Effect of water exchange intervals on water quality in culture tanks of Oreochromis niloticus (Linn.)

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Abstract
The objective of this study was to investigate the effect of water exchange intervals on the water quality used in fish culture systems. Three treatments were evaluated: water exchange after 24 hours, 48 hours and 72 hours. The experiment was done for six in 100x35x50 cm experimental tanks populated with Oreochromis fingerlings. The result showed that the concentration of ionized ammonia (NH₄) and unionized ammonia (NH₃) significantly increased with the time interval (P<0.05). The highest levels of ammonia (12.9±3.86 mg/l and 0.63±0.19 mg/l) occurred at 72 hours. Nitrites and nitrates showed an insignificant tendency to increase with time. The pH showed a non-significant negative tendency to decrease with time.

Introduction
In intensive fish culture system, good water quality is critical for survival and growth. The high biomass sustained in the system, coupled with fertilization and feeding can result in the accumulation of toxic metabolites such as unionized ammonia and carbon dioxide excreted as metabolic end products of fish, other organisms and micro-organisms (Leah-May et al., 1986). Toxicants may be either swallowed or absorbed by fish with resultant pathology varying from mild toxic response to severe haemorrhage and tissue destruction, terminating in death. Ammonia exists in ponds and tanks in two forms: ionized (NH₄) and unionized (NH₃) forms. Its toxic effects are mainly associated with the unionized (NH₃) form, the concentration of which determines total ammonia and affects water temperature and pH (Eddy, 1982).

Evidence of internal tissue damage in fish from ingested ammonia is not yet available but it is not unlikely that under certain conditions fish will swallow water with high ammonia content and tissue damage may result. Unionized ammonia can readily diffuse across gill membranes with its high biomass sustained in the system, coupled with fertilization and feeding can result in the accumulation of toxic metabolites such as unionized ammonia and carbon dioxide excreted as metabolic end products of fish, other organisms and micro-organisms (Leah-May et al., 1986). Toxicants may be either swallowed or absorbed by fish with resultant pathology varying from mild toxic response to severe haemorrhage and tissue destruction, terminating in death. Ammonia exists in ponds and tanks in two forms: ionized (NH₄) and unionized (NH₃) forms. Its toxic effects are mainly associated with the unionized (NH₃) form, the concentration of which determines total ammonia and affects water temperature and pH (Eddy, 1982).

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The toxicity of nitrite ions (NO\textsubscript{2}) to fish has received much attention (Russo et al., 1977; Tomasso et al., 1981; Palachek and Tomasso, 1984; Lewis and Morris, 1986; and Patricia, 1990). Nitrite may reach high concentrations in intensive or water-recalculating aquaculture systems where ammonia, the major nitrogenous waste product of fish, is first converted by bacterial action to NO\textsubscript{2}, a relatively toxic compound, and then to nitrite, a relatively nontoxic form. Nitrite may also reach toxic levels in streams because of contamination by industrial wastes or by the effluents of wastewater treatment plants.

Killian (2003) stated that nitrite enters a fish culture system after fish digests feed and the excess nitrogen is converted into ammonia, which is then excreted as waste into water. Total ammonia-nitrogen (TAN, NH\textsubscript{3} and NH\textsubscript{4}+) is then converted to nitrite (NO\textsubscript{2}) that, under normal conditions, is quickly converted to nontoxic nitrate (NO\textsubscript{3}) by naturally occurring bacteria. Uneaten (wasted) feed and other organic material also break down into ammonia, nitrite, and nitrate in a similar manner. So, the deterioration of water quality can negatively influence the well being of a fish by inducing toxicoses or by introducing ineffective agents into the fish (Shepherd and Bromage, 1992).

The objective of this study is therefore to compare the effect of different cleaning periods of fish tanks on the concentration of some water quality attributes.

Materials and methods

The experiment was conducted in six glass tanks (100x35x50 cm.) fitted with aerators installed in the middle of each aquarium for the period of the experiment (6 months). 25 fingerlings of Oreochromis niloticus (Lin.) were placed in each tank and were fed a meal of a manufactured diet equivalent to 5% of their body weight divided into 2 parts given twice daily in the morning and evening. The experimental tanks were cleaned and siphoned about 2/3 of their water every 24 hours for aquarium (A), 48 hours for (B) and 72 hours for (C). All the tanks were emptied and refilled every 21 days with tap water. The water level in the tanks was maintained at 30 cm throughout the experimental period. Water samples were taken from each tank, at 5 cm depth below the surface, before cleaning and water change at the intervals of 24, 48 and 72 hours of tank water change. The following parameters were determined using Lovibond colorimetric kits: total ammonium-nitrogen (indeophenol method), nitrate-nitrogen (GR reagent method), nitrite-nitrogen (Cu-Cd column method), pH (electronic digital pH-meter) and temperature. Water samples were also taken from the White Nile and analysed for the same parameters as control representing the continuous flowing water.

