

Behavioural Responses in *Tilapia guineensis* Treated with Sodium Bromide under Laboratory Conditions

Ayaobu-Cookey, Ibifubara Kalada

Department of Aquaculture, Nigerian Institute for Oceanography and Marine Research, Victoria Island, Lagos

*Corresponding Author

Ayaobu-Cookey, Ibifubara Kalada

Email: ibfcookey@gmail.com

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Abstract: Chemical spills into water have recently raised concerns. The goal of this study was to examine the long-term toxicity of *Tilapia guineensis*, a widely used aquacultured fish, to sodium bromide, a frequently used disinfection agent. 96-hour lethal concentration (96h.LC50), median lethal time (MLT50), operculum beating rate (OBF), tail beating rate (TBF), and behavioral reactions to each. 150 T. *guineensis* were examined at various sodium bromide concentrations (0.00 mg/L control, 5.00, 10.00, 15, 00, and 20.00 mg/L). Their average length and weight were 15.99 and 145.77 cm, respectively. The findings demonstrated that *T. guineensis* exhibited early signs of stress, including increased opercula ventilation, erratic swimming, and gasping for air. Pattern of TBF response to time and concentrations. The cumulative fatality scores increased as exposure time and concentrations increased. These behavioral responses in aquatic creatures have been found to be sensitive markers of pollution levels. When utilizing sodium bromide-based herbicides near aquatic areas, caution should be exercised.

Keywords: Contaminants, *Tilapia*, Toxicity, Aquatic Environment, Sodium bromide.

INTRODUCTION

Pollution has become a major issue in many regions of the world in recent years. Aquatic ecosystems continue to be the final receiver of pollution inputs into the ecosystem, both natural and human-made [1, 2]. Since almost all life depends on water, aquatic pollution is the most worrisome type of pollution. Additionally, pollutants decrease water bodies' quality, rendering them unsuited for aquatic life, particularly fish [3]. Toxic substance releases, such as chemicals, have been blamed for the global decline in aquatic life populations. Furthermore, the action of chemicals is regulated by a number of environmental conditions that are harmful to aquatic creatures [4]. One of the primary causes of rising levels of pollutants in aquatic habitats is an increase in human activity. Water contamination has resulted from the discharge of waters from cities, public spaces, and enterprises [5]. As fresh water and coastal pollution have increased considerably in recent years, so have environmental problems in many developing countries around the world [6].

Fish are exposed to pollutants through the water and through the food they consume. They can get in through the skin, gills, or even the mother while she is pregnant [7]. One of the most harmful characteristics of pollutants is that they tend to concentrate in animal body tissues since they are lipid soluble. The biomagnification process, which causes chemical concentrations to increase at higher trophic levels, exacerbates this issue [8]. The levels of contaminants found in the body tissue of amphibians are frequently many times higher than those found in the nearby waters [9]. Aquatic bodies have been shown to be heavily contaminated by chemicals from industrial and domestic sources [10]. Biocide is one of these compounds, which is used in both homes and industries. Biocides are essential in modern agricultural technology for controlling weeds and pests in order to increase food output and manage public health. To inhibit the growth and development of

fouling organisms, biocides such as sodium bromide are commonly used. The working life of a biocide in water cooling systems is determined by ambient variables, the amount injected, and the compound's physical and chemical destiny. Unfortunately, the residual of these practices, which are infrequently released towards waterways, watercourses, and coastal environments contain minute quantities of biocides and their dreadful conditions / conversion [11].

Furthermore, Gabriel et al [12] noted that toxicity is one approach for evaluating the effects of substances in an organism. This is used to describe a substance's potential to harm or negatively impact a living being. Acute toxicity studies look at whether a set of test organisms may be harmed by a specific amount of test substance or effluent following a brief exposure under controlled circumstances [13]. Fish behavioral responses are used as a valid technique by toxicologists worldwide to evaluate laboratory toxicity testing.

