Chronic Toxicity of Synthetic Based Fluid (Parateq©) on growth of three life stages of T. guineensis

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***Abstract*- This study investigates the growth of three life stages of *T. guineensis* exposed to different sublethal concentrations of Parateq for 12 weeks in a static renewal bioassay. Parateq a synthetic based Fluid (SBF) was added to water to obtain the following sublethal concentrations 0.32%, 0.63%, 1.25 % and 2.5% vol/vol. Fry (0.64cm – 0.65cm/0.52g – 0.55g) fingerlings (5.51cm–5.57cm/5.52g – 5.56g) and Post fingerlings (7.21 - 7.25cm / >10.5g) of *T. guineensis* were fed with NIOMR Feed. Proximate compositions of the feeds used were evaluated while the carcass composition of the fish was analyzed at the end of the experiment. Growth rates during the 12 weeks period were modest with fish in 2.5% of Parateq gaining the least weight. The highest percent growth rates were obtained from fish in control. The overall growth was significantly different between treatments and control. This study revealed that sublethal concentrations of toxicants will not only cause outright mortality but have significant effects which could lead to physiological dysfunctions in organisms that abound in the Niger Delta.**

***Index Terms*- drilling fluid; Niger Delta, T. guineensis, growth indices**

I. INTRODUCTION

Oil related pollution is a major cause of water contamination in the Niger Delta of Nigeria. The Niger Delta wetland is among the most important and productive ecosystems in the world and have the highest stand of mangrove in Africa. Despite the importance and sensitive nature of the Niger Delta, the area is replete with oil exploration and exploitation activities which involve the use of drilling fluids.

Drilling fluids which are suspension of solid in liquid emulsion and/or dissolved materials with chemical additives are employed during drilling activities to remove drill cuttings. Cutting piles contain petroleum hydrocarbons adhering to the drilling mud from the oil and gas formation being drilled (Gagnon and Bakhtyar, 2013). Drilling for oil in Niger delta results in release of large volume of drilling fluids into the environment. These releases usually come from regulated discharges by the authority and blowout or seepage from reserve pits (DMP, 2007).

Many formulation used in drilling by the oil companies are said to be of relatively low lethal toxicity (PAS, 1995), but the sublethal toxicity, bioaccumulation and sublethal threshold concentrations are not well understood and the information available is scanty. Studies on the impact of drilling discharges in the water have shown that drilling fluids and its additives may contain toxic substances that have the tendency to bioaccumulate and interfere with normal biological activities of organisms(Gagnon and Bakhtyar, 2013; Vincent-Akpu *et al.*, 2010; Soegianto *et al.*, 2008; Odokuma and Ikpe, 2003). The greatest impact occurs near the platform and is due to physical smothering and overloading of sediments with degradable organic material.

Investigations into degradation of drilling muds have shown that the cutting piles are more persistent than expected and can resist degradation for long periods of time (Bakhtyar *et al.*, 2011). Aquatic biota will be exposed in the longer term to the cutting piles containing up to 10% drilling mud (DMP 2007). Chronic exposure to weathering drilling mud has the potential to adversely affect fish health (Gagnon and Bakhtyar, 2013).

In aquatic ecosystems, Fish are located at the top of the food chain and are highly visible resources. They are known to be affected by pollutants due to their being in direct contact with water via their gills and body surface. Their health and subsequent growth are directly related to the quality of water in which they live. Most fish continue to grow in length and weight until they die and, the growth rate may be very fast or very slow, depending on the amount of food and other environmental conditions. Weight gain is a very reliable indicator of growth and important criterion for measuring fish response to experimental feed and quality of water (Gagnon and Bakhtyar, 2013; Akinwande *et al.*, 2005; Ogbe *et al.*, 2005).

Despite the extensive exploration and drilling activities in Nigeria, there is paucity of studies on chronic exposure of endemic organisms to drilling fluid. Therefore, there is need to evaluate the effect of sublethal concentrations of drilling fluids on the different life stages of *Tilapia guineensis*.

II. MATERIALS AND METHODS

Drilling fluid

Parateq (synthetic based fluid) was obtained from Baker Hughes Nigeria Limited. The physical and chemical characteristics of the drilling fluids were determined in Baker Hughes Nigeria Limited and Institute of Pollution Studies Rivers State University of Science and Technology Port Harcourt laboratories using standard methods (APHA, 1998).

Experimental design and fish

Fry (0.64cm –0.65cm/0.52g – 0.55g) fingerlings (5.51cm–5.57cm/5.52g – 5.56g) and Post fingerlings (7.21 - 7.25cm / >10.5g) of *T. guineensis* grouped according to Odiete (2003) were collected from the African Regional Aquaculture centre (ARAC), Buguma, Rivers State Nigeria. The fish were acclimatized for 28 days in holding tanks [120 x 120 x 120cm]. The holding tanks were aerated, cleaned and the water renewed regularly. The basic procedures followed according to the method of standard handling and water renewals (Chindah *et al*., 2004, Reish and Oshida, 1986). Mortality during the holding period was less than one percent of the whole population.

