Efficiency evaluation of polishing ponds operating as wastewater biological treatment process and rearing fish tank in an Integrated Biosystems Wastewater Treatment Plant

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Abstract This study aimed to evaluate the effectiveness of a polishing pond operating as a post-treatment effluent from biodigestor, biofilter, constructed wetlands and algae tank, and as rearing fish tank in an Integrated Biosystems Wastewater Treatment Plant. The polishing pond has 700 m^2 area, depth of 0.70 m and has an average flow of 0.58 L / s. A monitoring program was carried out from October 2007 to May 2008 and the evaluation of the tank was accomplished through the parameters: suspended solids, BOD_5, COD, COD_f, thermotolerant coliform and phytoplanktonic microalgae. The rearing fish tank presented low efficiency on removal of organic matter (BOD_5 = 27.2%). The high concentration of suspended solids are influenced by the increased amount of microalgae present in the tank. This treatment system showed a poor performance in removing coliforms, reducing of 1 to 2 logarithmic units. It was verified the predominance of chlorophytes in the polishing pond, indicating that a favorable environment for the fish rearing, however the occurrence of four genera of cyanobacteria toxic strains in Brazil, reflects the contamination potential by cyanotoxins, in case of water for fish farming.
Keywords Phytoplankton; polishing ponds; Rearing fish tank; wastewater treatment

INTRODUCTION

One of the major concerns in the sanitary area is domestic wastewater. The discharge of unnatural wastewater in water bodies may cause serious problems to water quality resources and puts in risk the domestic water supply. Among the existing wastewater treatment methods, the stabilization ponds, due to its simplicity and operational stability, has achieved wide acceptance in several countries, particularly in tropical regions. This systems present cost, simplicity, operational stability and high efficiency (MARA & PEARSON, 1987 apud van HAANDEL, 2001).

The wastewater has been worldwide used in several areas of aquaculture systems, especially in the rearing fish tank (FELIZATTO and SOUZA, 2000). According to von Sperling (2002), the stabilization pond produces effluent with ideal quality for fishing crops. However, according to Bastos et al. (2003) the additional removal of suspended solids and COD promoted by the fishs is still very debated, because some authors reported an effective removal of these parameters, on the other hand, while others citing it may contribute to its elevation, increasing to the suspension of solids.

The phytoplankton community, as the first trophic level, contributes substantially to the total primary production and may be the main food source for animals in the water column and sediment. In a polishing pond, the metabolic activity of aerobic bacteria, which decompose organic matter, release nutrients to be uptake by the phytoplankton, which play a fundamental role in maintaining the characteristic of aerobic environment.

This work presents an evaluation of the monitoring program of a polishing pond, known as the Rearing Fish Tank, operating in an Integrated Biosystems Wastewater Treatment Plant – Caxixe

WTP, which receive domestic wastewater from the community of Dordenone Village, located in Alto Caxixe, Venda Nova do Imigrante,ES, Brazil.

METHODS

The study was carried out from October 2007 to May 2008. The Caxixe WTP is contemplates a preliminary treatment, two chinese biodigestor working in parallel, an anaerobic filter, a constructed wetland, algae tank, rearing fish tank and macrophytes tank. It was designed to treat wastewater produced by 1.000 inhabitants, and nowadays operates receiving wastewater generated by the population of approximately 302 inhabitants with an average entry flow of 0.58 L / s. The rearing fish tank presents the characteristics of a polishing pond, with 0.70 m depth and an area of 750.0 m^2 area.The affluent of the pond has already passed by other biological treatment processes. However, still contains considerable amounts of nutrients, which promotes the development of phytoplankton, which can be used as a food source for creation of fish *Oreochromis niloticus* and *Poecilia reticulate*, introduced in the pond.

Liquid phases samples were collected fortnightly from the input and output of the rearing fish tank in a simple point, between 09 and 11 AM. The analyzed parameters (APHA, 2005) were: biochemical oxygen demand (BOD), chemical oxygen demand (COD), filtered chemical oxygen demand (DQO_f), total suspended solids (TSS), thermotolerant coliform and microalgae phytoplanktonic microalgae.

