Current Research Journal of Biological Sciences 5(5): 190-194, 2013
DOI:10.19026/crjbs.5.5434
ISSN: 2041-076X, e-ISSN: 2041-0778

Submitted: October 12, 2011 Accepted: March 07, 2013 Published: September 20, 2013

Research Article

Studies on Diel Oxygen Fluctuation in a Tidal Brackish Water Farm at Ikoyi, Lagos, Nigeria

[1]P.U. Uzukwu, [1]F.O. Nwadukwe and [2]N.A. Jamabo
[1]Nigerian Institute for Oceanography and Marine Research, P.M.B. 12729 Victoria Island, Lagos, Nigerian
[2]Department of Animal Science and Fisheries, Faculty of Agriculture, University of Port Harcourt, P.M.B. 5323, Port Harcourt, Rivers State, Nigeria

Abstract: This study provides baseline data on diel oxygen fluctuation in a tidal brackish water environment. Investigation on diel Dissolved Oxygen (DO) fluctuation was carried out in a tidal brackish water habitat at two-hourly intervals in three ponds (6, 8 and 9). The highest mean dissolved oxygen values of 6.80, 7.00 and 3.90mg/1 for ponds 6, 8 and 9 respectively were recorded during the afternoon in the dry season. On the other hand, the lowest dissolved oxygen levels of 1.98, 3.00 and 0.20mg/1 for ponds, 6, 8 and 9 respectively were recorded during periods of heavy influx of suspended clay and silt particles in the peak of the rainy season. Analysis of Variance (ANOVA) showed that DO values recorded during peak dry season were significantly higher ($p \leq 0.05$) than those of the rainy season.

Keywords: Brackish water ponds, diel oxygen, dry season, rainy season

INTRODUCTION

Nigeria has approximately 853 km coastline bordering the Gulf of Guinear, with over 1.5 million ha of unused coastal swamps. Her territorial sea of 30 nautical miles (Nm) and an Exclusive Economic Zone (EEZ) of 200 nm cover 210, 900 km^2 (World Resources, 1990). Brackish water aquaculture in West Africa is relatively recent and not well developed, when compared to the condition in Asia, where ponds, pens and cages are used for commercial fish production (Nwadukwe *et al*., 2006). Due to growing interest in commercial fish farming in Nigeria and the need to sustain and further promote its development, information on diel oxygen fluctuation of tidal fish farms is important for effective prediction of early morning Dissolved Oxygen (DO) deficiency in fish ponds (Boyd *et al*., 1978). This is because optimum level of DO is crucial for profitable cultivation of fish, whether phytoplankton feeders or carnivorous species (Boyd, 1979; Boyd and Lichtkoppler, 1979).

Diel oxygen fluctuation has been successfully used in predicting early morning dissolved oxygen concentration in fish ponds (Boyd *et al*., 1978). Apart from a study in fresh water ponds (Ali, 1986), information on diel oxygen fluctuation in tidal fish farm in Nigerian is scarce. It has been observed that dissolved oxygen is the most critical water quality parameter in pond fish culture (Boyd, 1979; Masser *et al*., 1999). The limiting effects of dissolved oxygen on biological activities of fish such as survival, swimming, growth and production have been earlier reported (Boyd, 1979; Fry, 1971; Kutty, 1981). It has been further observed that the quantity and quality of fish produced in fish ponds also depend on the dissolved oxygen level in pond waters (Ali, 1986; Boyd, 1979).

This study examined diel oxygen fluctuation in a tidal brackish water fish farm in Lagos to provide baseline data for similar studies elsewhere.

MATERIALS AND METHODS

The three ponds (0.1 ha each) used for this study are located on the shorelines of Lagos lagoon in Nigeria, which has direct connection with the sea (Fig. 1).

The ponds were not limed, fertilized or stocked with fish. The sluice gates of ponds were screened to prevent entry of wild fish. The sluice gates of ponds 6 and 8 were left open for 9 months, subjecting them to tidal water from the lagoon, while that of pond 9 was permanently closed for the same period thus precluding the influx of nutrients for plankton and served as control.

Water samples were taken twice a month during peak rainy season (July to September), peak dry season (January to March) and transition period (October to

Corresponding Author: P.U. Uzukwu, Nigerian Institute for Oceanography and Marine Research, P.M.B. 12729 Victoria Island, Lagos, Nigerian

December 2010) for each pond at two-hour intervals. They were immediately fixed and analyzed for Dissolved Oxygen (DO) using unmodified Winkler's method (Boyd, 1979). Analysis of Variance (ANOVA) and Duncan multiple range test were carried out to determine the significance ($p \leq 0.05$) of the effects of season on dissolved oxygen levels.

RESULTS

The mean values of dissolved oxygen fluctuations for ponds 6 and 8 (open) and 9 (closed) during dry season, rainy season and transition period is shown in Fig. 1.

