

Full Length Research Paper

Acute toxicity of ammonia to blue tilapia, *Oreochromis aureus* in saline water

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The acute toxicity of blue tilapia, *Oreochromis aureus* (3.28 ± 0.36 g in body weight, 61.84 ± 2.08 mm in body length) exposed to environmental un-ionized ammonia at different salinities (1, 8, 12, 16 and 20 ppt) was assessed via a series of static exposure trials. Median lethal concentrations of 24 h of exposure were calculated for each salinity. Tolerance of blue tilapia to acute un-ionized ammonia exposure was not influenced by salinity. Median lethal concentrations (24-h LC₅₀) values were found to be 2.83, 2.26, 3.14, 3.11 and 1.93 mg/l NH₃ at 1, 8, 12, 16 and 20 ppt of salinities, respectively. The results of this study indicate that using brackish water for blue tilapia culture may not be a single factor to reduce the toxicity of high ammonia.

Key words: *Oreochromis aureus*, blue tilapia, ammonia, salinity.

INTRODUCTION

All tilapia species can live in saline waters. *Oreochromis mossambicus* is the most tolerant species and *Oreochromis aureus* is more tolerant than *Oreochromis hornorum* but red tilapia can survive even marine water.

There are essentially two limiting water quality factors, that is, dissolved oxygen (DO) and ammonia in aquaculture practices. These factors limit feeding rate and stocking rate of fishes in ponds or raceway systems (Knud-Hansen et al., 1991). Ammonia is excreted through gills of most teleostean fish and they are secreted as a waste product of catabolic process taking place in the liver. If they are accumulated in the body, they are toxic to fishes. Ammonia consists of two forms, one is un-ionized ammonia (NH₃), which is toxic to fishes and ionized ammonia (NH₄⁺), which is comparatively nontoxic. These two ammonia forms are in balance in

aquaculture systems depending on the pH and temperature (Emerson et al., 1975). Moreover, the ammonia toxicity may also rely on salinity and DO (Alabaster et al., 1979). Previous studies on Atlantic salmon showed that ammonia toxicity could be decreased with increase in DO and salinity (Alabaster et al., 1979). Another study showed that the increase in temperature reduced the acute ammonia toxicity (96-h LC₅₀) in fathead minnows (Thurston et al., 1983). Another study showed that the un-ionized ammonia concentration could increase in pH (Tomasso et al., 1980). The choice of fish species in culture, size of fish, acclimation and type of culture system could also influence toxicity level (El-Sayed, 2006). The salinity has often shown beneficial effect on growth rate and effective in the reduction of un-ionized ammonia toxicity in many fishes. Researchers

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Table 1. Water quality parameters in fresh and salt water.

Parameter	Fresh water	Saltwater
EC (mmhos/cm)	147.80	842.20
Hardness (mg/l CaCO ₃)	109.80	732.50
Alkalinity (mg/l CaCO ₃)	90.00	600.00
Bicarbonate (mg/l)	71.40	348.90
Calcium (mg/l)	0.02	89.80
Magnesium (mg/l)	4.37	12.40
Total Ammonia (mg/l)	0.10	0.22
Nitrite (mg/l)	0.00	0.007
pH	7.94	8.18

have earlier reported that lowering the salinity concentration enhanced the growth rate in turbot (Imsland et al., 2001), European sea bass (Rubio et al., 2005), cobia (Resley et al., 2006), Atlantic halibut (Imsland et al., 2008) and Senegalese sole (Arjona et al., 2008). Nevertheless, elevating the salinity level also resulted in the increase in growth rate of fish species like, tilapia (Kangombe and Brown, 2008), Eurasian perch (Overton et al., 2008) and goldfish (Luz et al., 2008). In addition, increasing the salinity elevated the tolerance limit of ammonia toxicity in rainbow trout (Herbert and Shurben, 1965) and chinook salmon (Harader and Allen, 1983).

Hence, the present study was designed to evaluate the influence of different salinity levels of saline waters (1, 8, 12, 16 and 20 ppt) on un-ionized ammonia toxicity level in the fingerlings of blue tilapia, *O. aureus*.