RESULTS AND DISCUSSION

Rearing Fish Tank Monitoring

Table 1 presents the descriptive statistics of the effluent analysis at input and output of the tank.

Table 1 - Descriptive statistics of the effluent analysis results at input and output of the tank

Parameter	Unit	n	Average		SD		Efficiency (%)
			Input	Output	Input	Output	
TSS	mg/L	7	79	94	68.3	48.3	-35.1
BOD_5	mg O_2/L	7	54	39	22.6	17.1	27.2
COD	mg O_2/L	7	144	146	45.0	44.6	-1.5
COD_f	mg O_2/L	3	94	63	48.3	32.8	32.9
TC	NMP/100mL	4	8.75 E+05	2.34 E+05	5.38 E+05	4.44 E+05	73.2

Total Suspended Solids. The Total Suspended Solids concentrations from the input of the rearing fish tank ranged from 24.0 to 220.0 mg / L, and from the output of 36.0 to 182.0 mg / L (Figure 1). The suspended solids concentration was higher at the output of fish tank, because of the large presence of phytoplanktonic, increasing considerably the suspended particulate matter concentration in the effluent. Samples that not presented these characteristics, are justified by the maintenance tank activities or rain events prior to the sampling.

The increase of suspended solids concentration in the output of the tank was also noticed by Gonçalves et al. (2005) in a unique polishing pond with 1.3 m deep, operating after a anaerobic reactor type of CAR (Compartmented Anaerobic Reactor). The author attributed this increase to the presence of suspended microalgae in the pond.

Biochemical Oxygen Demand. The BOD_5 concentrations from the input of the rearing fish tank ranged from 27.0 to 92.2 mg / L, and from the output of 20.2 to 72.0 mg / L (Figure 2).

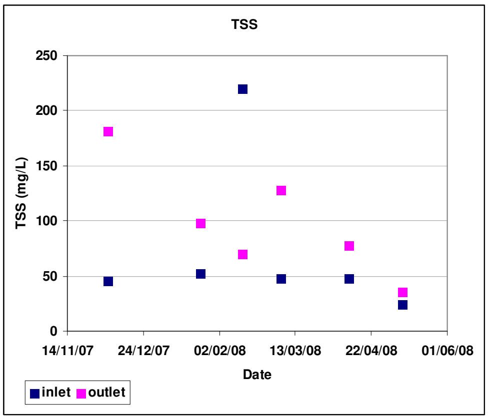

Figure 1 - Monitoring results of suspended solids from the input and output of the rearing fish tank.

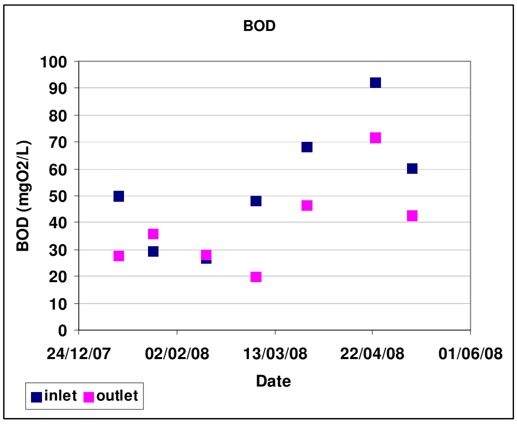

Figure 2 - Monitoring results of BOD from the input and output of the rearing fish tank.

Its possible to realize that the majority of the results presents lower values in the system output due to the biodegradable fraction removal by microorganisms and especially by fish, when feeding on microalgae and some particles of organic material present in the water.

Chemical Oxygen Demand. The COD concentrations varied from 103 to 240 mg / L at input and fram 80 to 207 mg / L at the output (Figure 3), while for the CODf concentrations at the input ranged 46.7 to 143.0 mg / L and from 36.7 to 100.0 mg / L at the output of the rearing fish tank (Figure 4).

