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# Correlation of Toxicity with Bilge Water Exposure in African Catfish [*Clarias gariepinus* (Burchell, 1822)] Juveniles

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## Abstract

Untreated bilge water is one of the causes of marine pollution. When discharged into the sea, aquatic organisms may ingest the chemical components of the wastewater and transmit them up the food chain which may ultimately be consumed by a variety of wildlife or humans. In this study, *Clarias gariepinus* juveniles were exposed to different concentrations (10, 20, 30, 40 and 50%) of bilge water for 96 hrs under laboratory conditions using a renewable static bioassay with continuous aeration to determine its acute toxicity. The $LC_{50}$ of exposed juveniles was found to be 35.97 ml/L with lower and upper confidence limits of 18.98 ml/L and 30.28 ml/L respectively. Respiratory disturbance, erratic swimming, loss of equilibrium, lethargies and sudden death were observed in the exposed fish and these varied greatly with increase in concentration of the wastewater. The differences observed in the mortalities of *C. gariepinus* at varying concentrations were significant ($p < 0.05$).

*Keywords*: Bilge water, African fish, *Clarias gariepinus*, Acute toxicity

## Introduction

Shipping has for a long time been recognized as one of the strong catalysts for socio-economic development. Shipping has led to a phenomenal growth in world merchandise trade, which has consistently grown faster than output. The maritime industry is international in nature and is acknowledged to be a very dynamic component in the socio-economic configuration of any given maritime nation. Nigeria is no exception. It is estimated that the world seaborne trade in 2013 amounted to 9.35 billion tons of cargo (Werschkun, 2014). Cargo throughput handled at the nation's Ports stood at 22,324,223 million metric tones in the third quarter of 2014, showing an increase of 12.5 per cent over 19,849,258 metric tonnes achieved in 2013. During the same period, a total of 1,405 oceans going vessels with a total Gross Registered Tonnage (GRT) of 38,047,705 called at all Nigerian Ports, an increase of 2.78 % over the number of vessels that called in 2013 (NPA, 2014).

Associated with phenomenal growth and development in the shipping industry worldwide, there is significant increase in the amount of oil used, most of which find their way into the water, forming pollution. After they have entered the marine environment, oils and fuels have a tendency to accumulate in sediments and in marine organisms. These harmful substances most commonly enter the waters through bilge pumping, fueling, and improper response to spills. Oily wastewater pollution affects drinking water and groundwater resources, endangering aquatic resources; endanger human health; cause atmospheric pollution; affect crop production and destruct the natural landscape (Poulopoulos *et al*., 2005).

Bilge water containing oily wastes is normally treated by regular operation of oily water separators, filtration and other related shipboard systems (Han *et al*., 2014). Still, accidental and intentional bilge water spills continually occur worldwide. Nigeria is a signatory to the Memoranda of Understanding on Port State Control in the West and Central African sub-region, but the MOU is yet to effectively reduce, control and prevent marine pollution in the country (Igbokwe 2001). The regulatory bodies charged with the responsibility for the management of the marine environment are yet to enforce full implementation of important international agreements and programmes, including the London Protocol to protect the marine environment (IMO/NIMASA, 2013).

Fish appear to posses the same biochemical pathways to deal with the toxic effects of endogenous and exogenous agents as mammalian species do; because of this, they are valuable in toxicity monitoring (Ahmad, 2012). Several investigations on

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the effect of environmental contaminants on the African catfish, *Clarias gariepinus* have been documented (Okayi *et al*., 2010; Okomoda *et al*., 2010; Ayuba *et al*., 2013; Dahunsi and Oranusi, 2013). We are not aware of any documented information on the health condition of bilge water on the African catfish, *C. gariepinus*. The objective of this study was therefore to investigate the effect of bilge water on mortality rate and behavioural pattern of juveniles of *C. gariepinus*

**Materials and Methods**

Samples of bilge water were collected from a seagoing vessel in April 2014. The vessel was used to transport crude oil along the Atlantic Ocean. It originated from Port Vila and was berthed on High Sea at Lagos Port Complex located at the Apapa area of Lagos, Nigeria. The bilge water samples were collected using washed and sterilized plastic containers. They were thoroughly mixed and transported in ice chest and stored in the refrigerator at 4 °C in the laboratory and their physicochemical characteristics were determined within 24 hours of collection using standard analytical methods (USEPA, 1999; APHA, 2005).