The LC_{50} was calculated based on the probit analysis from Vincent-Akpu *et al* (2010), through which five sublethal concentrations 2.5 %, 1.25 %, 0.63 %, 0.32 % and control were obtained in a volume to volume ratio.

Fifteen 25 liter capacity tanks were used for the fry and fifteen 50 liter capacity tanks for the fingerlings. Ten 500 liter capacity concrete tanks were constructed for the post fingerlings. Each aquarium was randomly stocked with ten healthy fish and screened with a mosquito net to prevent fish escape.

The fry and fingerlings were fed with NIOMR feed (35% protein) while the post fingerlings were fed with NIOMR Feed (30% protein). A fixed feeding regime of 4% of the body weight per day was employed for the first 8 weeks and 3% of the body weight for the next 8 to 12 weeks. The fish were fed twice daily, with ration divided in equal portions for 6 consecutive days and weighed in water without anesthesia on the 7^{th} days. This was done to reduce stress on the organisms. Feeding was adjusted accordingly when necessary. The proximate compositions of the feeds used were evaluated while the carcass composition of the fish was analyzed at the end of the experiment according to the AOAC methodology (AOAC, 2000; Aitken *et al.,* 2001).Water parameters (Temperature, pH, DO and alkalinity) of the test solution were monitored weekly throughout the duration of the experiment (APHA, 1998).

Growth indices:

The weight of the fish was measured with a top loader weighing balance (Mettler PN 163) and length taken using a measuring board. Two fish were randomly collected from each test solution and weighed. Body weight was recorded to the nearest gram and the total body length was measured to the nearest 0.1 cm. The data obtained were used for computation of weight gain, relative growth rate, specific growth rate and daily growth rate (Adiukwu, 2003; Sikoki and Ekwu, 2000). Statistical analysis of the growth parameters was carried using ANOVA and T- test in all the life stages.

The growth indices are calculated as following:

Relative growth (%RG) = [(W2-W1)/ W1] x 100 (% / fish)

Specific growth rate (SGR) = (ln W2 – ln W1) / T x100 (% / day)

Where

W1 is initial weight

W2 is final weight

T is the number of days of the feeding period.

III. RESULTS

Composition of Parateq

Parateq are synthetic based fluid (SBF) system called syn-teq. The based fluid is Parateq which is an olefin isomer base fluid formed by isomerization of linear alpha olefins in the presence of heat and a suitable catalyst (Neff *et al.*, 2000). The physical and chemical composition of Parateq is presented in Table 1. The formulation is 26.2% water and 73.8% base fluid with $CaCO_3$ as weighting agents and other additives. The total hydrocarbon content is 41.00mg/g. The drilling fluid is acidic (6.79) and contains Lead (2.16ppm), Manganese (2.05ppm), Barium (0.004ppm), Chromium (0.096ppm) and Zinc (5.82ppm) (Vincent-Akpu and Allison 2010).

Physiochemical parameters

The mean values of the physiochemical parameters ranged from 27.5 – 28.3^{0}C (Temperature); 4.21- 4.96 Mg/L (DO); 21.20 - 23.62Mg/L (Alkalinity) and 6.96 – 7.33(pH). There were no significant differences ($p < 0.05$) in the physiochemical parameter of the parateq treated tanks and control for each life stages and at different concentrations.

Table1. Physical and chemical characteristic of drilling fluid - Parateq

Composition	Values
Colour	White
Water	26.2%
Base Fluid	73.8%
Organophilic lignite (Carbongel 11)	12ppd
Organophilic clay (Omniplex)	2.16ppd
Lime	3ppd
$CaCl_2$	32.8ppd
$CaCO_3$	139.3ppd
Synthetic Polyamide (Omnimul)	8.62ppd
pH	6.76
Total Solid	587mg g^{-1}
Total organic carbon	1.65mg g^{-1}
Chloride	0.625mg g^{-1}
Nitrate	1.599mg g^{-1}
Sulphate	-
Phosphate	-
Total hydrocarbon	41.00mg g^{-1}
Lead	2.16ppm
Manganese	2.05ppm
Zinc	5.82ppm
Cadmium	-
Chromium	0.096ppm
Barium	0.004ppm

Proximate analysis

The proximate composition of the two feeds are protein (35 and 30%); ash (9.7 and 10.1%); lipid (4.9and 4.8%); moisture (12.5 and 9.3%); carbohydrate (31.8and 45.1%) and fiber (6.08 and 1.01%).

