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LIMNOLOGICAL ASPECTS OF A SHALLOW POND USED AS RECEIVER AQUACULTURE WASTES AND FOR AGRICULTURAL IRRIGATION*

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ABSTRACT

Water samples, zooplankton community and sediment samples were analyzed at three sites in a pond receiving wastes, bi-weekly for seven months, covering the rainy and dry seasons. Water quality parameters failed to show significant differences between the sites for turbidity, total suspended solids, dissolved oxygen, transparency, conductivity, alkalinity and total phosphorous. Only temperature was different between the seasons. In the case of sediment, only aluminum (Al) was not different during the experimental period when highest calcium (Ca) concentrations were reported. The relative abundance of Rotifera during the sampling period reached 80-96% (rainy season) and 59-98% (dry season) in total zooplankton. Current study demonstrated that the water quality of shallow pond associated with allochthonous materials from aquaculture farm significantly influenced the structure of zooplankton assemblage due to high nutrient concentrations, conductivity, alkalinity and chlorophyll-*a* causing more fertilized water. However, heavy rains (February-April) and continuous water flow favored aeration (dissolved oxygen > 5.2 ± 1 mg L^{-1}). The use of pond water for agricultural irrigation or for other purposes, must be analyzed more effectively, avoiding problems caused by its usage.

Keywords: water parameters; climatic seasons; zooplankton; sediment.

ASPECTOS LIMNOLÓGICOS DE UM VIVEIRO RASO UTILIZADO COMO RECEPTOR DE RESÍDUOS DA AQUICULTURA E PARA IRRIGAÇÃO AGRÍCOLA

RESUMO

Amostras de água, comunidade zooplanctônica e sedimento foram analisadas em três pontos de um viveiro receptor de resíduos a cada quinze dias, durante as estações de chuva e seca. Os parâmetros de qualidade da água não apresentaram diferenças significativas entre os pontos amostrais em relação a turbidez, sólidos suspensos totais, oxigênio dissolvido, transparência, condutividade, alcalinidade e fósforo total e a temperatura foi a única variável diferente entre as estações. Em relação ao sedimento, somente o alumínio (Al) não foi diferente durante o período experimental e foram encontradas elevadas concentrações de cálcio (Ca). Abundância relativa de Rotifera durante o período de amostragem representou 80-96% (estação chuvosa) e 59-98% (estação seca) em relação ao zooplâncton total. O estudo demonstrou que a qualidade da água do viveiro associada aos materiais alóctones provenientes da fazenda de aquicultura influenciaram significativamente a estrutura da comunidade zooplanctônica devido às altas concentrações de nutrientes, condutividade, alcalinidade e clorofila-*a*, tornando a água mais fertilizada. A utilização da água do viveiro para irrigação agrícola ou para outros propósitos deve ser analisada de forma mais efetiva, evitando assim qualquer problema decorrente do seu uso.

Palavras-chave: parâmetros da água; estações climáticas; zooplâncton; sedimento.

INTRODUCTION

The growth of aquaculture in Brazil has revealed that allochthonous material from aquaculture farms has caused serious problems in water quality, with wastes discharged without any type of treatment in the receiving bodies. As a rule, ponds receive good water quality which is transformed throughout its course within the aquaculture farm. The above, is due to management practices, producing several wastes such as fertilizers, feed remnants, feces, nutrients, and vitamins. Consequently, the use of shallow ponds closes to the water bodies to receive wastes, may minimize the negative effects of aquaculture wastes. The pond under analysis also used for agricultural irrigation. It is highly relevant to realize the importance of water quality in the irrigation of agricultural produce, frequently causing health problems.

The amounts of wastes generated from aquaculture practices depends on the characteristics of the culture system, choice of species, feed quality and management practices (Omitoyin et al., 2017). Aquaculture wastes should be treated to increase and maintain water availability and to prevent pollution (feed residual and fish excreta) of the water bodies (Omotade et al., 2019). About 60-80% of nitrogen and phosphorous in feeds enter the aquaculture farm as wastes and may lead to an increase of organic wastes and dissolved nutrients in the water column, with the subsequent polluting of adjacent water bodies (Montojo et al., 2020).

