LENGTH-WEIGHT RELATIONSHIP OF *TILAPIA ZILLII* AND *SAROTHERODON GALILEAUS* REARED IN CAGES IN ODEDA LAKE, OGUN STATE, NIGERIA

IYABODE OLUSOLA TAIWO[*], OLANIYI ALABA OLOPADE[**]

Comparative study was conducted to evaluate the growth performances of *Tilapia zillii* and *Sarotherodon galileaus* fingerlings caged reared using length-weight (LW) relationship technique. The water quality parameters were also assessed in the cages and outside the cages. The mean value of pH (7.03) inside the cages were slightly higher than outside the cage (6.80) similar results were observed for water temperature, ammonia and Total dissolved solid. The mean value of dissolved oxygen (9.17mg/L) and conductivity (1024 microfarads) inside cages were lower than outside the cages 11.07mg/L and 1356 microfarads respectively. The length-weight relationship showed that weight of the fish species increased with total length in both species. The length – weight relationship equations were given as follows: *Tilapia zillii* Log W=-0.34+1.21LogL; R^2 = 0.985; *Sarotherodon galileaus* Log W=-0.32+1.21LogL; R^2 = 0.959. *Sarotherodon galileaus* grew better and faster than *Tilapia zillii* indicating that *Sarotherodon galileaus* species are preferable for cage culture than *Tilapia zillii.* Odeda Lake contains water of acceptable quality suitable for cage culture.

Keywords: Cage culture, Length-weight relationship, water quality, Odeda Lake.

INTRODUCTION

Cage culture is not new in Nigeria. However, the practice has remained at the experimental level and unpopular among Nigerian fish farmers. There are encouraging studies on the viability of cage culture in Nigeria (Otubusin, 1989; Otubusin & Olatunde, 1992). Otubusin (1997) reported on cage culturability of some commercial important fish Viz. *Ctharinus citharus, Oreochromis niloticus, Clarias gariepinus, Sarotherodon galilaeus, Heterobranchus bidorsalis, Tilapia zillii, Alestes dentex and Distichodus rostratus* in Lake Kainji, Nigeria. All these scientific contributions have not translated to large scale cage culture either at the subsistence or commercial levels despite the vast Nigerian aquatic medium of numerous water bodies like rivers, streams, lakes reservoirs, flood plains, irrigation canals and coastal swamps which offer great potentials for cage culture in Nigeria.

In countries such as Nigeria which have similar socio-economic standards, cage culture has provided spectacular opportunities for creation of employment and large scale fish production. It is acknowledged that research in aquaculture is not always sufficiently geared towards ensuring commercial viability of aquaculture or benefits to end users. Williams *et al*. (1983) report that research into cage culture has been limited mainly because large scale open pond culture was more economically viable and, therefore, it received most of the research focus.

However, Beveridge (1987) opines that cage culture offers the farmer a chance to utilize the existing water resources which in most cases have only limited use for other purposes. This flexibility makes it possible to exploit underused water resources to produce fish. It could be operated in any type of aquatic environments. It is cheaper and more affordable than other forms of aquaculture practices.

A clear understanding of the growth of farmed fish is necessary for accurate prediction levels. The length-weight relationship has also a biological basis as it depicts the pattern of growth of fishes. Its importance is pronounced in estimating the average weight at a given group (Beyer, 1987) and in assessing the relative well-being of a fish population (Bolger & Connoly, 1989). Nevertheless, the biology of many tilapines in natural systems is well documented (Fryer & Iles, 1972; De Silva, 1985; Tudorancea *et al*., 1988; Stewart, 1988; Getachew and Fernando, 1989; Robotham, 1990; Gómez-Márquez *et al.*, 2003). There have been significant developments in the farming of tilapias globally, even in Nigeria. Due to the increasing commercialization and continual growth of the tilapia industry, the tilapia fish commodity is the second most important farmed fish globally, next to carps and it is also the most important aquaculture fish species of the 21st century with about 98% of tilapia produced in these countries grown outside their original habitats (Shelton, 2002). The fish is being farmed in about 85 countries worldwide (FAO, 2016).

However, information on the length-weight relationship of tilapia species in cage culture is limited. The objectives of this study were: (i) to determine the length – weight relationship of both *Sarotherodon galileaus* and *Tilapia zillii* cultured in cages and (ii) to determine the effects of the water quality parameters on the growth rate of fish.