In the carcass composition of fry, fingerling and post fingerling, there was slight increase in moisture and ash content as the concentration increased while crude protein and lipid content decreased as the concentration increased in all the life stages of *T. guineensis* exposed to Parateq. The moisture, protein, lipid and ash contents ranged from 81.20 to 76.30%; 62.9 to 51.93%; 12.5 to 1.30%; and 13.40 to 29.97% respectively (Fig 1). There was no significant difference in the carcass composition at different concentration.

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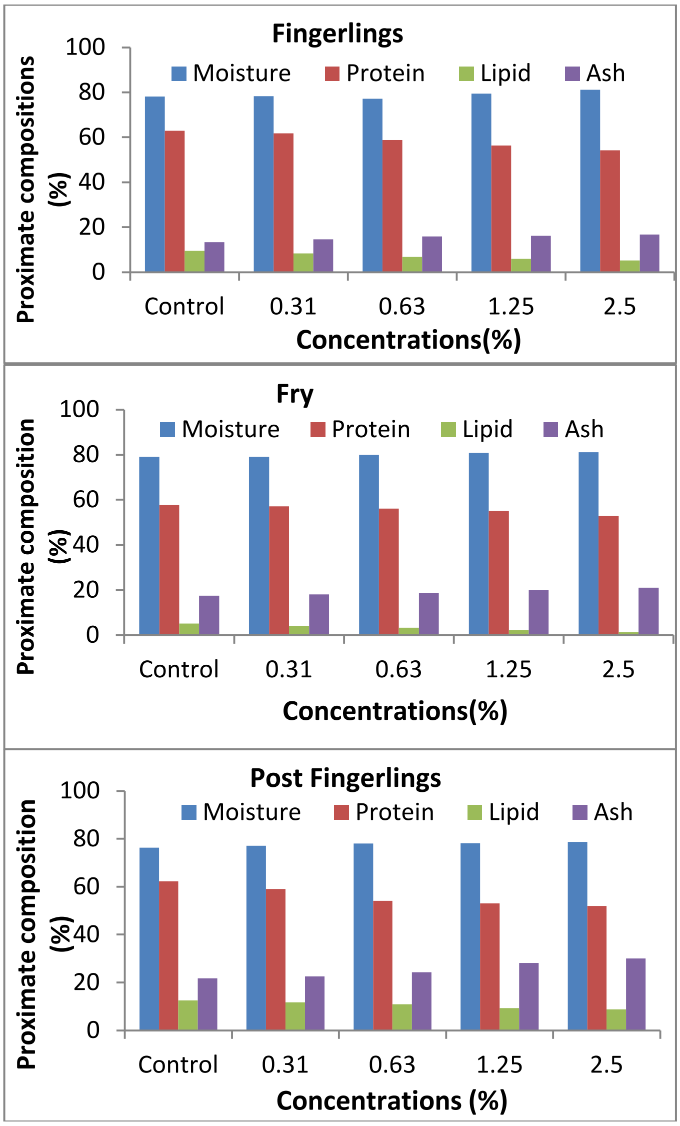

Fig. 1 Proximate composition of fry, fingerlings and post fingerlings after 12 weeks exposure to Parateq

The growth indices of *T. guineensis* at fry stages exposed to Parateq is presented in Table 2. From the cumulative mean weight increase, it was revealed that the fish in the control had the highest weight gain but in the highest concentration (2.5%), growth increment was minimal. Other growth parameters like specific growth rate, relative growth rate and daily weight gain followed the same growth pattern as the cumulative weight gain.
The growth indices of *T. guineensis* at fry stages exposed to Parateq is presented in Table 2.
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Table 2. Growth performance of *T. guineensis* fry exposed to Parateq for 12 weeks

Growth parameters	Concentrations (%)				
	0	**0.31**	**0.63**	**1.25**	**2.50**
Initial mean weight(g)	0.54^{a}	0.54^{a}	0.53^{b}	0.54^{b,c}	0.53^{c}
Final mean weight(g)	7.21^{a}	3.72^{a}	3.21^{b}	2.59^{b,c}	2.02^{c}
Mean weight gain(g)	6.67	3.18	2.68	2.05	1.49
Relative growth gain	1235.19	588.69	505.66	376.63	281.13
Daily weight gain	0.08	0.04	0.03	0.02	0.02
Specific growth rate	3.09	2.30	2.14	1.87	1.60
Percent survival rate	100	100	100	100	100

Means with the same letter for each parameter in the same column between are non-significant different ($P > 0.05$).