Freshwater aquaculture plays a significant role in the provision of food, which in several countries, is accompanied by environmental risks and impacts (Pearson and Duggan, 2018). Several aquaculture farms have used old ponds as waste receivers and have provided this system with favorable conditions for reducing organic load, sedimentation of suspended material, transformation of nutrients and, consequently, decrease of impacts generated by aquaculture farm (Cavalcante-Junior et al., 2005). The specific conditions of aquaculture ponds as a function of biological processes and chemical reactions of water seem to bring an equilibrium to artificial shallow ponds due to their direct interaction with the sediment (Sipaúba-Tavares et al., 2019). However, an excessive sediment load may lead to a reduction in ponds depth, a depletion in dissolved oxygen and the release of toxic gases (Dróżdż et al., 2020).

A common practice in aquaculture farms is the fertilization of shallow ponds to enhance algae growth and promote the production of zooplankton (Sipaúba-Tavares et al., 2010). Zooplankton is a key component of freshwater systems and it is used as a bioindicator in freshwater environment due to its short life cycle and high reproductive efficiency. The zooplankton community in shallow ponds quickly reacts on the physical and chemical quality of water, it occupies specific niches, and it is controlled by species composition, by consumers and by the source of nutrients introduced as fertilizers and/or fish food (Mantovano et al., 2019). These factors may promote changes in composition and diversity since they cause changes in the biomass and density of the zooplankton community characterized by intrinsic factors of environment such as, morphometry, depth, trophic level, chlorophyll-*a*, water residence time, grazing pressure, biotic and abiotic influences (Morales-Baquero et al., 2019).

Current study monitored the biotic and abiotic variables at three different sites of a shallow pond used for irrigation and as a receiver of aquaculture farm wastes during two distinct periods (rainy and dry seasons). The study was also carried out to find out whether current conditions are favorable for irrigation and to distribute water to the other purposes.

MATERIALS AND METHODS

Description of sites

Current study was performed in a shallow pond (21°15’19”S, 48°19’21”W) used for agricultural irrigation. Although it receives wastes from the aquaculture farm, it was employed for fish breeding more than 20 years ago. The pond has an area of 2,506 m^2, with maximum depth 1.7 m, water renewal (calculated by discharge volume) equivalent to 5% of total volume per day, continuous water flow (22 m^3 h^{-1}) and water discharge into Jaboticabal Creek through an underground pipe grid. The earthen fishpond is the sixth in a sequential series of six different-sized ponds (area between 2,506 m^2 and 8,067 m^2), each directly and/or indirectly receives water from the previous one through an underground pipe grid. Samples were collected for seven months in two different climatic conditions, during the summer rainy season (February-April) featuring 24.2 ± 1.2ºC air temperature and 84 ± 22 mm rainfall, and during the winter dry season (May- August), featuring daily means 20.2 ± 1.1ºC and 10 ± 14 mm, respectively. Surface water, zooplankton and sediment samples were collected bi-weekly at three sampling sites: one lies in the inlet water (IW) at its northern end and receives all water from the aquaculture farm; the second lies at a deep-water site (FP); the third site is close to the water outlet (WO) at the south end of the pond (Figure 1).

Water, sediment, and zooplankton samples

Water samples from a depth of 10 cm were collected with a 1-L van Dorn bottle and transported in refrigerated polyethylene bottles (500 mL) to the laboratory. Conductivity (Cond), water temperature (Temp), dissolved oxygen (DO), turbidity (Turb) and pH were measured in situ with a multi-sensor Horiba U-10. Total phosphorus (TP) and total inorganic nitrogen (TIN) were quantified