MATERIALS AND METHODS

The toxicity of un-ionized ammonia in tilapia was investigated via 24-h static acute bioassays at different salinity levels (1, 8, 12, 16 and 20 ppt). Bioassays were performed according to the techniques by Boyd and Tucker (1998). Ten (10) fingerlings of blue tilapia (3.28 ± 0.36 g in body weight and 61.84 ± 2.08 mm in body length) were placed into 10-L aquarium with two replicates (2 x 5 x 10, 100 fish). In order to optimize the desired salinity for the experiment, the artificial marine salt (NaCl) was added to fresh water, where the salinity was 1 ppt; and salt water, where the salinity was 8 ppt. The criteria for the two water sources are given in Table 1. Ammonia concentrations for four different treatments were prepared by using ammonium solution (Merck 25%, cat no: 105432) following fundamental laboratory techniques. Ammonia stock solution prepared was 0.91 kg/l. Before the commencement of each experiment, the fish were acclimatized for a week under saltwater source (8 ppt) in laboratory conditions. Acclimation was followed by methods suggested by Boyd and Tucker (1998). The experimental fishes were measured for length and weight and then they were placed into the desired ammonia concentration and salinity for the next 24-h period. During the experimental trial, feeding was stopped. Room temperature (24 to 25°C) was controlled by using an air conditioner, which maintained the temperature at a constant range. Fish mortality, water pH and temperature were recorded at 4 h interval. Approximately, 90% of mortality was seen within the first 8 h in all the four treatments. Un-ionized ammonia concentrations for each salinity and total ammonia treatments were calculated

(Emerson et al., 1975). Median lethal concentrations were estimated by the graphical method used by Finney (1971). During the exposure trial, ammonia concentration of water source and that of excretion by fish were ignored. Hazel et al. (1971) reported that ammonia excretion by test concentrations used for treatments.

RESULTS AND DISCUSSION

Median lethal concentrations of un-ionized ammonia in fingerlings of blue tilapia at salinities of 1, 8, 12, 16 and 20 ppt are presented in Table 2. There were no significant differences ($p < 0.05$) among the 24-h LC₅₀ values at different salinities. Mean 24-h LC₅₀ values were 2.83, 2.26, 3.14, 3.11 and 1.93 mg/l NH₃ at 1, 8, 12, 16 and 20 ppt of salinities, respectively. Mean LC₅₀ values slightly fluctuated among different salinities (Figure 1). Fresh water hardness and alkalinity were much more different from that of saltwater and this did not have any influence on 24-h LC₅₀ of un-ionized ammonia at different salinities.

Median lethal concentrations of un-ionized ammonia in fingerlings of blue tilapia were not influenced by salinity and showed only minimum changes with different salinities. The results from this exposure trial showed similar pattern with many other earlier studies. Weirich and Riche (2006a) found that the ammonia tolerance of Florida pompano, *Trachinotus carolinus* was not affected by salinity. Similarly, Weirich and Riche (2006b) also reported that 24 and 96-h LC₅₀ values of black sea bass were not influenced by salinity increase. Atwood et al. (2004) also examined ammonia toxicity in black sea bass and reported similar trend. Sunshine Bass (Weirich et al., 1993) and golden shiner (Sink, 2010) also did not show any difference in toxicity of ammonia at different Salinities. In this study, mean 24-h LC₅₀ was found to have 2.83 mg/NH₃ in fresh water (1 ppt). However, a study by Redner and Stickney (1979) estimated comparatively lesser level (2.4 mg/l NH₃) of LC₅₀ 48-h in blue tilapia (7 to 8 cm long).

Toxicity trials are classified as short-term tests (lethal or acute) and long-term tests (sublethal). Acute toxicity (median lethal concentration, LC₅₀) is defined as the

Table 2. Chemical characteristics of bioassay waters and associated median lethal concentrations (LC_{50s}) of un-ionized ammonia in tests with tilapia.

Salinity (ppt)	Mean fish weight (g)	Mean fish Length (mm)	Temperature (°C)	pH	Hardness (CaCO ₃) (mg/l)	Alkalinity (CaCO ₃) (mg/l)	TAN (mg/l)	24-h LC ₅₀ (mg/l) NH ₃
1	3.19±0.40	61.90±2.25	25.34±0.17	7.94±1.13 (7.14-9.56)	4.4	71.4	14.5	2.83
8	3.41±0.50	62.26±2.92	24.84±0.19	8.13±0.33 (7.85-8.97)	732.5	600.0	25.5	2.26
12	3.36±0.26	61.98±1.64	25.10±0.18	8.15±0.46 (7.77-8.94)	732.5	600.0	30.5	3.14
16	3.11±0.40	60.70±2.22	25.16±0.22	8.15±0.42 (7.73-8.89)	732.5	600.0	32.0	3.11
20	3.30±0.18	62.25±1.49	24.86±0.13	8.31±0.64 (7.79-9.00)	732.5	600.0	24.0	1.93

