Water quality and nutrient budget in experimental closed tilapia *Oreochromis niloticus* culture systems

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Calidad de agua y balance de nutrientes en un cultivo experimental cerrado de tilapia Oreochromis niloticus.

Abstract

Two experiments were conducted in an effort to determine the effects of stocking density, water quality, tilapia growth performance, and nutrient distribution and budget. Experiment was designed for an intensive culture of tilapia *Oreochromis niloticus* in recirculating aquaculture systems (RAS). Tilapia weight gain and production was higher in the treatment with higher stocking density. Total nitrogen, nitrite-nitrogen, nitrate-nitrogen, total phosphorus and phosphorus dissolved concentrations in all the treatments remained low in the safe range for tilapia during the study period. The major source of nutrient input was feed, tilapia feed accounted for 71-75% nitrogen and 53-65% phosphorus of the total inputs. Nutrient budget revealed the feed input, 40-43% of the nitrogen and 61-70% of the phosphorus were incorporated in the fish harvested. The production of one kilogram of tilapia required 1.8-1.9 kg of feed in different treatments, while 26-28 g nitrogen and 11-15 g phosphorus were released into the water, as metabolic waste. The drained water at harvest contained 13.0% nitrogen and 12.4% phosphorus of the total inputs. The study has demonstrated that RAS tilapia culture system can maintain acceptable water quality for tilapia growth, to increased efficiency and reduce nutrient loss through pond effluents.

Key words: Tilapia culture; Closed system; Water quality; Growth; Nutrient budget.

Resumen

Se realizaron dos experimentos en un esfuerzo por determinar los efectos de la densidad, calidad del agua, rendimiento de la tilapia y distribución y balance de nutrientes. El experimento fue diseñado para un cultivo intensivo de tilapia *Oreochromis niloticus* utilizando un sistema de recirculación de acuacultura (RAS). La mayor producción de tilapia fue para el tratamiento con mayor densidad de cultivo. Durante el periodo de estudio las concentraciones de nitrógeno total, nitritos, nitratos, fósforo total y fósforo disuelto en todos los tratamientos permanecieron en un intervalo seguro para la tilapia. El alimento fue la principal fuente de aporte de nutrientes, del total de las entradas el alimento representó del 71-75% de nitrógeno y 53-65% de fósforo. El balance de nutrientes reveló que del 40-43% de nitrógeno y 61-70% del fósforo que ingresó en el alimento se recuperó en los peces cosechados. Para la producción de un kilogramo de tilapia se requirió de 1.8-1.9 kg de alimento en los diferentes tratamientos, en tanto que 11-15 g de nitrógeno y 26-28 g de fósforo fueron liberados en el agua, como los desechos metabólicos. El agua drenada durante la cosecha representó un 13.0% de nitrógeno y 12.4% de fósforo del total de las entradas. El estudio demostró que sistema de cultivo de tilapia RAS puede mantener una calidad del agua aceptable para el crecimiento de la tilapia, aumentar la eficiencia y reducir la pérdida de nutrientes a través de los efluentes de los estanques.

Palabras clave: Cultivo de tilapia, sistema cerrado; Calidad de agua; Crecimiento; Balance de nutrientes.