Furthermore, Agular [14] defined behavioral toxicity as a change caused by stress that surpasses equilibrium. It is thought that behavioral alterations in fish are the most sensitive markers of neurotoxicity, which may explain the enormous number of animal research. An organism's behavior permits it to adjust to external and internal inputs in order to effectively meet the challenge of surviving in a changing environment. [15]. Sublethal toxicity can cause behavioral and morphological changes in aquatic organisms, reducing their health and fitness. Thus, behavioral and morphological changes have been shown to be more sensitive diagnostic endpoints than death [16]. Moreover, Agular [14] also described behavioral toxicity as a shift brought on by stress that exceeds homeostasis. Fish behavioral changes are believed to be the one of the greatest profound indicators of neurotoxicity, which may help to explain the vast amount of animal studies. The ability

of an organism to adapt to both internal and external inputs enables it to successfully tackle the task of surviving in a changing environment [15]. Aquatic species may experience behavioral and morphological changes as a result of sublethal toxicity, which will affect how fit and healthy they are. Therefore, it has been demonstrated that behavioral and morphological alterations are more sensitive diagnostic endpoints than death [16]. Behavioral toxicity indicators seem suited for evaluating the effects of aquatic pollutants on fish populations because behavior links physiological function to ecological processes. Importantly, research is starting to connect physiological alterations to behavioral disruption, lending ecological significance to physiological measures of toxicity [17]. The objective of the current study is to assess how sodium bromide exposure affected the behavior of *T. guineensis*.

MATERIALS AND METHODS

Location of Experiment

The experiment was carried out at the African Regional Aquaculture Centre's brackish water research facility in Buguma, Rivers State, Nigeria.

Experimental Fish Source

At low tide, 180 *T. guineensis* of the same size—mean length 15.99 4.08cm and mean weight 145.77 7.04g—were retrieved from the mangrove swamps of Buguma Creek. Four 50-litre polypropylene containers were used to carry them to the lab where they underwent the acclimatization procedure.

Fish Acclimatization and Feeding

The test fish spent seven days getting used to the experimental circumstances in four 150-liter circular plastic tanks with 150-liters of dechlorinated water and muck at the bottom. Netted textiles with central slots were fastened to the tops of the tanks to prevent fish from escaping. The water was changed every two days. The fish were fed a commercial feed at 3% body weight.

Test Solution Acquisition

In Garrison, Port Harcourt, Rivers State, Nigeria, at the "Analytical" chemical store, sodium bromide (NaBr), a biocide that is frequently used, was purchased off the shelf. Its chemical symbol is NaBr, which stands for sodium bromide. It resembles sodium chloride and is a white, crystalline solid with a high melting point. It is a typical bromide ion source with a wide range of uses **Test Solution Preparation**

The sequential application technique described by Nte *et al.* [18] was used to generate the chemical solution in water.

Exposure of Fish to Bromide of sodium

Ten *T. guineensis* were each placed into a tank that was 1.5 m x 1 m x 0.5 m and had a biocide concentration of 0.00 (control), 5.00, 10.00, 15.00, and 20.00 mg/L. The study period lasted 96 hours, with three copies of each treatment and control. Every day, a new batch of biocide solution was added to each concentration. The fish tanks were lined with netting fabric to prevent the fish from escaping. At 12, 24, 36, 48, 60, 72, 84, and 96 hour intervals, mortality, tail beat frequency (TBF), and pulmonary oedema beat frequency (PBBF) were all assessed. Every 12 hours, dead fish were counted and removed from aquariums. A fish was deemed dead if there was no discernible movement and no response when the caudal pendicle was touched.

Water Quality Parameter Evaluation

Temperature readings were taken using a Celsius thermometer that was loaded with mercury. A pH meter was used to determine the pH. While salinity was assessed using a hand-held refractometer (model HRN-2N, Atago Products, Japan), nitrite, sulphate, chloride sulphide, and ammonia were analyzed using a calorimetric char designed by SUNPV, Biochem, Beijin China. Two droplets of water and effluents were placed on a piece of refractive glass, and

the results were observed from the back. Dissolved oxygen concentration was measured using Winkler's technique, APHA [19].