MATERIALS AND METHODS

Six cages were constructed with aluminium pipes and synthetic net, each with a dimension of 1m × 1mx 1m. Fingerlings of *Sarotherodon galileaus* and *Tilapia zillii* were purchased from fishermen at Odeda fish farm. They were then acclimatized in floating net cages for two weeks before they were stocked for monoculture trials. 50 fingerlings with mean weight 3 ± 0.13g were stocked per cage, three cages for *Tilapia zillii* and three cages for *Sarotherodon galileaus* respectively.

The fishes were fed twice daily, in the morning and the evening at (5%) of their body weight. The proximate analysis of feed was 42% crude protein, crude fat 13%, crude fibre 1.8%, ash content 7.4%, phosphorus 1%, vitamin A1500iu/kg, Vitamin D3 2000iu/kg, Vitamin E 200mg/kg, Vitamin C 159mg/kg and Cu 5mg/kg.

At the end of the experiment (12 weeks), all fish from each experimental cage were counted. The total length was measured using a measuring board to the nearest cm. Each fish sample was weighed using a spring platform scale to the nearest gram. The length-weight (log-transformed) relationships were determined by linear regression analysis and scatter diagrams of length and weight were plotted.

Water temperature, dissolved oxygen, pH, ammonia, total dissolved solid and conductivity were measured weekly following standard methods (APHA, 2005).

Pearson moment correlation test was used to establish the relationship between the water quality parameters inside and outside the cage in Odeda Lake and its effect on the growth of fish.

RESULTS

WATER QUALITY

The results of the physicochemical parameters of the water samples inside and outside cages are presented in Tables 1 and 2. The mean pH varied between 6.7 and 7.03 inside the cages while outside the cages the pH ranged from 6.5 to 7.0. The mean temperature of the water inside the cages varied between 29°C and 30°C and was slightly higher than outside the cages with mean values of 27 to 28°C. The DO ranged from 9.0 to 9.5 mg/L inside the cages while outside the cages the values were slightly stable and higher (11–11.07 mg/L) than inside the cages. The mean values of the total suspended solids (TSS) ranged from 124–190 ppm inside the cages and 60–80 ppm outside the cages.

The mean values of the ammonia oscillated between 0.9241 mg/L and 1.0822mg/L inside the cages and also between 0.93 mg/L and 1.0092 mg/L for outside the cages. Conductivity values inside and outside the cages were constant 1024 microfarads and 1386 microfarads, respectively.

The effect of water quality parameters on one another showed that a significant ($P<0.05$) relationship existed between temperature and dissolved oxygen. There was a significant ($P<0.05$) relationship between the pH level and dissolved oxygen. pH had a negative non-significant relationship with temperature and dissolved oxygen indicating that the higher the temperature, the lower the pH . In summary, all parameters were within the range for normal growth expected conductivity values recorded during the study.

The minimum and maximum observed Total length of *S galileaus* was 16.50 and 16.75 cm respectively and the weight ranged from 3–75 g. The log transform of the

LWR is presented in Fig. 1 and expressed as: Log W=-0.34+1.21LogL (r = 0.959) for *S galileaus*. The TL measurements of *T zillii* specimens ranged from 16.20 to 16.35cm and the weight ranged from 2 to 65 g. The length-weight relationship (Fig. 2) is expressed as: Log W=-0.32+1.21LogL (r=0.985) for *T zillii*. Positive allometric growth (b) existed between the two species even though low values of b= 1.21 were exhibited by both species. High regression coefficient values of r =0.959 and 0.989 were recorded respectively by *S. galileaus* and *T. zillii*.

Table 1

Water Quality Parameters inside the Cage

Week	Temperature (ºC)	Dissolved Oxygen (mg / litre)	pH	[x1.216] Ammonia (mg / litre)	Totally dissolved solid (ppm)	Conductivity (microfarads)
2	30	9.0	7.3	0.9241	190	1024
4	29	9.5	7.1	1.0822	176	1024
6	30	9.0	6.7	1.0822	124	1024
8	30	9.0	7.3	0.9241	190	1024
10	29	9.5	7.1	1.0822	176	1024
12	30	9.0	6.7	0.9241	190	1024
Mean	29.7	9.17	7.03	1.00	174.3	1024

Table 2

Water Quality Parameters outside the Cage

Week	Temperature (ºC)	Dissolved Oxygen(m/ L)	pH	[x1.216] Ammonia (mg / litre)	Totally dissolved solid(ppm)	Conductivity (microfarads)
2	27	11.0	7.0	0.8512	60	1356
4	27	11.0	6.9	1.0092	70	1356
6	28	11.2	6.5	1.0092	80	1356
8	27	11.0	7.0	0.8512	60	1356
10	27	11.0	6.9	1.0092	70	1356
12	28	11.2	6.5	0.8512	60	1356
Mean	27.3	11.07	6.80	0.93	66.7	1356.