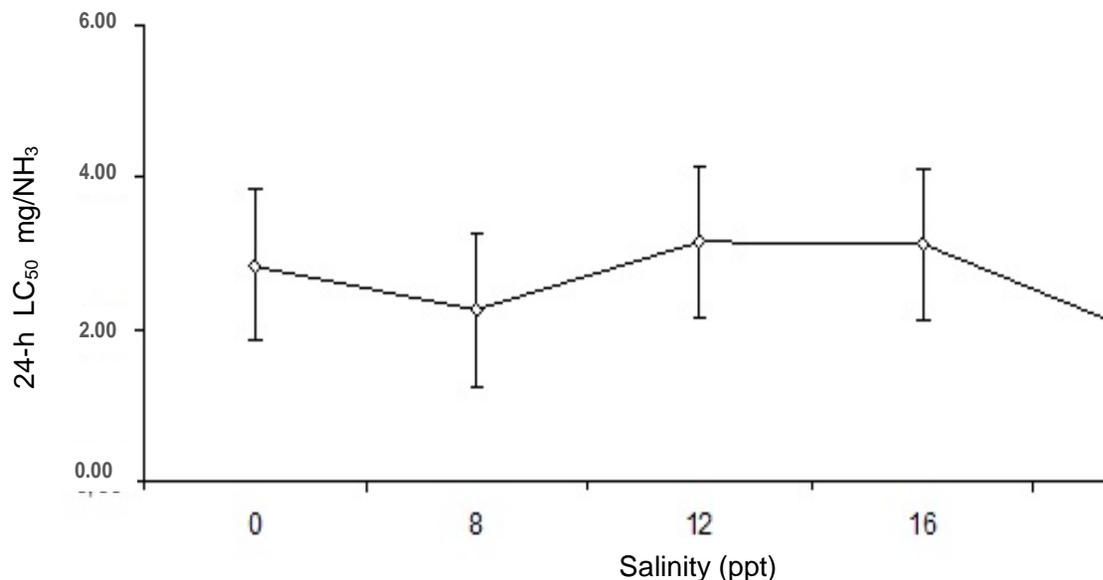


Figure 1. Median lethal concentrations of ammonia in blue tilapia at salinities of 1, 8, 12, 16 and 20 ppt.

concentration in which 50% of fishes show mortality. Various test durations such as 24, 48 and 96 h are used for toxicity studies. Actually, acute ammonia concentration is rarely been encountered in aquaculture areas but it is used to find out the maximum allowable toxicant

concentration (MATC) for a particular species. Toxicity of un-ionized ammonia to fingerlings of blue tilapia in saline waters has not been studied in detail yet. Therefore, this study was undertaken to examine the 24-h UIA toxicity to fingerlings of blue tilapia in various salinities.

Most of the recent studies examined the effects of sublethal ammonia on various species (Kawamoto, 1961; Robinette, 1976; Colt and Tchobanoglous 1978; El-Shafai et al., 2004; Redner and Stickney 1979). Long-term ammonia exposure causes growth reduction and physiological

disabilities in fishes. Kawamoto (1961) reported that higher ammonia level reduced growth in common carp. Robinette (1976) indicated that ammonia exposure at 0.12 to 0.40 mg/l NH₃ decreased growth rate in channel catfish. Colt and Tchobanoglous (1978) observed that channel catfish grew 50% less when exposed to 0.517 mg/l NH₃ and showed no growth when exposed to 0.967 mg/l NH₃. El-Shafai et al. (2004) estimated the effect of chronic ammonia exposure to Nile tilapia fed with duckweed. Chronic ammonia ranging from 0.07 to 0.14 mg/l NH₃ caused a negative effect on tilapia growth. They recommended chronic ammonia concentration to be less than 0.1 mg/l NH₃. Redner and Stickney (1979) also indicated that acute and sublethal ammonia exposure caused histological effects (capillary congestion, hemorrhaging and telangiectasis) on gills of *Tilapia aurea*.

In conclusion, the result of this study demonstrates that manipulation of salinity may not mitigate the acute toxicity of un-ionized ammonia to fingerlings of blue tilapia.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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