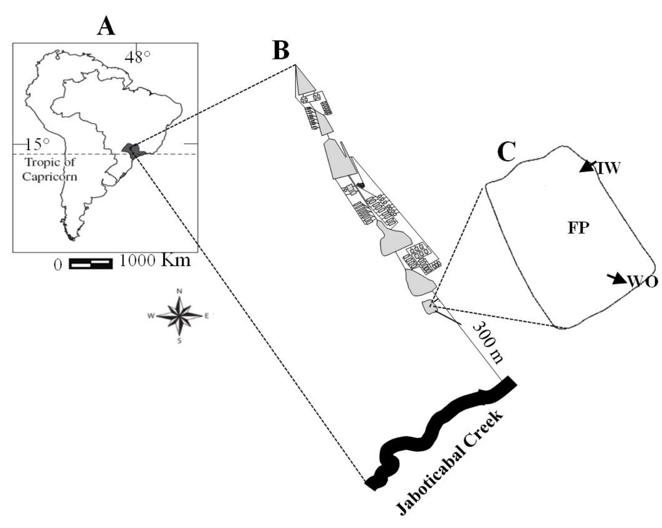

Figure 1. Diagram of the aquaculture farm: Inset A: shaded area indicates southeastern Brazil (state of São Paulo). Inset B: fishponds in sequential disposition of aquaculture farm. Inset C: pond studied with sampling sites: IW= inlet water; FP = deep-water site; WO = water outlet.

by spectrophotometry, following Golterman et al. (1978) and Koroleff (1976), respectively. Water transparency (Transp) was measured by Secchi disk. Chlorophyll-*a* (Chlo-a) concentration was determined by extracting pigments with alcohol 90% and reading a spectrophotometer (663 nm and 750 nm) processed according to methodology presented by Nusch (1980). Alkalinity (Alk) was determined following Mackereth et al. (1978). Total suspended solids (TSS) and total dissolved solids (TDS) were determined according to Boyd and Tucker (1992). Water samples for microbiological analysis, using the multiple-tube methods, were collected in sterilized 500-mL flasks and taken to the laboratory in an isothermal container. The material for microbiological analysis (thermotolerant coliforms - TC) was sterilized prior to use (APHA, 1998). Vertically mixed sediment samples were retrieved with a 4-cm diameter PVC core up to approximately 10 cm deep. Sediments were air dried, gently disaggregated, and dried in a convection oven at 70°C until completely dry. Organic matter (OM), pH, Al, Ca, K, Mg and P were determined following Raij et al. (2001).

Zooplankton was sampled by filtering 20-L of water through a plankton net (58 µm) and concentrated up to 50 mL. Samples were preserved in formalin 4% and allowed to settle. Total collected volume was measured and stored in amber glass jars. Copepoda, Cladocera and Ostracoda were counted in a reticulated chamber under a stereomicroscope (40X). Samples of Rotifera were analyzed in Sedgewick-Rafter chamber under a Leitz microscope (100X). Species of Rotifera, Copepoda, Cladocera and Ostracoda were identified according to specialized literature (Koste, 1978; Reid, 1985; Elmoor-Loureiro, 1997).

Data analysis

Lillierfors and Bartlett test and residual analyses were employed for abiotic variables and sediment to verify normality and homogeneity of variances. One-way ANOVA was employed to compare the difference of water variables and sediment between samples sites (IW, FP and WO) during the rainy and dry seasons with Statistica 10 (Stat Soft Inc., 2007) when criteria were met. Fisher´s exact test measured difference between means at p <0.05. Kruskall-Wallis non-parametric test was employed when the ANOVA criteria were not met. Abiotic data were evaluated by Principal Components Analysis (PCA) and undertaken according to software Statistic 10 (Stat Soft Inc., 2007). Species were considered dominant when density was higher than 50% of the total number of specimens in the sample; they were abundant when the number of specimens was higher than the mean density of all occurring species (Lobo and Leighton, 1986). Zooplankton community diversity was calculated by Shannon-Wiener index (Pielou, 1975). Richness was calculated as the total number of species present; evenness or equitability was determined as: H/H max, where H is the Shannon-Wiener index and H max = lnS.