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Introduction

Fish farming has been an important development in recent decades in response to the growing global market demand (Costa-Pierce *et al*., 2012). To meet the current demand for tilapia farming, production systems have been developed that range from extensive to intensive with increasing use of artificial food and high water quality (Crab *et al*.., 2007). Nevertheless, crop wastes accumulate in water, as in the case of uneaten food and metabolic wastes that increase as time goes on with the intensification of cropping system (Lin, 1995). In a traditional intensive farming of tilapia deteriorated water ponds is exchanged frequently, using external water to maintain good water quality and a better growth of tilapia (Avnimelech, 2007). Nutrient discharges effluent from fish farms can cause eutrophication problems in receiving water bodies and its impact has been a major environmental concern (Phillips *et al*.., 1993). Previous studies show that nutrient balance in an open system for tilapia culture, only 21.4% and 18.8% nitrogen phosphorus incorporated in the feed are retrieved at the time of harvest, the rest are losses that are downloaded as metabolic contaminants through effluent (Siddiqui and Al-Harbi, 1999). The residual nitrogen produced in the culture system (eg ammonia and nitrites) generally exceeds the assimilative capacity of the system, which impairs water quality creating a toxic environment for tilapia (Avnimelech, 1999, Hargreaves, 2001). Global growth of tilapia reported various problems, among them, the presence of disease, environmental degradation and poor management practices (Dominguez, 2001; Pongthana, 2010; Martins *et al*., 2011). One way to mitigate the impact to the environment through the discharge of cropping systems and reduce the risk of disease spread by contaminated water, is using intensive farming systems with water recycling, also known as recirculating aquaculture systems, or RAS (by its acronym), which have been developed in recent years (Timmons *et al*., 2002, Piedrahita, 2003; Wilk *at al*., 2009). However, the main problem associated with the closed system is the rapid eutrophication of ponds, the increase in power rates and organic matter accumulated during the growing season (Piedrahita, 2003). Obviously, the balance between production and waste assimilation capacity in the pond environment is critical to the success of the closed system. Closed culture systems need to account for the impact of waste, the growth of culture organisms and mortality to assess the potential for sustainable scaling (Martins *et al*., 2010). The manipulation of the environment to encourage increased production requires an understanding of the chemical and biological processes of the ponds (Boyd, 1986). The establishment of a balance of nutrients in ponds is a basic step to evaluate the efficiency of fertilizer use and food, and to learn the fate of nutrients, water quality and understand the biological and chemical processes of ponds (Páez-Osuna and Fernández, 2005; Thakur and Lin, 2003; Avnimelech and Kochba, 2009). Experiments in short times have shown results and significant conclusions (Seawright *et al*., 1998; Siddiqui and Al-Harbi, 1999). The present study was designed to investigate the growth of tilapia, water quality, distribution and balance of nutrients in a recirculating water intensive system.

Materials and Methods

System description and determination of treatment

We used a recirculating aquaculture system (Aquatic Habitats ™), consists of four subunits which recirculate independently water for fish farming. Each subunit using volumes of 120 liters of water distributed in six tanks of 10 l capacity each and a 60 liter reservoir. The experiment was conducted at the Aquaculture Department of the Technological Institute of Sonora (ITSON), Mexico. Two experiments were conducted, the first with a duration of 30 days to evaluate the best density in the culture system and thereby develop the second experiment, which lasted 46 days which evaluated tilapia production, water quality and nutrient balance. In both cases we used juvenile *Oreochromis niloticus*, purchased from a nursery that grew them in rectangular pools (depth of 1.5 mm; volume of 100 m^3) and cultured at a density of 10 organisms per m^3.

First experiment

Tilapia were selected of uniform weight of 6.2 to 6.6 g and seeded in 10-liter tanks to different biomass crop: 25, 51, 74 and 99 g per aquarium. Each treatment had six replicates. During cultivation tilapias were fed three times a day (08:00, 14:00 and 20:00 h) using commercial fish food formulated with 88% dry matter, 8% lipid and 25% protein. The daily feeding began considering a 4% body weight index and the adjustment was made based on the daily consumption. The criterion for evaluating survival was: Survival (%) = number of organisms end / initial number of organisms * 100. The net earned Biomass (/week) was calculated using the following equation: [(average final weight - initial weight) / days of the experiment] * 7.

Second experiment

Tilapia were seeded with an average weight of 6.5 to 6.9 g and placed in 10-liter tanks trying to match the best crop biomass remaining in the first experiment of 26.3 to 27.9 g per aquarium. The experiment was repeated three times each with six replications. All tilapia were fed with the same food. The same manner was used to calculate survival and growth using the same criteria as Experiment 1.