One-way analysis of variance was used to study the effect of treatments on water quality. Difference between means were tested by comparing the different cleaning intervals and the control for each parameter. Linear regression was also used to trace the trend of the concentration of each parameter with time according to Crawshaw and Chambers (1988).

Results

The effect of cleaning interval on the concentration of various parameters is given in Table 1. The concentration of ionized (NH\textsubscript{4}) ammonia showed significantly ($P<0.05$) higher concentration for the 72 hours cleaning interval, however the concentration at 24 and 48 hours intervals were not significantly different and unionized (NH\textsubscript{3}) and the White Nile water had the lowest concentration. The unionized (NH\textsubscript{3}) ammonia, concentration was also significantly ($P<0.05$) different among different time intervals indicating an increase with increasing time interval of cleaning.
Nontoxic nitrate (NO₃⁻) gave the values of 0.1±0.2, 0.9±0.01 and 0.18±0.04 mg/l for the White Nile at intervals 24 and 72 respectively, values which were not significantly different (P>0.05). Only the time interval 48 hours was significantly different at the same probability levels (P<0.05). Nitrites (NO₂⁻) showed a similar trend to that of nitrates.

| pH values were not significantly (P>0.05) different in the four treatments. The temperature of the three time intervals were also not different from each other, but were significantly (P<0.05) different from that of the White Nile. NH₄ increased with time interval at a rate of 0.21±0.03 mg/l per hour. The regression was significant indicating a linear trend for NH₄ to increase with time (Table 2). NH₃ exhibited a significantly linear relationship increasing with time period at a rate of 0.01 mg/l per hour; NO₃ and NO₂ did not significantly vary with time though they showed a weak tendency to increase as the cleaning intervals increased.

Discussion

The time interval for changing and cleaning of water had no significant effect on pH and temperature of water. It had a slight insignificant effect on the concentration of NO₃ and NO₂. These tended to change slowly as exemplified by the slopes of their regression equation slopes.

| Table 1: Physico-chemical characteristics of water samples as affected by changing interval time (means are significantly different from each other) |
|-----------------|-----------------|-----------------|-----------------|-----------------|
|                | pH              | Temperature    | NO₃             | NO₂             |
| White Nile     |                  |                |                 |                 |
| 24 hours       | 7.4±1.35        | 150±40         | 0.03±0.02       | 0.12±0.04       |
| 48 hours       | 7.28±0.16       | 25.6±5.44      | 0.19±0.01       | 0.17±0.08       |
| 72 hours       | 7.15±0.19       | 24.79±4.08     | 0.18±0.04       | 0.17±0.08       |
| Measurements are in mg/l for compounds, C for temperature |
Experimental tanks cleaned and have their water changed every 24 hours, maintained the most suitable and close to the acceptable concentration range of tested water quality parameters. However, this still comes next to the White Nile water which has the most acceptable concentration. Experimental tanks left for three days (72 hours), without changing and cleaning their contents caused concentration levels of NH₄, NH₃ to accumulate in quantities which were significantly different from other different time intervals studied. NO₃ and NO₂ showed a tendency to increase also. This is in agreement with Lucia et al., (2003) who investigated the effect of continuous water exchange on water quality. The ammonia (NH₄ and NH₃) in the tank is excreted by fish through gills and in faeces as part of the protein and amino acid metabolism and the excreta of fish and other organisms, microorganisms, and decomposition of waste food and organic matter in the experimental water tanks. Small amounts of ammonia induce stress on fish leading to many complications. In this study the running water of the river, the natural habitat of fish, showed levels below toxicity due to the presence of nitrifying bacteria in the water. In the presence of nitrosomonas bacteria, ammonia is oxidised first to NO₂ by nitrobacter bacteria and then to NO₃ by nitrobacter bacteria (Freese, 2003). However as these nitrifying bacteria may take some time to form in the tank, the other treatments developed toxic levels of ammonia due to paucity of nitrifying bacteria which might not have yet developed to equilibria levels.

From this study, it is concluded that ionized (NH₄) and unionized (NH₃) ammonia forms accumulated in fish tanks as the cleaning interval is increased, whereas nitrite (NO₂) and nitrate (NO₃) showed a weak tendency to increase with time probably due to the slow growth of nitrifying bacteria in the tanks. It is also concluded that 24 hours of cleaning intervals gave comparatively less concentration of waste and is therefore recommended as the best time interval for flushing fish culture tanks.

References


Palachech, R. M. and Tomasso, J. R. 1984. Toxicity of nitrite to channel catfish (Ictalurus punctatus), tilapia (Tilapia aurea) and large mouth bass (Micropterus salmoides): evidence for nitrite exclusion mechanism. Canadian journal of fisheries and aquatic sciences. 41, 1739-1744.