RESULTS

Significant differences (p <0.05) regarding water samples were reported between sites, except for pH, temperature, TDS, thermotolerant coliforms, TIN and chlorophyll-*a* (Table 1). During sampling period, a decrease from IW to WO of water variables concentrations was not observed, except TDS during rainy season, which showed 298 ± 124 mg L^{-1} at the inlet water and 176 ± 29 mg L^{-1} at the water outlet. Temperature remained above 20.3 ± 1.1°C, with direct influence from climatic conditions (Table 1). The pH was alkaline above 6.3 ± 0.2 (IW–rainy season) whilst transparency ranged between 44 ± 7 cm (FP–rainy season) and 63 ± 10 cm (WO-dry season). Thermotolerant coliforms were high at WO than at the other sites, with 496 ± 124 MPN 100 mL^{-1} and 173 ± 121 MPN 100 mL^{-1} during rainy and dry seasons, respectively. Total inorganic nitrogen concentrations were two times higher than total phosphorus. Total inorganic nitrogen concentrations ranged between 566 ± 144 µg L^{-1} and 686 ± 232 µg L^{-1} (rainy season) and 531 ± 131 µg L^{-1} and 689 ± 201 µg L^{-1} (dry season). Total phosphorus concentrations were above 103 ± 16 µg L^{-1} (WO–dry season) during the sample period and similar between sampling sites. In general, due to management practices of aquaculture farm, chlorophyll-*a* was high during the sampling period, mainly in the rainy season ranging between 65 ± 19 µg L^{-1} (FP) and 77 ± 17 µg L^{-1} (IW); in the dry season the highest concentration was reported at FP with 42 ± 12 µg L^{-1}. However, at WO during the dry season, chlorophyll-*a* was higher (36 ± 10 µg L^{-1}) than IW (33 ± 12 µg L^{-1}) (Table 1). Conductivity was above 99 ± 6 µS cm^{-1} (FP–rainy season) and dissolved oxygen concentrations was above 5.2 ± 1 mg L^{-1} (WO–rainy season), during the sampling period. Turbidity was below 23 ± 5 NTU (IW–rainy season), and TSS concentrations were low (< 17 ± 5 mg L^{-1}). The opposite has been observed for TDS which was above 144 ± 56 mg L^{-1} (IW–dry season). Alkalinity was below 49 ± 3 mg L^{-1} (dry season) during sampling period (Table 1).

Principal components analysis (PCA) with 13 abiotic variables retained 86.32% of the original data variability in the first two axis (axis 1 = 74.56%; axis 2 = 11.76%). IWR and WOR during rainy season were grouped on the negative side of axis 1 together with the variable temperature (-0.96), turbidity (-0.85), TSS (-0.97), TDS (-0.70), TP (-0.89), chlorophyll-*a* (-0.98) and thermotolerant coliforms (-0.95). During the dry season (IWD, FPD and WOD), the sites were grouped on the positive side of axis 1 together with variables pH (0.91), conductivity (0.96), DO (0.76), transparency (0.86) and alkalinity (0.89). The first component of the PCA indicated that the rainy season presented more eutrophic water than the dry season. Axis 2 indicated a positive association between the FPR point and the TIN variable (0.93) which were the most relevant variables for ordination (Figure 2).

In the sediment, only Al was not significant (p<0.05) between sampling sites and remained above 29 ± 5 mg L^{-1} (IW–dry season). However, Ca was the highest compound above 988 ± 470 mg L^{-1} (WO–rainy season) with the highest concentration at FP (dry season) with 1,583 ± 414 mg L^{-1}. Mg also showed high concentration, mainly during the dry season at IW with 246 ± 70 mg L^{-1} (Table 1). Sediment was acidic and ranged between 4.8 ± 0.1 (WO–dry season) and 5.6 ± 0.2 (IW–dry season). Organic matter was higher in both seasons and lowest at IW (1.0 ± 0.3%) during the dry season. The highest concentrations of P (46 ± 9 mg L^{-1}) and K (79 ± 22 mg L^{-1}) were reported during the dry season at FP (Table 1).

Table 1. Mean and standard deviation of variables measured in the water and sediment (mg L^{-1}) between sites during the experimental period at IW (inlet water), FP (deep water) and WO (water outlet). In each row, means followed by the same letter do not differ significantly (p <0.05) between sites in each season.