Sampling and chemical analysis

For obtaining water samples a similar location or sampling site was established in the reservoir tank of each subsystem. Samples were taken weekly, before any water exchange. The samples were collected in clean plastic bottles (500 ml) and immediately transported to the laboratory. The determination of nitrite (NO_2^--N), nitrate(NO_3^--N) and phosphate (PO_4^-) were performed according to Strickland and Parsons (1972) and APHA (2012), total nitrogen (TN) and total phosphorus (PT) were performed using potassium persulfate digestion described Valderrama (1981), the digested samples were analyzed by methodologies of Strickland and Parsons (1972). The water quality, temperature, dissolved oxygen and pH were monitored daily at the same time (12:00 AM) to 20 centimeters below the water surface.

Partial estimates of the mass balance

The total feed provided to each of the subsystems was quantified. The entry of nitrogen and phosphorus nutrients (N/P) in the form of feed was calculated according to the following equation: Nutrients (N/P) in the feed = concentration of nutrients from food multiplied by the total feed added. The input and output of nutrients in the form of tilapia were calculated as follows: nutrients (N/P) in the tilapia = concentration of nutrients in the body of the tilapia x total biomass harvested tilapia. The concentration of nitrogen and phosphorus in fish was estimated at three organisms at the end of the 40 days of culture. The food and fish samples were oven dried and analyzed in triplicate according to the standard method AOAC, 1984. They were then determined nitrogen and total phosphorus in dry weight using the Kjeldahl method (Siddiqui and Al-Harbi, 1999). The total feed added during the 46 days the experiment was used to calculate the nitrogen and phosphorus input to each of the subsystems. Water flows were controlled in the aquariums by considering exchange volume plus water evaporation of 4.0% of the total water volume (Shnel *et al*., 2002). The water lost by evaporation and transpiration was replaced daily with tap water without chlorine. The values obtained with weekly data of water quality were linearly interpolated to estimate daily values and determine the total mass of each nutrient recycling in the system. Total (N and P) inflows, which came out, recovered and accumulated at the end of the cycle in the cropping system, were measured considering the procedure described by Takur and Lin (2003). The budget of nutrients (N and P) was calculated based on water inlets, tilapia cultivation and food, and the outputs were calculated based on tilapia harvested and the water drained.

Statistical Analysis

Variables tilapia production and total nutrient flows were determined and expressed as mean ± standard deviation (±). The water quality data were examined by two-way ANOVA with repeated measures using SAS software (Geof and Everitt, 2000). The average values of water exchange, water intake, stocking density, survival, production, feed conversion and chemical fluxes were compared by one-way ANOVA using STATISTICA software (2005). Differences between treatments were compared using Duncan's test and differences were considered significant at levels of $p < 0.05$. Appropriate transformations (arcsine logarithm) and corrections for non-normality were applied.

Results

Growth, survival and production of tilapia

Experiment 1

The results of the growth rates are presented in table 1. The growth of tilapia (net biomass gained) and the survivals of the different crop densities were significantly better in treatments with densities of 25 and 51 g/10 l water. In these treatments the average gained biomass was 6.6 and 9.9 g / week survivals of 100 and 94%, respectively. Survival rates and earned net biomass were significantly lower ($p < 0.05$) in treatments with crop densities of 74 to 99 g/10 l.

Experiment 2

The growth results are shown in table 2. Both growth factor feed conversion and survival showed some similarity. Earned net biomass was 22.3 to 32.0 grams, the conversion factor ranged from 1.80 to 1.99 and the survival of 80-86% at the end of the 46 days of the experiment.

Water quality parameters

Experiment 1. The water quality variables recorded during the 30 days of culture show values of oxygen of 2.1 to 3.0 mg l^{-1}, temperatures of 26 to 31 °C and pH of 8.0 to 8.5, values in the range suitable for the tilapia.

Experiment 2. During the 46 days of the experiment the concentration of dissolved oxygen in the water

Table 1. Effects of stocking density (25, 50, 75 and 100 g tilapia/10 l^{-1}) on tilapia performance indices in aquaria stocked with *Oreochromis niloticus* during a 30-day trial.