Inside the cages the total dissolved solid showed a significant and positive correlation with dissolved oxygen (r = 0.03, P<0.05) while dissolved oxygen showed a significant and negative correlation with totally dissolved solid (r = 0.01, P<0.01) (Table 3). While outside the cages pH and totally dissolved solid showed a significant and negative correlation with dissolved oxygen (r = -0.98 and 0.01 respectvely, P<0.01) (Table 4).

Table 3

Pearson Correlation of Water Quality Parameters inside the Cage

	Temperature (ºC)	Dissolved Oxygen (mg / litre)	pH	[x1.216] Ammonia (mg / litre)	Totally dissolved solid (ppm)				
Temperature (ºC)	0.00	-0.12	-0.06	0.10	1.00				
Dissolved Oxygen (mg / litre)	0.00	0.12	0.06	-0.10	-1.00**	1.00			
pH	-0.47	-0.51	-0.41	-0.42	-0.19	0.19	1.00		
[x1.216] Ammonia (mg / litre)	-0.10	0.07	-0.09	-0.24	-0.71	0.71	-0.27	1.00	
Totally dissolved solid (ppm)	0.14	0.03*	0.19	0.23	-0.05	0.05	0.58	-0.67	1.00

* P < 0.05 **P <0.01 level

Table 4

Pearson Correlation of Water Quality Parameters outside the Cage

	Temperature (ºC)	Dissolved Oxygen (mg / litre)	pH	Ammonia (mg / litre)	Totally dissolved salt (ppm)				
Temperature (ºC)	0.414	0.41	0.344	0.404	1				
Dissolved Oxygen (mg / litre)	0.414	0.41	0.344	0.404	1.000**	1			
pH	-0.452	-0.47	-0.389	-0.419	-0.98**	-1.000**	1		
[x1.216] Ammonia (mg / litre)	-0.098	0.07	-0.088	-0.238	-0	0	-0.154	1	
Totally dissolved solid (ppm)	-0.131	0.02	-0.158	-0.256	0.316	0.32	-0.414	0.89	1

* P < 0.05 **P <0.01 level

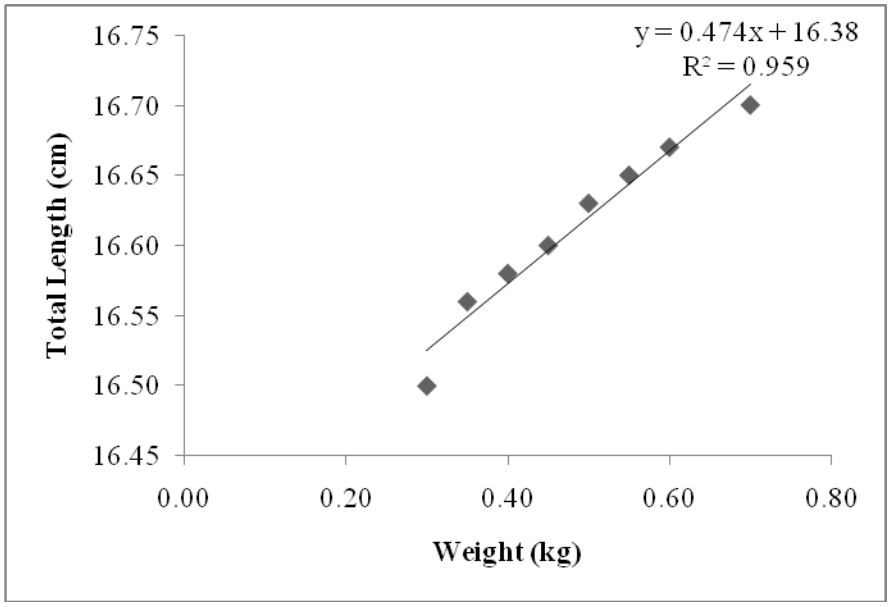

Fig. 1. Total Length – Weight relationship of *Sarotherodon galileaus*.