Variables	Rainy season			Dry season		
	IW	FP	WO	IW	FP	WO
Water						
pH	6.3±0.2^{b}	6.5±0.2^{a}	6.6±0.2^{a}	6.8±0.5^{b}	6.7±0.2^{b}	6.7±0.2^{b}
Temperature (ºC)	26.1±1.3^{a}	26.2±1.3^{a}	26.2±1.4^{a}	20.3±1.1^{b}	20.3±1.1^{b}	20.3±1.0^{b}
DO (mg L^{-1})	5.7±1.0^{a}	6.1±0.6^{a}	5.2±1.0^{a}	6.4±0.5^{a}	6.5±1.0^{a}	6.1±0.8^{a}
Turbidity (NTU)	23±5^{a}	19±3^{a}	22±3^{a}	20±8^{a}	17.4±6^{a}	18±5^{a}
TSS (mg L^{-1})	17±5^{a}	15±1^{a}	14±6^{a}	9.6±6.0^{a}	7.7±6.0^{a}	9.3±5.0^{a}
TDS (mg L^{-1})	298±124^{a}	225±79^{a}	176±29 ^{b}	144±56^{b}	180±50^{a}	164±25^{a}
TC (MPN 100 mL^{-1})	471±171^{ab}	480±194^{ab}	496±124^{a}	135±99^{b}	154±150^{b}	173±121^{ab}
Transparency (cm)	45±7^{a}	44±7^{a}	50±5^{a}	56±11^{a}	57±10^{a}	63±10^{a}
TIN (µg L^{-1})	566±144^{ab}	686±232^{b}	582±87^{ab}	689±201^{a}	596±121^{c}	531±131^{ab}
TP (µg L^{-1})	133±14^{a}	121±10^{a}	126±9^{a}	114±16^{a}	108±20^{a}	103±16^{a}
Alkalinity (mg L^{-1})	46±3^{a}	46±1^{a}	46±3^{a}	49±3^{a}	49±4^{a}	49±3^{a}
Cond (µS cm^{-1})	99±9^{a}	99±6^{a}	10± 3^{a}	106±14^{a}	112±8^{a}	112±5^{a}
Chlo-*a* (µg L^{-1})	77±17^{a}	65±19^{ab}	70±25^{ab}	33±12^{b}	42±12^{a}	36±10^{ab}
Sediment						
Al (mg L^{-1})	40±27^{a}	47±26^{a}	40±15^{a}	29±5^{a}	44±28^{a}	44±38^{a}
Ca (mg L^{-1})	1,008±361^{bc}	1,089±195^{bc}	988±470^{c}	1,032±252^{bc}	1,583±414^{a}	1,363±268^{ab}
K (mg L^{-1})	48±7^{b}	53±10^{ab}	53±14^{b}	62±19^{ab}	79±22^{a}	75±24^{a}
Mg (mg L^{-1})	187±29^{abc}	211±88^{c}	162±110^{d}	246±70^{a}	228±62^{ab}	188±36^{bc}
P (mg L^{-1})	47±11^{ab}	42±13^{ab}	44±24^{b}	30±4^{c}	46±9^{a}	39±8^{ab}
pH	5.2±0.4^{a}	5.1±0.3^{bc}	4.8±0.6^{d}	5.6±0.2^{a}	5.1±0.1^{b}	4.8±0.1^{cd}
OM (%)	2.2±1.7^{cd}	4.4±2.9^{a}	3.9±2.4^{bc}	1.0±0.3^{d}	4.7±1.6^{a}	2.8±1.4^{c}