	Stocking density (g tilapia/10 l)			
Variable	25	50	75	100
Mean initial weight (g)	6.2 ± 0.5a	6.4 ± 0.7a	6.7 ± 1.2a	6.6 ± 0.4ª
Mean biomass initial (g/10 l)	24.8 ± 2.3 a	51.2 ± 3.0 a	73.7 ± 2.9 a	99.0 ± 3.1 a
Mean biomass final (g/10 l)	50.4 ± 5.6 a	89.0 ± 8.0 b	88.7 ± 5,8 b	112.9 ± 10.1 b
Net biomass gained (g/week)	5.97	8.82	3.50	3.24
Survival (%)*	100a	94.0a	61.0b	58.0b
Oxygen (mg l^{-1})	2.5 – 3.6	2.1 – 3.3	2.1 – 3.2	2.15 – 3.0
Temperature (°C)	27.6 – 31.9	27.4 – 31.9	26.9 – 31.2	26.8 – 31.2

Values are mean ± /S.E. (n =6 for each treatment). Different letters = significantly different p<0.05.
*Data transformed (arcsine x^{05}) prior to statistical analysis. The range (minimum and maximum) for temperature and DO was given for each treatment.

Table 2. Growth and water quality (second experiment) of juvenile tilapia *Oreochromis niloticus* during a 46-day trial.

Variable	Repetition			
	1	2	3	Control
Mean initial weight (g)	6.5 ± 2.5a	6.9 ± 3.6a	6.8 ± 2.9a	-
Biomass initial (g/tilapia/10 ^{l})	26.3 ± 3.2a	27.9 ± 3.9a	27.3 ± 2.9a	-
Biomass final (g/tilapia/10 l)	55.2 ± 8.0a	50.2 ± 7.0a	59.3 ± 9.0a	-
Net biomass gained (g tilapia/10 l)	28.9 ± 10.3a	22.3 ± 10.2a	32.0 ± 11.2a	-
Food conversión ratio**	1.84 ± 0.79	1.99 ± 0.29	1.80 ± 0.40	-
Survival (%)*	86	86	80	-
Water quality variable				
Temperature (°C)	28.0 – 32.0	28.0 – 32.0	28.0 – 32.0	28.0 – 32.0
pH	8.5 – 8.0	8.5 – 8.0	8.5 – 8.0	7.5 – 8.0
Total nitrogen (mg l^{-1})**	65.2 – 0.8	44.0 – 0.8	48.0 – 0.8	1.9 – 0.8
NO_2-N (mg l^{-1})**	0.6 – 0.0	0.4 – 0.0	0.3 – 0.0	0.0 – 0.0
NO_3-N (mg l^{-1})**	65.0 – 0.8	43.7 – 0.8	47.9 – 0.8	1.8 – 0.8
PO_4- (mg l^{-1})**	2.6 – 0.1	1.2 – 0.1	1.6 – 0.1	0.4 – 0.1
Total phosphorous (mg l^{-1})**	4.1 – 0.1	3.3 – 0.1	3.9 – 0.1	0.1 – 0.0

Values are mean ±/S.D. (n =/6 for each repetition). Different letters = significantly different p<0.05. For each experiment, water quality data for all sampling times were averaged. The range (maximum and minimum) water quality variable was given for each treatment. *Data transformed (arcsine x^{05}) prior to statistical analysis. **Data transformed (log x) prior to statistical analysis.

recirculation system is kept at concentrations of 3.4 to 4.4 mg l^{-1}, with temperatures of 26.8 to 31 ° C and pH values of 7.5 to 8.0 (Table 2). There was no significant difference between the concentrations of dissolved oxygen in the water, the temperature and pH between treatments during the study period (Table 2). As expected concentration of total nitrogen (NT) fluctuated throughout the experiment in ascending order (Figure 1). NT values in both experiments were 5.4 mg l^{-1} up to a maximum of 66.3 mg l^{-1}. The concentration of NT in the control treatment was maintained throughout the