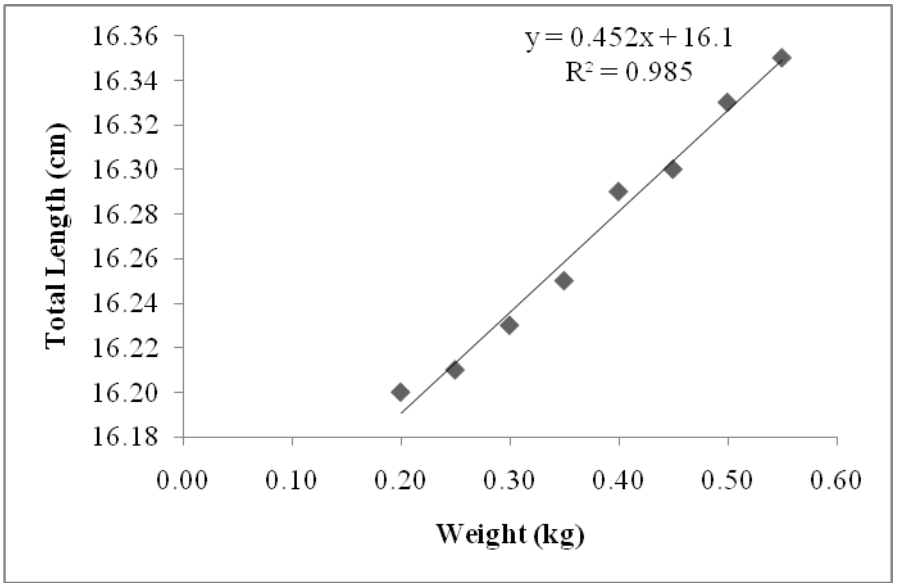

Fig. 2. Total Length – Weight relationship of *Tilapia zillii*.

DISCUSSION

Growth is a specific adaptive property, ensured by unity of the species and its environment (Nikolsky, 1963). In this study both *Sarotherodon galileaus* and *Tilapia zillii* showed a positive allometric growth pattern with the b values of 1.21 obtained for the two species. Positive allometric growth implies the fish becomes relatively stouter or deeper-bodied as it increases in length (Riedel *et al*., 2007). Thus, when b is not equal to 3, allometric pattern of growth occurs, which could be positive if >3 or negative if <3. The result obtained on *T. zillii* is below the b values recorded from the recent works of Haruna (2006) and Bala *et al*. (2009) from the Magaga Lake and Kano Daberam reservoir in Katsina state respectively. Imam *et al*. (2010) recorded a 'b' value in *T. zillii* of 1.53 and 2.5 for wet and dry seasons respectively. The coefficient in the present study indicated that there was a high degree of correlation between total length and body weight in the two fish species. This was in conformity with the observations of Taiwo & Odunaiya (2004). The results obtained indicated that *S. galileaus* has a faster and better growth rate than *T. zillii.*

The water quality of the lake under study was within the recommended limits for the culture of this type of fish (*Tilapia* sp.). The mean pH values both inside and outside the cages varied between 6.80 and 7.30 indicating that the lake was moderately alkaline and was within the range of pH known for most lakes and streams of the world (Welch, 1952). The electrical conductivity was constant both inside (1024 microfarads) and outside the cages (1356 microfarads). This result was above the maximum limit of 1000.00 μS/cm specified by WHO and Nigerian standard for drinking water quality (WHO, 2004; NSDW, 2007). The mean values of ammonia inside the cages were slightly higher than outside the cages. Ammonia was higher at fish culture site due to feces released by the fish (Nyanti *et al*., 2012). However, the mean values of ammonia both inside cages and outside were within the range as suggested by Boyd & Tucker (1998). The mean totally dissolved solid value was higher in cages (174.3 ppm) than outside the cages (66.7 ppm). This could be attributed to the application of artificial feed inside the cages. Higher value of TSS in the cage culture site was due to the fish excretion and excess fish feed (Boyd, 2004). The result in this study falls within the WHO recommended value of 1000.00 mg/L and 500.00 mg/L of the National standard for drinking water quality (WHO 2004; NSDW, 2007). The mean dissolved oxygen value was higher outside the cages (11.0 mg/l) than inside the cages (9.17 mg/l). The lower DO at some aquaculture sites is mainly caused by consumption of DO by microorganisms in decomposition of organic matter (Yee *et al*., 2012). Karnatak & Kumar (2014) reviewed that localized water quality problems, particularly low dissolved oxygen, are common in cage culture.

High water quality observed presently was also reported by Akinbuwa (1999), Obodai & Waltia (2003) and Komolafe & Arawomo (2008) in Erinle, Tono and Osinmo reservoirs.