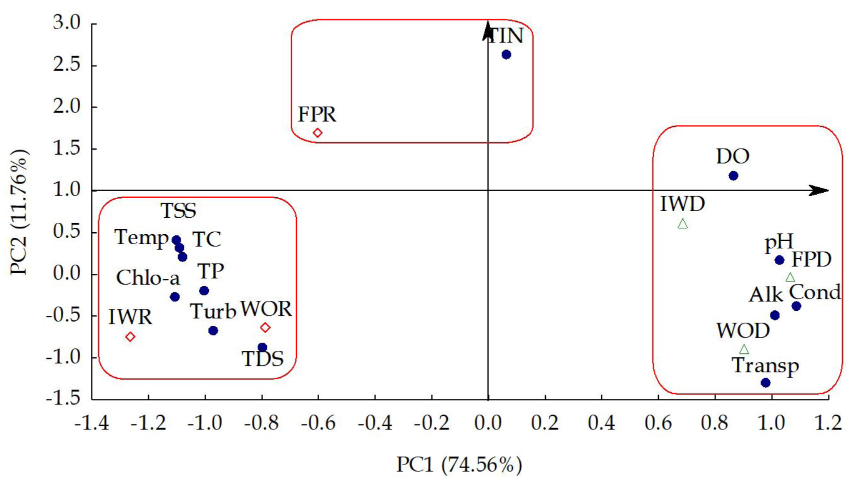

Figure 2. Results of the principal component analysis (PCA) for water variables: blue circles = water characteristics; green triangles = sites during dry season; red rhombus = sites during raining season. IWR, FPR and WOR = sites during rainy season; IWD, FPD and WOD = sites during dry season.

The zooplankton community comprised 64 species of Rotifera, 5 species of Copepoda, 8 species of Cladocera, and Ostracoda that was considered as a class. Rotifera had high abundance during the sampling period, featuring 80-96% during rainy season and 59-98% during dry season (Figures 3 and 4). However, higher density occurred in February at FP with 1,212,361 ind L^{-1} and at WO 1,275,714 ind L^{-1} of total zooplankton during the rainy seasons (Figure 3).

Ostracoda also had high density during the rainy season ranging between 1,680 ind L^{-1} (April) and 7,311 ind L^{-1} (March). However,

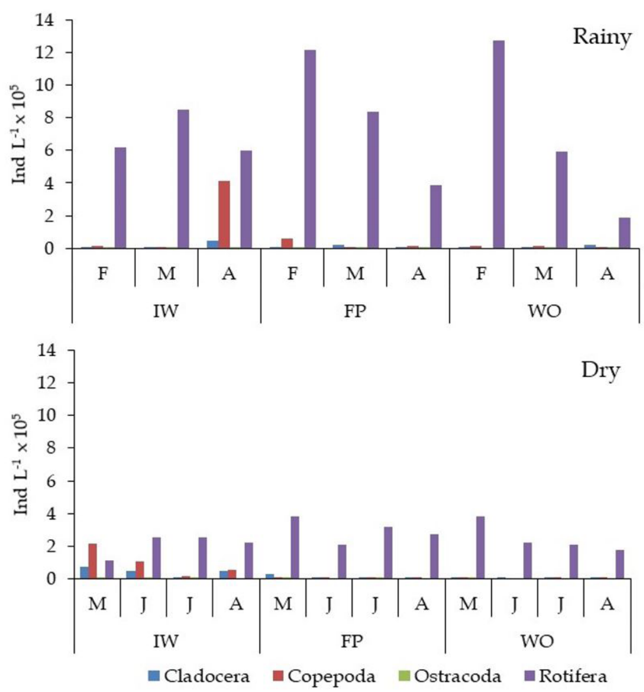

Figure 3. Total density (ind $L^{-1}x10^5$) of zooplankton identified at IW (inlet water), FP (deep water) and WO (water outlet) during the rainy and dry seasons.

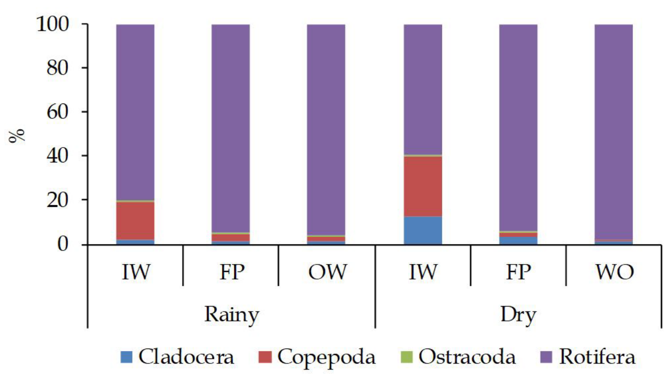

Figure 4. Relative abundance (%) of zooplankton identified at IW (inlet water), FP (deep water) and WO (water outlet) during the rainy and dry seasons.