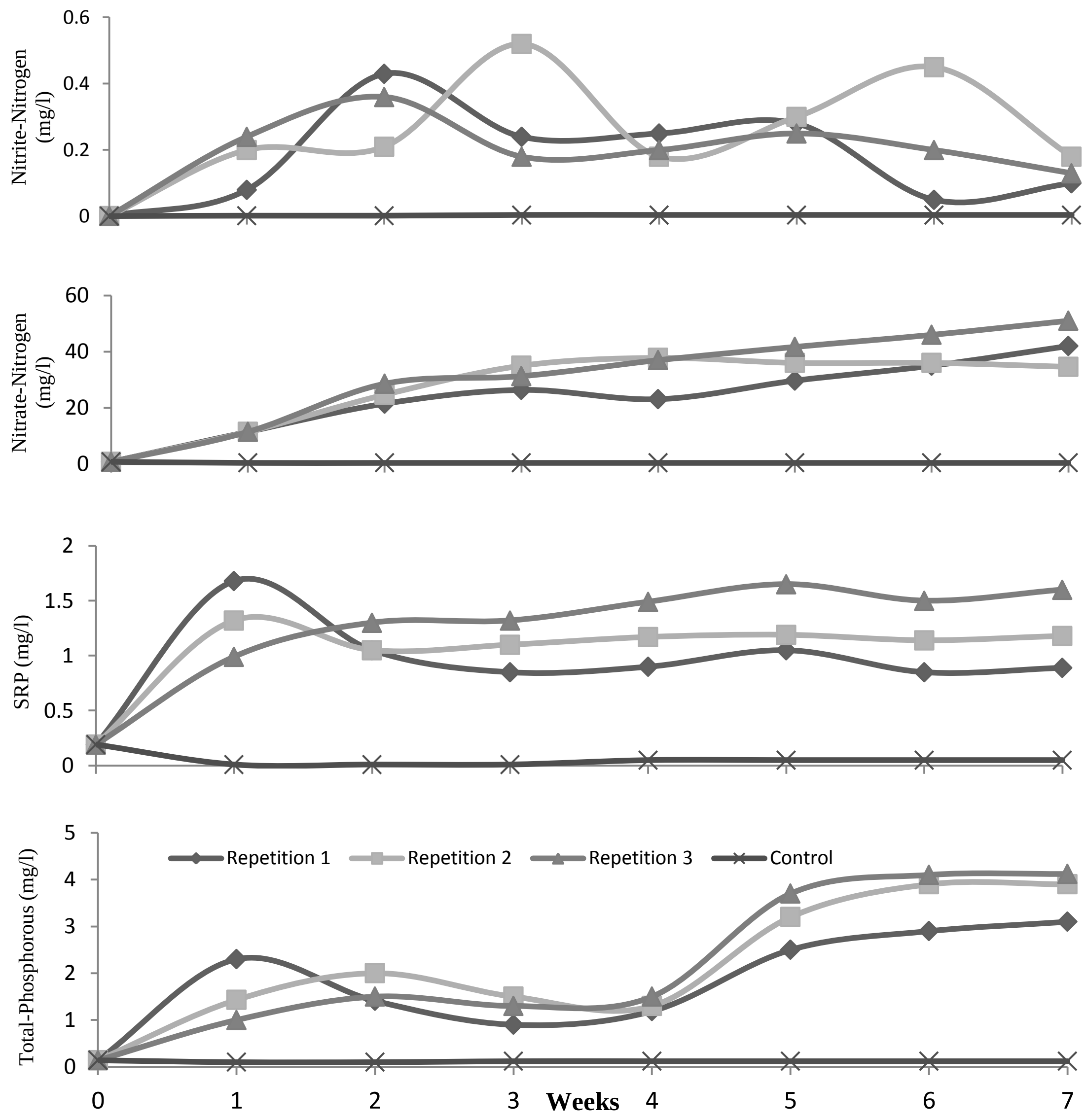

Figure 1. Fluctuation of total nitrogen, nitrate-nitrogen, nitrite-nitrogen, phosphorus dissolved and total phosphorus concentrations in different experiment over 46-day trial.