Juveniles of the African catfish (measuring 17±1.0 cm and mean weight 12.4±0.5 g) used for this investigation were purchased from a fish farm in Benin City, Nigeria. The test organisms were transported in a sealed oxygenated polythene bag which contained freshwater from the farm. The specimens were kept in large glass aquaria tanks measuring 20×15×30 cm with well aerated and dechlorinated borehole water at room temperature of 27±1.7 °C for fourteen (14) days to acclimatize them to the laboratory conditions. Water was changed at two days' interval to prevent the build-up of metabolic wastes. They were fed twice daily with fish meal at 3% body weight. Feeding was discontinued 24 hours prior to the commencement of the experiment that lasted for 96 hours. Before the bioassay started, ten acclimated fingerlings were introduced into each tank containing different concentrations of the wastewater effluents with two replicates. Control experiments were also set up in replicates with dechlorinated water and ten fingerlings each.

Acute toxicity test followed methods recommended by UNEP (1989). Ten fishes were stocked per aquarium in bilge water concentrations (10, 20, 30, 40, 50 ml/L) and control. The fish were examined for abnormal behaviours and mortality for 12, 24, 48, 72 and 96 hours. Dead fish were removed from test solutions as soon as observed. A fish was considered dead when it was totally immobile and no respiratory/opercula and tail movements. The 96 hour $LC_{50}$ toxicity was determined as a probit analysis using the arithmetic method of percentage mortality (Randhawa, 2009). Results obtained for the lower and upper confidence limits of the $LC_{50}$ were subjected to regression statistical analysis with Duncan's multiple range test in one way ANOVA, using SPSS version 16.0 for windows at $p<0.05$ level of significance to compare the various concentrations of bilge water and the control.

**Results**

Table 1 shows the physicochemical characteristics of bilge water. The wastewater was slightly acidic with a pH 6.09 and complex with a variety of dissolved cations and suspended particles. Some of the parameters notably nitrates, phosphates, chlorides, iron and nickel showed deviation from national (NESREA) and international (USEPA) specifications for maximum limit allowed for effluent discharge into water bodies for all categories of industries.

Table 1: Physicochemical properties of bilge water

| Parameter | Bilge Water | NESREA (2009) Limit | USEPA (2009) Limit |
|---|---|---|---|
| pH | 6.09 | 6-9 | 6.5.-8.5 |
| Turbidity | 12.1 | - | - |
| Ammonia | 0.04 | 1 | 0.03 |
| Sulphates | 43.00 | 250 | 250 |
| Nitrates | 57.01 | 10 | 10 |
| Phosphates | 54.04 | 2 | - |
| Carbonates | 188 | - | - |
| Chloride | 338.00 | 250 | 250 |
| Iron | 0.13 | - | 0.3 |
| Zinc | 0.04 | - | 0.12 |
| Manganese | 0.02 | 0.2 | 0.05 |
| Aluminum | 0.02 | - | - |
| Nickel | 0.09 | 0.05 | 0.005 |
| Cobalt | 0.01 | - | - |

*All values are expressed in mg/L except pH (no units). NESREA = National Environmental Standards and Regulations Enforcement Agency (2009), USEPA = United States Environmental Protection Agency (2009) maximum permissible limits for effluent from wastewater.*

The mortality rate of *C. gariepinus* juveniles exposed varied concentrations of bilge water is presented in Table 2. The fish exposed to the wastewater were restless, erratic in their movement and gasping for breath. However, normal behaviour was observed in the control groups. Moreover, the concentration of the bilge water increased, the affected fish became very weak and eventually died.

Table 2: Mortality rate of *C. gariepinus* juveniles exposed varied concentrations of bilge water

| **Conc. (ml/L)** | **Mortality (hours)** | | | | | **No of mortality** | **Percentage mortality** | ***Corrected % mortality** | **Probit** |
|---|---|---|---|---|---|---|---|---|---|
| | **12** | **24** | **48** | **72** | **96** | | | | |
| Control | 0 | 0 | 0 | 0 | 0 | 0/10 | 0 | 2.5 | 3.04 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0/10 | 0 | 2.5 | 3.04 |
| 20 | 0 | 0 | 0 | 0 | 4 | 4/10 | 40 | 40 | 4.75 |
| 30 | 0 | 0 | 6 | 0 | 0 | 6/10 | 60 | 60 | 5.25 |
| 40 | 0 | 8 | 0 | 0 | 0 | 8/10 | 80 | 80 | 5.84 |
| 50 | 0 | 10 | 0 | 0 | 0 | 10/10 | 100 | 97.5 | 6.96 |

The $LC_{50}$ at 95 hours was 35.97 ml/L with lower and upper confidence limits of 18.98 ml/L and 30.28 ml/L respectively. At this concentration of the bilge water in the aquatic environment, half of the entire fish population would die. The computed regression equation was found to be Y= -3.8571 + 2.8571* (R = 1.5283, Y = probit kill) (Fig. 1).