during the dry season, they were absent in August at the three sites and in June at FP and WO. Ostracoda appeared in all sites during the two seasons, albeit below 1% of total zooplankton community (Figure 4). Copepoda and Cladocera species had high density at IW in the two seasons with 438,420 ind L^{-1} and 60,000 ind L^{-1} and 386,500 ind L^{-1} and 183,680 ind L^{-1}, during the rainy and dry seasons, respectively (Figure 3). During the sampling period Copepoda was more representative in April at IW (rainy season) with 411,600 ind L^{-1} and in May (dry season) with 212,010 ind L^{-1} (Figure 3). At FP and WO and during dry season Copepoda was not representative, or rather, below 7,140 ind L^{-1}; similarly, Cladocera, except in March at FP with 29,240 ind L^{-1} (Figure 3). During the rainy season, Cladocera and Copepoda occurred during sampling period, albeit the lowest density at FP and WO, except in February for Copepoda with 61,920 ind L^{-1}, less than 3% of zooplankton community. In general, the lowest density of zooplankton community was observed at WO, except Rotifera in the two seasons. However, the during dry season Rotifera represented more than 60% of total zooplankton with high biomass at WO with 98% of total zooplankton. In general, the zooplankton community density at IW and FP was similar to Rotifera, almost making up the total zooplankton community (Figures 3 and 4).

During the sampling period in the two seasons, high biomass was observed at IW and the lowest density at WO. However, during high flow (rainy season), the highest density occurred with 2,575,937 ind L^{-1} (IW), 2,579,083 ind L^{-1} (FP) and 2,132,004 ind L^{-1} (WO) than dry season (Table 2). The ecological indexes of zooplankton community during dry season were high at FP, but they were highest during the rainy season at IW, except for richness (70) reported at FP. High number of abundant species (20) was reported where evenness and diversity were high in both seasons. The lowest abundant species and ecological index were reported at WO (rainy season) and IW (dry season), except richness in the dry season, reported at WO (61) (Table 2). Fifteen of the recorded species were abundant at any site or in any season: two Copepoda, namely, *Thermocyclops minutus* nauplii and *Argyrodiaptomus furcatus* nauplii and twenty eight Rotifera, namely: *Anuraeopsis fissa*, *Ascomorpha* sp., *Asplanchna* sp., *Asplanchnopus* sp., *Brachionus falcatus*, *B. havanaensis*, *Cephalodela* sp., *Collotheca* sp., *C. mutabilis*, *Colurella* sp., *Epiphanes* sp., *Euchlanis* sp., *Filinia longiseta*, *F. opoliensis*, *Gastropus* sp., *Keratella tropica*, *Lecane proiecta*, *L. scutata*, *Proales doliaris*, *P. globulifera*, *Ploesoma* sp., *Polyarthra* sp., *Trichocerca* sp, *T. flagelata*, *T. cavia*, *T. similis*, *T. cilindrica* and *T. similis*.

Table 2. Total number of zooplankton community (ind L^{-1}), total abundant species and ecological indexes: species richness, evenness, Shannon-Wiener diversity index (H') in the inlet water (IW), deep water (FP) and water outlet (WO) during the rainy and dry seasons.

Zooplankton	Rainy season			Dry season		
	IW	FP	WO	IW	FP	WO
Total of individuals (ind L^{-1})	2,575,937	2,579,083	2,132,004	1,416,052	1,256,101	1,006,276
Richness	66	70	65	64	67	61
Evenness	0.78	0.73	0.71	0.70	0.79	0.77
Diversity (H')	1.41	1.35	1.28	1.29	1.44	1.37
Total abundant species	20	17	15	16	20	18

DISCUSSION

Although water samples analyzed did not show any difference between inlet water and water outlet during sampling period, climatic conditions had strong influence on temperature, total dissolved solid and chlorophyll-*a*. Consequently, the management practices in aquaculture farms to induce a higher concentration of nutrients, chlorophyll-*a*, TDS, alkalinity, turbidity, conductivity, and sediment nutrients, interferes in the zooplankton community with high density of opportunistic species such as Rotifera. Significant biomass was reported during the rainy season. PCA evidenced a strong association of environmental variables with two climatic conditions, where chlorophyll-*a* concentrations were associated with rainy season. On the other hand, during the rainy season the high flow of water in the fishpond studied due to sequential disposition of ponds in the aquaculture farm, brought a lot of allochthonous materials, including planktonic populations, becoming more eutrophic than during the dry season. However, the heavy rains (February-April) and continuous water flow favored the pond's aeration (dissolved oxygen > 5.2 ± 1 mg L^{-1}).