Statistical Evaluation

The Statistical Package for the Social Sciences (SPSS) version 20 was used to analyze the study's data using ANOVA, and the Duncan Multiple Range test with a 0.05% significance level was used to distinguish between mean differences. The dependent trial variables (OBF, TBF, and death) were compared based on the toxicant concentration. The median lethal time for the different biocide concentrations, as well as the deadly concentration (LC50) values for the 24, 48, 72, and 96 hour time periods, were determined using Probit Analysis. The fatal value was multiplied by 0.1 to determine the safe concentration of the biocide at each time period [20].

RESULTS

Water Quality Parameters

Table 1 displays the findings of the physico-chemical characteristics of the exposure tanks in research on chronic toxicity. The dissolved oxygen values in the *T. guineensis* aquariums that were exposed to sodium bromide for 96 hours showed a significant decrease ($p > 0.05$), but significant increases with higher concentrations of the chemical were noted in the values of ammonia, chloride, and sulphide.

Changes in General Behavior

Anomaly behavior was observed in the fish after contact with the toxin. The abnormal behaviour was a Neural Paralytic Syndrome (NPS) manifestation. An increased sensitivity to outside stimuli, as well as a lack of movement coordination and direction in water, were signs of intense restlessness and excitement. There was additional abdominal twisting and jerk weakness (areflexia). Jumps over the water's surface were seen, especially in those who received the greatest dose of the toxin, along with rapid opercular movement and continuous air gulping. Fish behavior was unaffected by lower doses (5.0 and 10.0mg/L). When the amount of sodium bromide in the water increased, these fish abnormalities also did, but they diminished with time (Table 2).

T. guineensis Behaviour Responses (Opercula Beat Frequency and Tail Beat Frequency) and Mortality after 96 hours of Sodium Bromide Exposure

OBF/min and TBF/min both showed a similar pattern of response to exposure duration and toxicant concentration; they both increased with exposure time and concentration and decreased with exposure time and concentration, particularly at the highest concentration and exposure time (Tables 3 and 4). OBF/Min and TBF/Min have comparable, narrow variation ranges. The fish's cumulative mortality increased over time and varied greatly between concentrations and time periods. OBF and TBF values significantly changed as a result of different biocide extraction concentrations, according to an ANOVA ($P < 0.05$) (Tables 2 and 3). Both the OBF and the TBF had significant changes as a result of the exposure period ($P < 0.05$).

The OBF and TBF significantly changed as a result of the interaction between exposure time and toxicant concentration ($P < 0.05$). According to an ANOVA, there was no difference in the cumulative mortality of the fingerlings for exposure duration ($P < 0.05$) or for interactions between exposure time and toxicant concentration ($P < 0.05$). Both the concentration of the toxin and the

duration of exposure increased death. There was no evidence of mortality in the control group (Table 4).

T.guineensis Lethal Concentration (LC) of Sodium Bromide for 96 hours

The deadly effects of bromide on *T. guineensis* exposed to LC5, LC50, and related 95% confidence limits of the toxicant concentration are presented in Table 4, which also revealed that the

range of values between 24hr LC50 and 96hr LC50 was relatively narrow. For *T. guineensis*, bromide had an unusually high LC50 (2.08 mg/l for 24 hours and 1.20 mg/l for 96 hours). The toxicity factor (T.F.) of the various doses increased with exposure time from 24 to 96 hours, as evidenced by the observed drop in LC50 value. T.F. was reported as being at 1.0 after 24 hours and 1.26 after 96 hours. (Table 5).

