake (Brasília, DF), noticed that the excretion rate of larger fishes was lower than the one observed for smaller fishes, considering the same biomass. This could have occurred in the present study, where several locations have been identified with high densities of small-sized tilapias (Fapesp, 2003). Also as a consequence of the eutrophication process, Eler et al. (2001) associated the mortality of matrinxã and pacu fishes with *Anabaena spiroides* and *Microcystis aeruginosa* blooms in fee-fishing ponds (Descalvado, São Paulo, Brazil),. The results of the water physical and chemical variables and chlorophyll-*a* indicated low water transparency, oxygenated environment, pH equal to 7.0, chlorophyll-*a* content 1.5 mg/L and total nitrogen and total phosphorous contents:

8.0 and 0.4 mg/L, respectively. On Fig. 1 to 5, high phosphorous, and chlorophyll-*a* concentrations and Carlson Index can be checked, characterizing eutrophic and hyper-eutrophic environments. The low water transparency (Fig. 4) confirms such results indicating light attenuation by the phytoplankton community and by suspended particles, such as sands and clays.

Assad & Bursztyn (2000) state that the fish ponds may become unfeasible as a consequence of eutrophication.

The high values of phytoplankton biomass and low transparency values found in the ponds may be explained by the management strategies employed, which include ration distribution by the pond owners (76,7%) as well as the use of fish baits by the fishermen, associated to low water flow, especially during the dry season (Fapesp, 2002). Kitamura et al. (1999) studying fishing ponds in the Piracicaba basin found similar results, once 72% of the owners allow the fishermen to use the fish baits. The authors also observed that the majority of sites presented water transparency below 0.20m. They concluded that, in general, the quality of the water used in recreational fisheries is poor, and that although many problems result from inadequate management, some of them can be attributed to the quality of the water used.

One of the several aspects of management that could be changed for the improvement of water quality is the fact that, in general, there is no production in the fishing ponds; the provisions are given by suppliers and the animals are fully grown when they arrive at the properties. Thus, the policy of promoting the increase of phytoplankton productivity should be reconsidered because it would decrease the use of manure and/or ration, avoiding waste and decay of water quality due to uncontrolled development of algae. Another factor which would help water quality improvement is increasing water flow. Our results suggest that inadequate management associated to low water flow is the main factors that explain the deteriorated water conditions. However, other factors may also contribute to the eutrophication process as the use of fertilizers and the presence of crops nearby the lakes. The manure can be carried to the water of the ponds, collaborating in the eutrophication of the environments.

Finally, the achieved results have shown that a nitrogen and phosphorus intake control by means of the preliminary knowledge of the quantity and quality of the introduced ration, bait intake, as well as water flow (retention time control) are basic for maintaining water quality. The knowledge and control of fish densities, especially the smaller ones such as young tilapias may contribute to reduce the internal phosphorous release. Finally, from the water quality point of view, the fee-fishing ponds shall be seen through an approach different from the pisciculture management practices. It means that this activity deals neither with fish production nor with their reproduction, thus invalidating some management practices, commonly used in psciculture, such as plankton production increase and high protein content ration.

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References

Assad, L.T. & Burstzyn M. 2000. Aqüicultura Sustentável. In: Valenti,W.C. Aqüicultura no Brasil – Bases para um desenvolvimento sustentável. CNPq, Ministério da Ciência e Tecnologia, Brasília. p.33-70.

CONSELHO NACIONAL DO MEIO AMBIENTE – CONAMA. Resolução n. 020, de 18 de junho de 1986. Classificação das águas doces, salobras e salinas do Território Nacional. Disponível em: <http://www.lei.adv.br/020-86.htm>. Acesso em: 12 mar. 2002.

Drapcho,C.M. & Brune, D.E. 2000. The partitioned aquaculture system: impact of design and environmental parameters on algal productivity and photosynthetic oxygen production. Aquacult. Eng., 21:151-168.