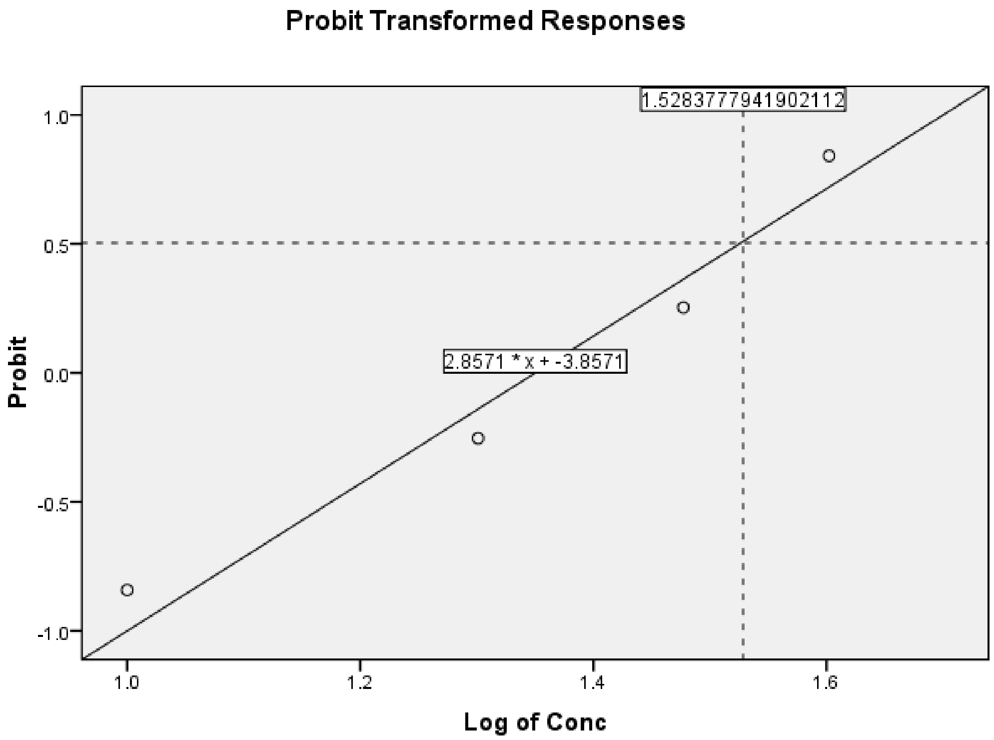


Figure 1: Linear relationship between mean probit mortality and log concentration of *C. gariepinus* juveniles exposed to bilge water for 96 hours

**Discussion**

The physicochemical characteristics of the bilge water sample used in this study showed a number of deviations from national and international specifications for maximum limit allowed for effluent discharge into water bodies (NESREA, 2009; USEPA, 2009). The toxicity of the wastewater could be attributed to the synergistic effects of the pollutants which could affect vital organs of the fish. Similar observations have been reported with agricultural and pharmaceutical effluents (Adewoye *et al*., 2005; Agboola and Fawole, 2014). The unpleasant odour of the bilge water may have resulted from the biodegradation activities of anaerobic bacteria of organic matter in it, possibly facilitated by the low dissolved oxygen and high biochemical oxygen demand of the wastewater (Adewoye *et al*., 2005).

Kazlauskiene *et al*. (2012) has argued that the assessment of water pollution using only physicochemical methods is not sufficient to provide integrated information on the effects of pollutants on aquatic life because toxicity is a biological characteristic. The test organism in this study gasped for breath prior to mortality. This observed respiratory abnormality is in agreement with results obtained by Dahunsi and Oranusi (2013) for the same test organisms exposed to rubber processing effluents. Also observed was the erratic swimming pattern and motionlessness of the fish which are indications that mortality of the exposed fish is not only due to impaired metabolism, but could in addition be due to nervous disorder (Okayi *et al*., 2013).

To the best of our knowledge, this is the first documented report on the acute toxicity of bilge water on *C. gariepinus* juveniles. Several investigators have reported similar results on concentration-dependent increase in mortality rates for the African fish exposed to agricultural effluents (Adewoye *et al*., 2005), resin effluent (Dahunsi and Oranusi, 2012), rubber processing effluents (Dahunsi and Oranusi, 2013) and pharmaceutical effluents (Agboola and Fawole, 2014). The degree of acute toxicity values differs with different types of pollutants and this could be attributed to differences in the nature of the pollutant, age of the organism and environmental conditions (Ayuba *et al*., 2013).

In conclusion, results obtained in our study has shown that bilge water induced acute toxicity on *C. gariepinus* juveniles and calls for caution in the manner in which bilge water is disposed in the aquatic ecosystem.

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