Table 1: Water Physicochemical Parameters in *T.guineensis* Experimental Tanks Exposed to Sodium Bromide for 96 Hours

PARAMETERS	0.0	5.0	10.0	15.0	20.0
Temperature (°C)	28.99± 5.09 ^a	28.72± 4.04 ^a	28.09 ± 5.03 ^a	28.58± 6.88 ^a	28.12±4.19 ^a
pH	6.57± 2.04 ^a	6.66± 0.07 ^a	6.63± 1.87 ^a	6.66± 2.07 ^a	6.69± 0.77 ^a
Ammonia (mgL ⁻¹)	0.09± 0.00 ^a	0.11± 0.01 ^b	0.40 ± 0.02 ^a	0.43± 0.03 ^b	0.46± 0.02 ^b
Dissolved Oxygen (mgL ⁻¹)	7.89± 2.55 ^c	6.77± 1.81 ^b	6.73± 1.91 ^b	5.89± 1.73 ^b	3.55± 1.91 ^c
Nitrite (mgL ⁻¹)	0.01± 0.00 ^a	0.02± 0.01 ^b	0.02± 0.00 ^b	0.03± 0.01 ^c	0.04± 0.02 ^c
Sulphate (mgL ⁻¹)	0.02± 0.01 ^a	0.02± 0.01 ^a	0.03± 0.01 ^a	0.05± 0.01 ^a	0.06± 0.01 ^a
Chloride (mgL ⁻¹)	7.55± 1.03 ^a	8.18± 2.19 ^a	8.77 ± 1.80 ^a	9.68± 2.09 ^b	10.04± 2.6 ^c
Sulphide (mgL ⁻¹)	0.10± 0.01 ^a	0.11± 0.02 ^a	0.32± 0.02 ^b	0.39± 0.11 ^b	0.48± 0.02 ^c

Mean within the same superscripts in the row are not significant different (P<0.05)

Table 2: Responses in *T. guineensis* Behaviour Sodium Bromide Exposure

Behaviour	Concentrations of Sodium Bromide (mg/L)				
	0.00	5.00	10.00	15.00	20.00
Air gasping	-	+	+	++	++
Swimming Erratically	-	+	+	++	++
Loss of Colour	-	-	+	++	++
Critical Injuries	-	-	-	++	++
Decline in reflex	-	-	+	++	++
Skin wrinkling	-	-	-	++	++
Secretion of Mucous	-	-	-	++	++

Key : ++ = highly present; + = present; - = absent

Table 3: Changes in Tail Beat Frequency, Opercula Beat Frequency, and Cumulative Mortality (%) in *T.guineensis* after 96 hours of Sodium Bromide exposure (Mean ±SD)

Variables	Time of Exposure (Hours)			
	24	48	72	96
TBF/min	20.77 ± 5.21 ^a	27.89± 4.04 ^b	22.87± 6 .66 ^b	14.05± 3.03 ^c
OBF/min	110.45± 12 .99 ^a	125.98± 7.06 ^b	111.04± 9. 04 ^a	68.44± 9 .42 ^c
Cum. Mortality	35.22± 1 .99 ^a	56.05± 6.77 ^b	66.91± 8.88 ^b	75.88± 9 .31 ^c

Mean within the same superscripts in the row are not significant different (P<0.05)

Table 4: Changes in the Tail Beat Frequency, Opercula Beat Frequency and Cumulative Mortality (%) in *T.guineensis* at Different Concentrations of Sodium Bromide

Variables	Concentration of Sodium bromide (mg/L)				
	0.0	5.0	10.0	15.0	20.0
TBF/min	15.58± 4.88 ^b	15.78± 4.03 ^b	18.55± 2 .03 ^b	12.00± 3.03 ^a	10.32 ± 3.12 ^a
OBF/min	97.04±4.54 ^a	129.99± 9.88 ^a	109.88± 8 44 ^a	102.46±8.84 ^{a-}	70.04±7.19 ^c
Cum. Mortality		25.04± 2 .99 ^d	26.44± 4.64 ^d	32.88±1 .81 ^a	50.66± 7.99 ^b

Mean within the same superscripts in the row are not significant different (P<0.05)

Table5: Sodium bromide exposure to *T. guineensis*: lethal concentration and associated 95% confidence limit