Table 3. Growth performance of *T. guineensis* fingerings exposed to Parateq for 12 weeks

Growth parameters	Concentrations (%)				
	0	**0.31**	**0.63**	**1.25**	**2.50**
Initial mean weight(g)	5.55^{a}	5.56^{a}	5.53^{b}	5.54^{b,c}	5.53^{c}
Final mean weight(g)	13.38^{a}	9.48^{a}	8.46^{b}	8.03^{b,c}	7.40^{c}
Mean weight gain(g)	7.83	3.92	2.92	2.47	1.85
Relative growth gain	141.08	70.50	52.71	44.42	33.33
Daily weight gain	0.09	0.05	0.04	0.03	0.02
Specific growth rate	1.05	0.64	0.50	0.44	0.34
Percent survival rate	100	100	100	100	100

Means with the same letter for each parameter in the same column between are non-significant different ($P > 0.05$).

Table 4. Growth performance of *T. guineensis* Post fingerings exposed to Parateq for 12 weeks

Growth parameters	Concentrations (%)				
	0	**0.31**	**0.63**	**1.25**	**2.50**
Initial mean weight(g)	10.53^{a}	10.85^{a,b}	10.53^{b}	10.51^{b,c}	10.53^{c}
Final mean weight(g)	17.20^{a}	15.41^{a,b}	14.18^{b}	13.17^{b,c}	11.20^{c}
Mean weight gain(g)	6.67	4.88	3.65	2.66	0.67
Relative growth gain	63.34	46.34	34.66	25.31	6.36
Daily weight gain	0.08	0.06	0.04	0.03	0.01
Specific growth rate	0.58	0.45	0.35	0.27	0.07
Percent survival rate	100	100	100	100	100

Means with the same letter for each parameter in the same column between are non-significant different ($P > 0.05$).

highest weight gain but in the highest concentration (2.5%), growth increment was minimal.

From the cumulative mean weight increase, it was revealed that the fish in the control had the highest weight gain but in the highest concentration (2.5%), growth increment was minimal. Other growth parameters like specific growth rate, relative growth rate and daily weight gain followed the same growth pattern as the cumulative weight gain.

Table 3 indicates steady increase in the weight of *T. guineensis* at fingerling stage exposed to Parateq. The highest weight gain (7.83) at the end of the experiment was obtained in the control.

A concentration dependent decrease in weight gain was observed in post fingerling exposed to sublethal concentration of Parateq (Table 4). The fish in the control have the highest SGR (0.58), while the highest concentration (2.5%) had specific growth rate of 0.07.

Differences observed in weight over the weeks was significant ($p<0.05$) which implied that there are distinct variations in the response of the fish to various concentrations of the toxicant. With the exception fish exposed to 0.31%Parateq, the fish in the control was significantly different ($P<0.05$) when compared with other concentrations.

IV. DISCUSSION

Most of the physicochemical parameters of the drilling fluid were within the range allowed by EGASPIN (2002) except the hydrocarbon content which was higher compared to 20mg/l that is acceptable for discharge in nearshore waters. The toxicity of drilling fluids has been attributed to their hydrocarbon content (Neff *et al*, 2000). Low Hydrocarbon content in the Synthetic Based Fluid can be responsible for the low toxicity.

The various physicochemical parameters recorded for the test solution were favourable and adequate to support growth and survival of T. *guineensis* within the system (Vincent–Akpu, 2001). The limited variations in the water quality observed between control and treated tanks suggested that the drilling fluid did not adversely alter the water quality integrity.

T. guineensis grew during the exposures as the mean length and weight of both the treated and untreated fish were larger than their respective initial values. This means that the feed was adequate enough to cause growth. The carcass composition in this study gave high enough values for the different food class which was similar to what was recommended by Adiukwu (2003). The protein content increased with decrease in lipid. Ogbe *et al (*2005) and Adiukwu (2003) obtained similar results using experimental feed.

The mean final weight and mean weight gain showed that there was a trend of increase from the highest concentration of the toxicant to the control. Weight gain is known to be the most important criterion for measuring fish responses to experimental feed and a very reliable indicator of growth (Akinwande *et al*, 2005; Ogbe *et al*, 2005; Sikoki and Ekwu, 2000). Data analysis using weight gave useful information concerning the growth of the fish.

There were no significant differences ($P < 0.05$) among the initial weights of the tilapia, but the final weights for most of the treatments were significantly different. This shows that the concentrations of the toxicant produced different effects on the growth of *T. guineensis,* which follows that growth of fish is affected by exposure to drilling fluid. Lowest growth rates were obtained in the fish exposed to highest concentration of Parateq. Dose-dependent effect of toxicant on growth has been documented (Jones *et al*, 1991). The authors concluded that the decrease in growth at most times have been caused by loss of appetite and not by metabolical changes. In contrast, Adiukwu (2003) Sikoki and Ekwu (2000) attributed the decrease in growth to be due to metabolical chages induced by increase in plasma glucose.

The results of the present study revealed that sublethal concentrations of toxicants will not only cause outright mortality but have significant effects which can lead to physiological dysfunctions such as reduced growth.

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