The frequency and abundance of the zooplankton community is related to changes in chlorophyll-*a* concentrations (Mantovano et al., 2019). Thus, a great availability of resources positively favors aquatic communities by supporting a higher abundance and frequency of zooplankton organisms (Schwind et al., 2017). Rotifera have high tolerance to environments with high anthropic influence. Consequently, they are r-strategist species. High density of Rotifera in ponds is due to small size, reproductive adaptability to environmental changes and wide temperature range (Abubackar and Abubackar, 2013).

High Rotifera density such as *Filinia*, *Brachionus* and *Anuraeopsis* in the shallow pond, is dependent on organic matter, total dissolved solids, chlorophyll-*a* and temperature that influence the abundance of species. Ismail and Adnan (2016) observed that Rotifera species, particularly *Brachionus* sp., are better trophic indicators than crustaceans since they are less affected by microalgae availability and changes in water parameters.

Cladocera, Copepoda and Ostracoda had low representativity during the sampling period. The presence of crustaceans mainly at IW during dry season, could be linked with nutrient assimilation from algae and detritus. Further, at IW site high concentration of chlorophyll-*a* (77 ± 17 µg L^{-1}) and total inorganic nitrogen (566 ± 144 µg L^{-1}), was reported. Consequently, the diversified input of allochthonous material in the shallow pond triggered a high zooplankton biomass and chlorophyll-*a* concentration, with a rise in species diversity and richness with a great number of abundant species in the two seasons under analysis.

Chlorophyll-*a* has the greatest influence on the composition of Cladocera assemblages when compared with other independent variables. However, other environmental factors affect the structure of crustacean community such as alkalinity (low concentration), water acidity and conductivity (Chen et al., 2010). In current study, alkalinity was above 46 ± 3 mg L^{-1} and conductivity above 99 ± 6 µS cm^{-1}, in which case, they may have influenced the crustacean biomass, even though these organisms vary along the climatic gradient.

Shallow ponds that receive wastes tend to accumulate nutrients, over time, mainly in the sediment due to ion exchange at the sediment/water interface. In current study, Ca and Mg concentrations were extremely high regarding the other compounds, fact associated with management practices. Mg is an important compound since it serves as a central atom of the chlorophyll-*a* molecules in the photosynthetic system and influences many enzymatic activities (Dong et al., 2019). Low Ca and Mg concentrations directly impact the acid pH since compounds are liming components employed to increase pH (Sipaúba-Tavares et al., 2013). High Mg and Ca concentrations observed in the sediment are not directly reflected in the water pH which remained acidic during the sampling period. However, chemical characteristics of sediments in fishponds may be affected by several factors such as, management practices, kind of soil and climatic conditions.

Current study demonstrated that the water quality of shallow pond, associated with allochthonous materials from aquaculture farm, significantly influenced the structure of zooplankton assemblage due to high nutrients concentrations, conductivity, alkalinity and chlorophyl-*a*, making the water more fertilized. Thus, the use of shallow pond for irrigation or for other purpose must be analyzed.

CONCLUSION

In current analysis, most of the water variables from the aquaculture farm did not decrease throughout the pond. The inlet water during the two seasons registered a higher density of zooplankton species than at the other sites. The dominance of Rotifera during sampling period, proved that some zooplankton species can responding to environmental changes. The sediment is also saturated with high concentration of Ca and Mg. The use of shallow pond close to the receiving body is a tool that may be adopted on an aquaculture farm to minimize the impact on the receiving body. Usage of alternative technology provides more advantages in terms of cost and efficiency. Results partially corroborate our hypothesis since the diversified use of the water, irrigation, or water supply for other sectors must be analyzed. Several water variables such as chlorophyll-*a*, conductivity, solids, and nutrients were not reduced during passage through the shallow pond. In fact, a novel management is required to improve the water conditions mainly regarding irrigation or re-use for other purposes.

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