experiment at concentrations of 0.8 to 1.9 mg l^{-1}. In this study the concentration of NT presents a significant difference from the control (Table 2). The concentration of nitrite (NO_2^--N) fluctuated throughout the study period with minimum values of 0.0015 mg l^{-1} and a maximum of 0.675 mg l^{-1} (Table 2). The highest concentration of NO_2^--N (0.675 mg l^{-1}) was recorded in one of the crops, but during the seventh week values dropped sharply with similar values to other crops (Figure 1). In all crops are fluctuations similar nitrite values from 0.001 to 0.45 mg l^{-1}, with no significant differences ($p <0.05$) between them. Concentrations of NO_2^--N in the control remained with values <0.001 mg l^{-1}, and when compared against the values of the cultures were significant differences (Table 2). The concentration of NO_3^--N was increased with initial values of 0.839 to 58.9 mg l^{-1} (Figure 1). Values NO_3^--N experiments fluctuated with some similarity, without significant differences between them. Nitrate concentrations in the control group during the experiment showed concentrations ranging from 0.02 to 0.4 mg l^{-1}. Control whether significant differences with respect to the values generated in the rest of the experiments (Table 2). The values of total phosphorus (TP) present an upward fluctuation along the experiment very similar between experiments with values of 0.192 to 3.94 mg l^{-1} (Figure 1). Te values recorded in the control remained at concentrations <0.09 mg l^{-1}. Similarly PT values generated during the experiment show a significant difference from the control group (Table 2). The values of dissolved phosphorus (P) during the experiment ranged between 0.142 and 2.1 mg l^{-1}. Control values were maintained at 0.01 to 0.04 mg l^{-1}. According to the statistical analysis values (P) in the experiments did not show significant differences between them (Table 2).

Nutrient balance

Table 3 shows the results of Experiment 2. Nutrient balance revealed that the main entrance was nitrogen and phosphorus through food for tilapia. The entry of nitrogen via food was 71.0 to 75.0%, and phosphorus 53.0 to 65.0% of total inputs (Table 3). Nutrient balance showed that the total nutrients that entered the culture system were recovered (via tilapia) 40-43% nitrogen and 61-70% phosphorus. The average output of nitrogen and phosphorus in the water discharged during harvest was 13% and 4%, respectively. Moreover, what the balance of nutrients found during cultivation, there is a part of the nitrogen and phosphorus that his fate is unknown (44 to 47% N and 26 to 34% P) of the total inputs, suggesting that the recirculation system retained a portion of the nutrients in filters and another portion was possibly volatilized.

Discussion

Growth, survival and production

Experiment 1 showed that the best density for tilapia during the 30 days of culture was to the density of 25 to 51 grams of tilapia per 10 l of water. The survival percentage and the net biomass gained in these densities suggests accordance with the loading capacity of the culture system. The low

Table 3. Nutrient budget (repetition 1, 2 and 3) during a 46-day trial tilapia *Oreochromis niloticus.*

Treatments	Inputs				Outputs			
	Water	Tilapia	Feed	Total	Water	Tilapia	Total	Unaccounted
Nitrogen								
Repetition 1 (g)	0.6±0.1	12.3±1.2	33.3±5.1	46.2	7.41±1.9	18.36±2,1	27.8	20.4±3.2
(%)	1	27	72	100	16	40	100	44
Repetition 2 (g)	0.6±0.2	14.0±1.4	35.9±6.2	50.5	4.86±1.6	21.9±5.2	28.6	23.8±5.1
(%)	1	28	71	100	10	43	100	47
Repetition 3 (g)	0.6±0.2	10.2±1.6	33.3±5.2	44.1	5.73±2.2	17.9±3.8	26.2	20.5±3.2
(%)	1	24	75	100	13	41	100	46
Phosphorus								
Repetition 1(g)	0.02±0.l	4.8±1.3	5.5±2.9	10.4	0.46±0.1	7.3±2.1	3.13	2.8±1.8
(%)	0.02	47	53	100	4	70	100	26
Repetition 2 (g)	0.02±0.1	3.9±2.2	5.9±2.3	9.9	0.39±0.2	6.1±1.9	3.78	3.4±2.1
(%)	0.02	40	60	100	4	62	100	34
Repetition 3 (g)	0.02±0,1	2.9±1.9	5.5±3.1	8.5	0.42±0.3	5.2±1.7	3.31	2.9±1.7
(%)	0.02	35	65	100	5	61	100	34

Values are mean, S.D. (n=6 for each repetition).

densities survivals obtained in culture 74 and 99 g l tilapia/10 possibly relate water quality, feed intake and overcrowding. A similar effect is reported by Gall and Bakar (1999), which indicate that at densities of 18-200 per liter tilapia growth is not affected as long as you keep the flow and suitable water quality.