These results presented varianting values from the COD concentration, not maintaining a declining standard to the removal of the Rearing Fish Tank, when compared to the input. It's possible to notice that the average COD value from input and output are very close. The presented average values for COD, which were high, were influenced by the presence of microalgae in the system. At the input of the tank, the COD concentrations,it was closed to the COD_f, to two of the three analysis, because most of the organic matter was in its soluble form, however, in the tank output, the COD_f had lower values than COD, indicating that most of the organic material was found in microalgae.

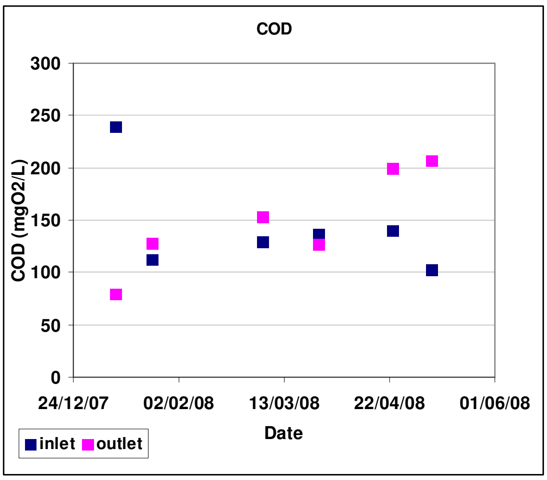

Figure 3- Monitoring results of COD from the

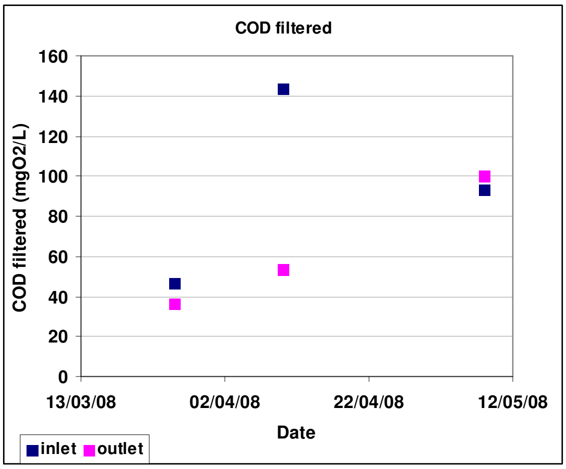

Figure 4 - Monitoring results of COD_F from the entry

entry and output of the rearing fish tank. and output of the rearing fish tank.

Thermotolerant coliform. The treatment process has not demonstrated an excellent performance in bacterial removal. It can be noticed that the reduction of thermotolerant coliforms in the output of the rearing fish tank, was 1 to 2 logarithmic units (Figure 5).

The monitoring results at the rearing fish tank output could has been better due to of the characteristics found, as intense algae production, solar radiation and the fish farming in the tank once they help in the removal of coliforms, as quoted by Metcalf & Eddy (1991). This high thermotolerant coliforms concentration may be related to some animals (ducks and goose) in the fish tank, which by eliminating their waste, may contribute to low efficiency in wastewater treatment. As it could be noted in the study of Araújo et al. (2005) the concentration of thermotolerant coliforms, in five of the six tanks studied, achieved the removal of two logarithmic units. The best results were identified in the study of van Haandel et al. (2001), with registered values ranging from removal of 3 and 5 logarithmic units.

Phytoplankton. It was found 35 microalgae taxa of phytoplanktonic Classes: Cyanophyceae (22.9%), Chlorophyceae (34.3%) and Euglenophyceae (22.9%), Bacillariophyceae (11.4%), Chlamydophyceae (5.7%) and Zygnemaphyceae (2.9%). Throughout the study period, were recorded blooms of cyanobacteria and chlorophytes were recorded, with maximum densities of 2.7 and 2.8 x 105 ind/mL, respectively, in March 2008 (Figure 6).

The wide availability of nutrients in a hypereutrophic environment enhances facilitates growth of small size species. The chlorophytes predominated in the warmer months and with low rainfall (data not shown), when *Oocystis lacustris* and *Chlorella vulgaris* were the dominant species. With the proximity of the dry season, the cyanobacteria predominated, represented by small colonial species (*Aphanocapsa delicatissima*, dominant species, and *A. incerta*) and a unicellular (*Synechocystis aquatilis*), both already registered as hepatotoxic in Brazil (except *A. incerta*).