Eler, M.N. Ceccarelli, P.S., Bufon, AG.M. & Espindola, E.L.G. 2001. Mortandade de peixes (matrinxã, *Brycon cephalus*, e pacu, *Piaractus mesopotamicus*) associada a uma floração de cianobactérias em pesque-pague, município de Descalvado, Estado de São Paulo, Brasil. Bol. Téc. CEPTA, 14:35-45.

Esteves, K.E. & Ishikawa, C.M. 2003. Management practices in fee-fishing ponds of the metropolitan region of São Paulo, SP, Brazil. Books of Abstracts World Aquaculture, Salvador. p.234.

FAPESP. 2002. Diagnóstico ecológico-sanitário de pesqueiros da região metropolitana de São Paulo. Relatório parcial. 144p.

FAPESP. 2003. Diagnóstico ecológico-sanitário de pesqueiros da região metropolitana de São Paulo. Relatório parcial. 160p.

FUSP. 2000. Plano da Bacia do Alto Tietê relatório de situação dos recursos hídricos: Revisão I. FUSP, Comitê da Bacia Hidrográfica do Alto Tietê. São Paulo.

Graziano-Silva, J. 1999. O novo rural brasileiro. Instituto de Economia, Unicamp, Campinas.

Kitamura, P.C., Lopes, R.B. Castro Jr., F.G. & Queiroz, J.F. 1999. Avaliação ambiental e econômica dos lagos de pesca esportiva na bacia do Rio Piracicaba. Bol. Industr. Anim., 56:95-107.

Kibria, G., Nugeogoda, D., Lam, P. & Fairlclough, R. 1998 Can nitrogen pollution from aquaculture be reduced? Naga, the ICLARM Quaterly, January-March: 17-25.

Marker, A.F.H., Nusch, H., Rai, H. & Riemann, B. 1980. The measurement of photosynthetic pigments in freshwaters and standardization of methods: conclusion and recommendations. Arch. Hydrobiol. Beih., 14:91-106.

Mercante, C.T.J. & Tucci-Moura, A. 1999. Comparação entre os índices de Carlson e de Carlson modificado aplicados a dois ambientes aquáticos subtropicais, São Paulo, SP. Acta Limnol. Brasiliensia, 11(1):1-14.

Pereira, J.M. & Ribeiro Filho, R.A. 2003. O ciclo do fósforo e seus efeitos em reservatórios e viveiros de piscicultura e da introdução de espécies exóticas nas Bacias Hidrográficas. NEEA/CRHEA, Itirapina/SP. Resumos, p.12.

Proença, C.E.M.1998. Legislação aquícola. Panorama da Aqüicultura, 48:35-36.

Strickland, J.D.H. & Parsons, T.R. 1960. A mannual of sea water analysis. Bull. Fish. Res. Board Can., 125:1-185.

Smith, D.W. 1998. Phytoplankton and catfish culture: a review. Aquaculture, 74:167-189.

Toledo Jr., A.P., Talarico, M., Chinez, S.J. & Agudo, E.G. 1983. A aplicação de modelos simplificados para a avaliação e processo de eutrofização em lagos e reservatórios tropicais. In: Anais do 12° Congresso Brasileiro de Engenharia Sanitária, Engevix, Rio de Janeiro, p.1-34.

Tundisi. J.G. 2003. Água no século XXI: Enfrentando a escassez. RiMa, IIE, São Carlos. 284p.

UNEP. 2001. Planejamento e gerenciamento de lagos e represas: uma abordagem integrada ao problema de eutrofização. RiMa, São Carlos. 385p.

Venturieri, R. 2002 Pesque-pague no Estado de São Paulo: vetor desenvolvimento da psicultura e opção de turismo e lazer. Eco Associação para Estudos do Ambiente, São Paulo. 168p.

Wetzel, R. G. & Likens, G.E. 1991. Limnological analyses. 2.ed. Springer-Verlag, New York. 391p.

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