Time (hrs)	Lethal Concentration (mean +C.L.)	Optimal Concentration	Formula for the probit model estimate
24	LC ₅₀ - 20.37 (18.66-24.97)	2.04	y=-4.72+0.21×
24	LC ₉₀ - 25.99 (23.74-32.66)	2.60	
48	LC ₅₀ - 17.31 (15.02-18.07)	1.73	y=-5.12+0.25×
48	LC ₉₀ - 20.99 (18.92-25.51)	2.09	
72	LC ₅₀ - 15.38 (14.22-16.99)	1.54	y=-5.32+0.33×
72	LC ₉₀ - 19.02 (17.66-22.77)	1.90	
96	LC ₅₀ -13.71(10.99-15.89)	1.37	y=-5.16+0.27×
96	LC ₉₀ - 17.02 (14.02-19.99)	1.70	

DISCUSSION

Four main stages have been identified as verifiable responses of fish to toxicants in the assessment of fish behavior in response to pollutants: interaction (brief period of excitability), application (visible avoidance characterized by fast swimming, leaping, and an attempt to jump out of the toxicant), loss of balance, and mortality [21]. In *Oreochromis mossambicus* treated with carbamate pesticide, Rita et al. [22] discovered the same behavioral effects. The energy required for metabolism may have been increased beyond normal levels by hyperactivity, a greater ventilatory rate, dash and erratic swimming, more surfacing, and other abnormal activities, leading to fatigue and stress [23]. Because sodium bromide affects the fish's gills and general metabolism, the traumatic behavior reactions of the exposed *T. guineensis* revealed that they experienced respiratory impairment. The gill structure of exposed fish was disrupted, and mucus cells produced more mucus, indicating that oxygen exchange across the gills may have been hampered. These results are in line with earlier studies that examined the immediate effects of Cadmium in *Channa punctatus* [23]. They explained these actions by a neurological disorder brought on by the toxins.

The 24 hour LC50 value of sodium bromide for *T. guineensis* was found to be 20.81 mg/l, demonstrating that sodium bromide is toxic to fish. Various fish species have different susceptibilities to sodium bromide [24]. This result is in line with Rani's [25] findings in laboratory experiments using *Labeo rohita* and the pesticide Nuvan. Three elements work together to generate bromide toxicity in fish: a sensitive central nervous system, delayed hydrolytic detoxification, and direct gill absorption into the bloodstream. Additionally, biocides could result in a secondary osmotic imbalance, which heightens their toxicity. Sodium bromide's neurotoxic effects could have affected how nerve cells regulate their manufacturing process [26]. The findings of Nwani *et al.* [27], who assessed the acute effects of a glyphosphate-based herbicide on *Tilapia zilli*, are consistent with the response pattern of exposed fish tail beat frequency with respect to time and biocide concentration. It was different from Chandanshive's [28] discoveries in *Mystus montanus* exposed to detergents, though. In several investigations, TBF levels seemed to increase with passing time and toxicant concentration. As demonstrated in fish exposed to paraquat [29], the mode of action of the biocide on exposed fish may entail interruption of nerve impulse transmission.

The fish may have been less sensitive to the biocide than *Labeo rohita* when exposed to paraquat, possibly as a result of its mode of action and fish size, as seen by the generally low levels and less varied TBF values reported in this study [30]. OBF showed to be a more responsive metric in assessing behavioral toxicity in *T. guineensis* exposed to biocide than TBF. OBF tends to grow, peak, and then fall over time for the different toxicant concentrations investigated in this study and others [31]. However, differences in fish species, life stages, and toxicant mode of action may be able to account for the disparities revealed in this analysis. Ndome et al. [32] found that decreased oxygen uptake, transport, or metabolic rate efficiency could be the root of greater opercular rate. The fish may have increased both TBF and OBF to deal with the stress brought on by herbicide exposure, but the latter specifically to increase the rate of water flow over the gills, hence increasing oxygen intake from the water.

CONCLUSION

This investigation showed that, other from dissolved oxygen, which decreased as the chemical content grew, exposure to sodium bromide had no influence on water quality measurements. Unbalances or disruptions in the studied biomarkers showed a rapid response once the fish came into contact with the biocide. The behavioral responses observed in this study are sensitive indicators of the pollution burden in aquatic organisms. Additionally, extra caution should be used when using herbicides containing sodium bromide close to aquatic ecosystems.

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