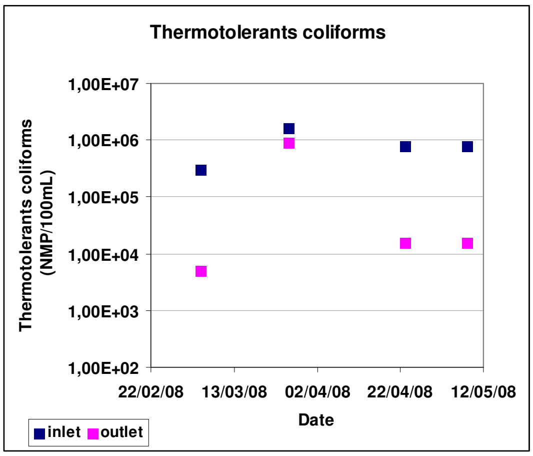

Figure 5 - Monitoring results of TC from the entry and output of the rearing fish tank.

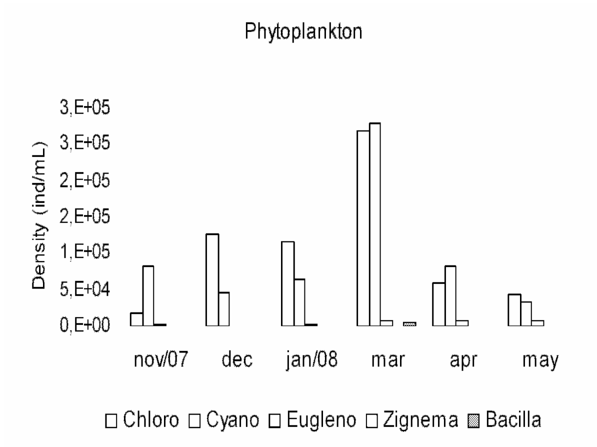

Figure 6 - Monitoring results of Phytoplankton from the entry and output of the rearing fish tank.

Efficiency. Table 1 shows the average efficiency of the rearing fish tank in the removal of the analyzed parameters. Some results did not show a high percentage in efficiency, since the Caxixe WTP works as an integrated biosystems, the rearing fish tank, which is the sixth stage of the treatment will can contribute with the removal of small concentrations of some of these parameters, considering that its affluent comes with reduced values.

The concentration of suspended solids showed an increase at this stage of the treatment system due to the presence of microalgae.

The efficiency in the BOD and COD removal was not satisfactory because of the high concentration of microalgae found in the rearing fish tank, thereby increasing the concentration of organic matter. The removal efficiency of these parameters showed no lower values due to the presence of fish in the system, wich contributes to the removal of microalgae.

The rearing fish tank performance, attributed to the removal of thermotolerant coliforms, showed as not satisfactory, once the efficiency of treatment was only 73.3%. Interference in this system, as the presence of animals such as ducks and goose may have contributed to its increase.

CONCLUSIONS

After analysis the monitoring results, can be emphasized that the reason to a low organic material removal capacity is because it already has been reduced sharply in previous stages of de WTP. Although the rearing fish tank has contributed to the BOD_5 removal, there was a significant suspended solids concentration increase due to the presence of microalgae, also contributing to an increase in the COD concentration, indicating a necessity of after-treatment tank of fish stages, to attend the effluent discharge quality standards.

The pathogens removal efficiency was not as expected, because the removal of 1 to 2 logarithmic units does not contribute to disinfect the effluent, requiring further treatment stages. It’s necessary to check the influence of fish in the treatment efficiency of the polishing pond, by counting them and performing genotoxic test.

The predominance of chlorophytes in the polishing pond indicates that it is a favorable environment for the fish rearing, because it’s a source food. Thus, the fish farming can be a gainful activity for the local people. The occurrence of four genera of cyanobacteria already registered as toxic in other parts of Brazil, reflects the contamination potential by cyanotoxins, in the case of fish farm water use and also requires more detailed studies.

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