CONCLUSIONS

The study has revealed the growth rate of *Sarotherodon galileaus* and *Tilapia zillii* in cage culture. It was proved from this study that *S. galileaus* grew better than *T. zillii* indicating that *S. galileaus* species are preferable to *T. zillii* species in cage culture. This study has revealed variations in some water quality parameters which were due to high metabolic activities by the fish inside the cage than outside the cage. The effect of the water quality parameters on *S. galileaus* and *T. zilli* growth rate was investigated and was proved that it had no significant effect on their growth rate thus indicating that Odeda Lake is likely to be highly productive and confirmed to be very suitable for aquaculture and agricultural purposes. It was also found that most of the physio-chemical parameters were in conformity with the recommended values for tropical waters.

REFERENCES

AKINBUWA O., 1999, *The rotifera fauna and physicochemical conditions of Erinle Lake and its major inflows at Ede, Osun State, Nigeria.* (PhD Thesis). Obafemi Awolowo University, Ile-Ife, Nigeria, 327 pp.

BALA U., LAWAL I., BOLORUNDURO P.I., ONIYE S.J., ABDULLAHI S.A., BICHI A.H., 2009, *Study of ichthyofauna of Daberam reservoir in Katsina state.* BAJOPAS, **2** (2): 172–174.

BEVERIDGE M.C.M., 1987, *Cage Aquaculture*. Fishing News Books LTD. Farnham, Surrey, England, 352 pp.

BEYER J.E., 1987, *On length-weight Relationships. Part I: Computing the mean weight of the Fish of a given length class*. Fishbyte, **5**: 11–13.

BOLGER T., CONNOLY P.L., 1989, *The selection indices for the measurement and analysis of fish condition*. Journal of Fish Biology, **17** (3): 1–182.

BOYD C.E., 2004, *Farm-level issues in aquaculture certification: Tilapia.* (Available at: http:// www.aces.edu/dept/fisheries/aquaculture/documents/W WFboyd.pdf)

BOYD C.E., TUCKER C.S., 1998, *Pond aquaculture water Quality Management*. India: Springer India Pvt ltd.

DE SILVA S.S., 1985, *Body condition and nutritional ecology of Oreochromis mossambicus (Pisces Cichlidae) populations of man-made lakes in Sri Lanka*. Journal of Fish Biology, **27**: 621–Ffryer633.

FRYER G., ILES T.D., 1972, *The Cichlid Fishes of the Great Lakes of Africa, Their Biology and Evolution*. Oliver & Boyd, Edinburgh, 641 pp.

GETACHEW T., FERNANDO C.H., 1989, *The food habits of an herbivorous fish (Oreochromis niloticus Linn.) in Lake Awasa, Ethiopia*. Hydrobiologia, **174**: 195–200.

GÓMEZ-MÁRQUEZ J.L., PEÑA-MENDOZA B., SALGADO-UGARTE I.H., GUZMÁN-ARROYO M., 2003, *Reproductive aspects of Oreochromis nilotiucs (Perciformes: Cichlidae) at Coatetelco lake, Morelos, Mexico*. Revista de Biologia Tropical, **51**: 221–228.

HARUNA M.A., 2006, *Length-weight relationship of four fish species Cichlidae from Magaga Lake, Kano, Nigeria.* BEST Journal, **3** (3): 109–111.

IMAM T.S., BALA U., BALARABE M.L., OYEYI T.I., 2010, *Length-weight relationship and condition factor of four fish species from Wasai Reservoir in Kano, Nigeria*. African Studies, **6**: 125–130.

KARNATAK G., KUMAR V., 2014, *Potential of cage aquaculture in Indian reservoirs*. IJFAS. **1** (6): 108–112.

KOMOLAFE O.O., ARAWOMO G.A.O., 2008, *Preliminary Observations on Fish Species in a Newly Impounded Osinmo Reservoir*. Turkish Journal of fisheries and aquatic sciences, **8**: 289–292.

NIKOLSKY G.V., 1963, *The Ecology of Fishes*. Academy Press, London and New York, 352 pp.

NYANTI L., HII K.M., SOW A., NORHADI I., LING T.Y., 2012, *Impacts of Aquaculture at different Depths and Distances from cage culture sited in Batang Ai Hydroelectric Dam Reservoir Sarawak, Malaysia*. World Applied Sciences Journal, **9** (4): 451–456.