In experiment 2, as expected crop density tested (26 to 27 grams of tilapia per 10 l of water) had no significant differences in growth and survival factor conversion. This may indicate that the provided artificial food and water quality variables of the system contributed positively in the growth and survival of tilapia. The weight gain obtained in the present study during the 46 days of the experiment was 22 to 32 g of tilapia in 10 l, values lower than those recorded by Shnel *et al*. (2002), reporting yields of 62 to 81 tilapia kilogramos m^{-3} in a water recirculation system. Obtained survival rates of 80 to 86% in this study are similar to that reported by other authors either when tilapia were cultured in cages (Huchette and Beveridge, 2003) or in crops using bio-flocs technology (Crab *et al*., 2009). Feed conversion rates observed in this study (1.8 to 1.9) may be acceptable when compared with previous reports where cultivation tipia reported conversion rates of 0.71 to 3.0 (Schneider *et al*., 2005). The values of feed conversion factor obtained in this study can be attributed to the control of power factor based on observed daily consumption, similarly to the possible accumulation of natural food that over time, may have supported the growth of tilapia. This study demonstrated the potential of the closed system to produce tilapia with low feed conversion factor. It is known that in a closed culture system, nutrients, organic matter and recycled in the system can produce significantly natural food for tilapia (Avnimelech, 2007).

Water quality parameters

In the second experiment in tilapia growth was not limited by the parameters of the water quality. Although total nitrogen concentrations of ammonia NO_2^--N were increased during cultivation, it never reached toxic levels (Colt, 2006). High concentrations of NO_2^--N (0.64 mg l^{-1}) were recorded at the end of the crop, however were very similar to values reported for tilapia culture when they are using different technologies (Twarowska *et al*., 1997; Yousef *et al*., 2005). In other studies with cultured tilapia in intensive zero water exchange have been reported concentrations up to 2.0 mg l^{-1} of NO_2^--N, apparently unaffecting growth and survival of tilapia (Shnel *et al*., 2002). The concentrations of NO_3^--N showed an increasing trend in the experiment ending with concentrations of 40 to 60 mg l^{-1}. Shnel *et al* (2002) reported fluctuations of NO_3^--N from 40 to 150 mg l^{-1} in an intensive system of zero water exchange, no problems for tilapia. Overall fluctuations NO_2^--N and NO_3^--N recorded in our work were within acceptable ranges for tilapia farming. According to some studies the concentration of nutrients in farming systems can be treated with the help of phytoplankton and microbial activity (Diab and Shilo, 1988) or by filtering systems used by RAS such as filters drip, biological filters, digestion processes and stratified reactors, among others (Shnel *et al*., 2002). In our study the concentrations of nitrogen and total phosphorous in the water increased towards the end of culturing. During the study it was found that the concentration of soluble phosphorus was slightly lower than the total phosphorus concentration, suggesting that a portion of phosphorus in the water may have been also in the form of suspended solids. In cultivation of other species it has been reported that orthophosphate concentrations generally ranging between 5 and 20 mg l^{-1} (Boyd, 1990). The food added during the experiment and the closed culture system influenced accumulated phosphorus levels, this might be an advantage to the closed culture system for both nitrogen and phosphorus recycled within the system may have generated various food sources. This coincides with the study of Crab *et al*., (2009), who observed that rapidly growing tilapia in ponds with abundant natural organisms, phytoplankton, bacteria and particulate organic matter. Other variables are known to enhance the growth of fish in intensive farming systems, food dissolved, light intensity, temperature and pH (Krom and Neori, 1989).