OBODAI E.A., WALTIA S.C., 2003, *Preliminary observations on fishing activities in the Tono reservoir, Upper-East Region, Ghana.* Journal of Ghana Science Association, **5**: 69–76.

OTUBUSIN S.O., 1989, *Fish culture in cages, pens and enclosures: A possibility of meeting the fish demand in Nigeria*., pp.: 9–15. *In:* A.D. Onyia and G.N. Asala (eds.), 1989, Proceedings of the Fisheries Society of Nigeria Conference.

OTUBUSIN S.O., 1997, *Cage culturability of some commercially important fish species in lake Kainji, Nigeria*. Tropical Freshwater Biology, **6**: 41–47.

OTUBUSIN S.O., OLATUNDE A.A., 1992, *Utilization of waste waters in fish production: preliminary results from fish culture studies in floating cages in a sewage pond, New Bussa, Nigeria*, pp.: 39–46. *In*: A.A. Eyo and A.M. Balogun (eds.), Proceedings of the 10th Annual Conference of the Fisheries Society of Nigeria.

RIEDEL R., CASKEY L.M., HURLBERT S.H., 2007, *Length-weight relations and growth rates of dominant fishes of the Salton Sea: implications for predation by fish-eating birds*. Lake and Reservoir Management, **23**: 528–535.

ROBOTHAM P.W.J., 1990, *Trophic niche overlap of the fry and juveniles of Oreochromis leucosticus (Teleostei, Cichlidae) in littoral zone of tropical lake (L. Naivasha, Kenya).* Revue Hydrobiological Tropical, **23**: 209–218.

SHELTON W.L., 2002, *Tilapia culture in the 21st century*, pp.: 1–20. *In*: Guerrero R.D. III and M.R. Guerrero-del Castillo (eds.), Proceedings of the International Forum on *Tilapia* Farming in the 21st Century (*Tilapia* Forum 2002), Philippine Fisheries Association Inc. Los, Banos, Laguna, Philippines, 184 pp.

STEWART K.M., 1988, *Changes in condition and maturation of Oreochromis niloticus L. population of Ferguson's Gulf, Lake Turkana, Kenya*. Journal of Fish Biology, **33**: 181–188.

TAIWO I.O., ODUNAIYA O., 2004, *Sex Ratio and Fecundity of Chrysichthys nigrodigitatus (Family – Claroteidae) from Asejire Lake, Nigeria*. Nigerian Journal of Animal Production, **31** (1): 135–143.

TUDORANCEA C., FERNANDO C.H., PAGGI J.C., 1988, *Food and feeding of Oreochromis niloticus (Linnaeus, 1758) juveniles in Lake Awassa (Ethiopia)*. Archiv fűr Hydrobiologie Supplements, **79**: 267–289.

WELCH P.S., 1952, *Limnology*, 2nd Eds., McGraw Hill Book Co. Inc., New York.

WILLIAMS K., SCHWARTZ D.P., GEBHART G.E., 1983, *Small-Scale Caged Fish Culture in Oklahoma Farm Ponds.* Cooperative State Research Service, Langston University, Langston, OK, 25 pp.

YEE L.T., PAKA D.D., NYANTI L., ISMAIL N., EMANG J.J.J., 2012, *Water Quality at Batang Ai Hydroeletric Reservoir (Sarawak, Malaysia) and Implications for Aquaculture*. International Journal of Applied Science and Technology, **2** (6): 23–30.

***APHA (American Public Health Association), 2005, Standard methods for the examination of water and wastewater. 21. Washington, DC.
***FAO (Food and Agriculture Organization of the United Nations), 2016, The State of World Fisheries and Aquaculture 2016. Contributing to food security and nutrition for all. Rome, 200 pp.
***NSDW (Nigerian Standard for Drinking Water), 2007, Nigerian Industrial Standard. NIS 554, Standard Organization of Nigeria. Lagos, 30pp.
***WHO (World Health Organisation), 1987, Guideline for drinking water, vol. 1 recommendations WHO. Geneva.
***WHO (World Health Organisation), 2004, Drinking Water Guidelines, 130 pp. (Available at http://103.whosea.org.tehifor/water.litm/).

Received December 22, 2017

[*]*Federal University of Agriculture,*
IFSERAR,
P.*M.B. 2240, Abeokuta,*
Ogun State, Nigeria, NG-110212
e-mail: iomtai@yahoo.com

[**]*University of Port-Harcourt*
Department of Fisheries
P.M.B. 5323, Choba
East/West Road, NG-500211
e-mail: olaniyi.olopade@uniport.edu.ng