Nutrient balance

Previous studies have reported that higher inputs of nitrogen and phosphorus in systems for fish culture is through food with values greater than 70% of the nitrogen and 70% phosphorus (Wallin and Hakanson, 1991). Similar values have been reported for shrimp farming, over 75% of the nitrogen and 57% phosphorus entering the system via food culture (Casillas *et al*., 2006). The values entered via food nutrients in the present study (71 to 75%

nitrogen and 53 to 65% phosphorus) are similar to those reported previously for other crops. The balance of nutrients showed that 40-43% of nitrogen and phosphorus 61-70%, of the total that entered the system could be recovered via the tilapia harvest, the rest of the nutrients derived from uneaten food and metabolic activities of excretion, recirculated in the culture system serving as nutrients for phytoplankton and heterotrophic activity of the culture system. In our study the percentage of nitrogen and phosphorus recovered via tilapia harvest is higher than that reported by other studies (Siddiqui and Al-Harbi, 1999), probably due to the influence of the closed system on the recycling and reuse of nutrients. For salmon farming of *A. salmon*, nitrogen and phosphorus retentions of 49 and 36% were recorded, respectively, attributed in part to the improvement in feed conversion factor and the use of closed systems (Bergheim and Asgard, 1996 cited by Piedrahita, 2003). In general retention of nitrogen and phosphorus reported for several fish species is 10 to 30% nitrogen and 17 to 40% phosphorus (Piedrahita, 2003). Recent studies indicate that one way to retrieve the nutrients is through integrated farming systems or multi-trophic. Schneider *et al*. (2005) reported for an integrated culture of *Oreochromis niloticus* and macrophyte *Lemna minor*, recoveries of 42% of N at harvest tilapia. In addition to the economic importance of an integrated produce some aquatic plants, they can reach up to 300 kilograms of removing nitrogen and 43 kg of phosphorus per hectare per year in the ponds, reducing discharges to the environment (Lin and Yang, 2003; Martins *et al*., 2010). Moreover, the balance of nutrients in our work showed that 1 kg of tilapia grow as loss was 26 to 28 g of nitrogen and 11 to 15 g of phosphorus. These losses are lower when compared to the study of Siddiqui and Al-Harbi (1999), reported that loss of 87 to 96 g of nitrogen and 12 to 14 g of phosphorus to produce one kilogram of tilapia. For shrimp farming in open systems are wasted from 36 to 112 g of nitrogen and 13 to 58 g of phosphorus to produce one kilogram of shrimp (Casillas *et al*., 2006). In the current study, there is a low amount of nitrogen as waste generated by the production of tilapia. The low losses are possibly related to the closed culture system, the excess nutrients that entered the system especially uneaten food and generally was accumulating within the system, may have supported the growth of natural food for the development of tilapia. It is known that natural food in form of microbial flocs are an effective source for tilapia as it can contribute with about 50% of the protein requirements of the fish (Avnimelech, 2007). Additionally, microbial flocs offer the possibility to simultaneously maintain good water quality in closed aquaculture systems (Schryver *et al*., 2008). According to the balance of the total nutrient inputs, the destination or circumstances of 44 to 47% nitrogen and 26 to 34% of phosphorus is unknown. We assume that this part of the nitrogen in the system may have been lost due to volatilization of the ammonia in gas form and/or through denitrification biological filters. Boyd (1986) noted that nitrogen losses are more likely to occur by volatilization of ammonia as a gas, the effect of vigorous aeration and high pH in the ponds. The unaccounted phosphorus is probably related to possibly retention by the filters and/or by adsorption onto particulate matter or sedimentation, since it is known that they have a significant affinity for trapping phosphorous (Boyd, 1986). In conclusion, this study provides valuable information for the practical management of closed systems of tilapia farming as a viable alternative to traditional systems with water exchange. It also showed that the closed culture system can maintain good water quality for growing tilapia: it may increase efficiency or utilization of nutrients and reduce the loss of them through the pond effluents, and minimize environmental impacts by growing tilapia. The amounts of nutrients in crops recovered with minimal recirculation water exchange can be treated easily and integrate them into other productive activities such as agriculture and/or aquaponics.

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