During the rainy season, the mean DO fluctuation over a twenty-four hour period for pond 6 increased from 2.10 mg/1 at 6.00 am to a maximum value of 4.00 mg/1 at 2.00 pm before declining to a lowest value of 1.98 mg/1 at 6.00 am next morning (Table 1). For pond 8, the mean DO fluctuation over a twenty-four hour period increased from 2.15 mg/1 at 6.00 am to a maximum value of 4.00 mg/1 at 2.00 pm and then declined to a lowest value of 3.00 mg/1 at 6.00 am next morning. For pond 9, the mean DO fluctuation over a twenty-four hour period increased from 0.45 mg/1 at 6.00 am to a maximum value of 2.50 mg/1 at 12.00 noon before declining to a lowest value of 0.20 mg/1 at 6.00 am next morning (Table 1).

The dry season, had mean DO levels over a twenty-four hour period increased from 3.20 mg/1 at 6.00 am to a maximum value of 6.80 mg/1 at 8.00 pm

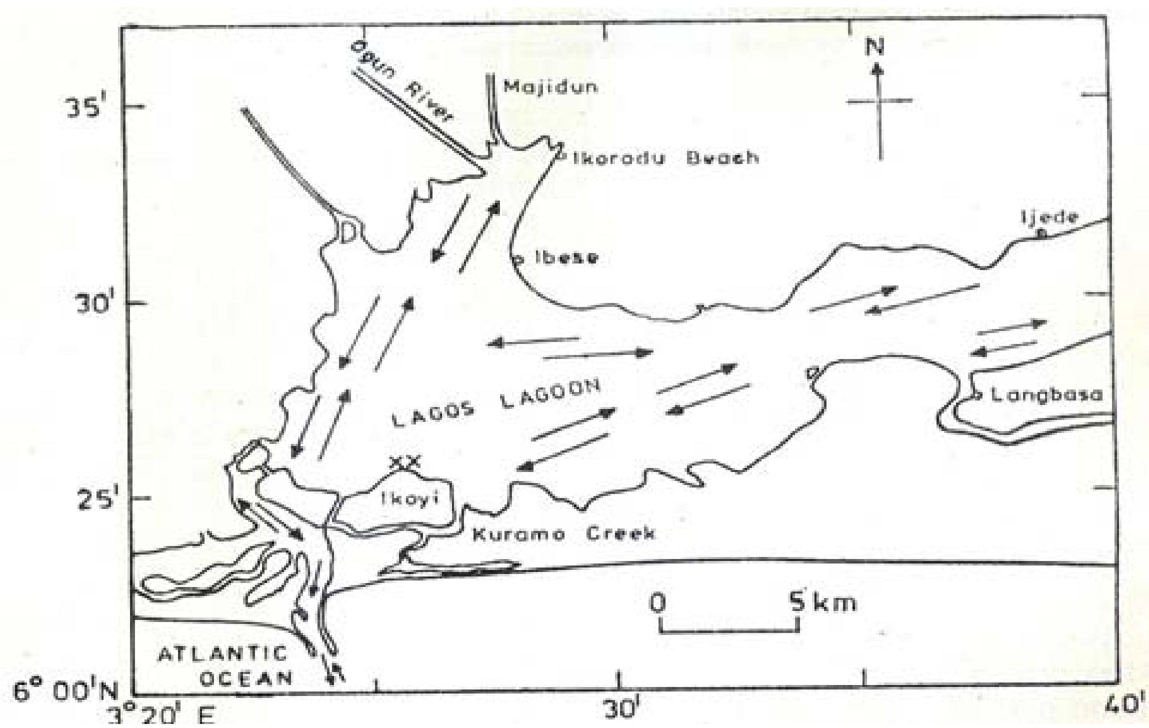
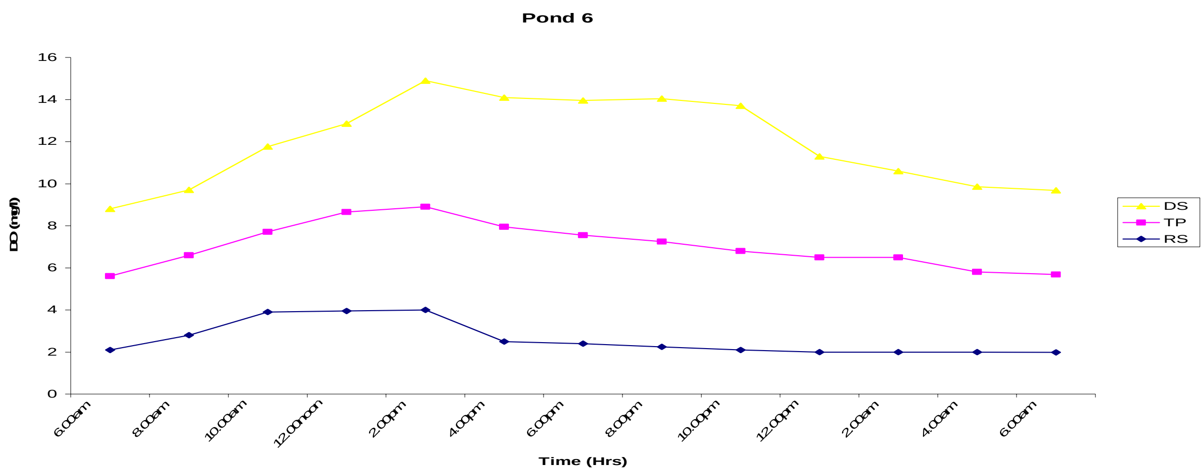


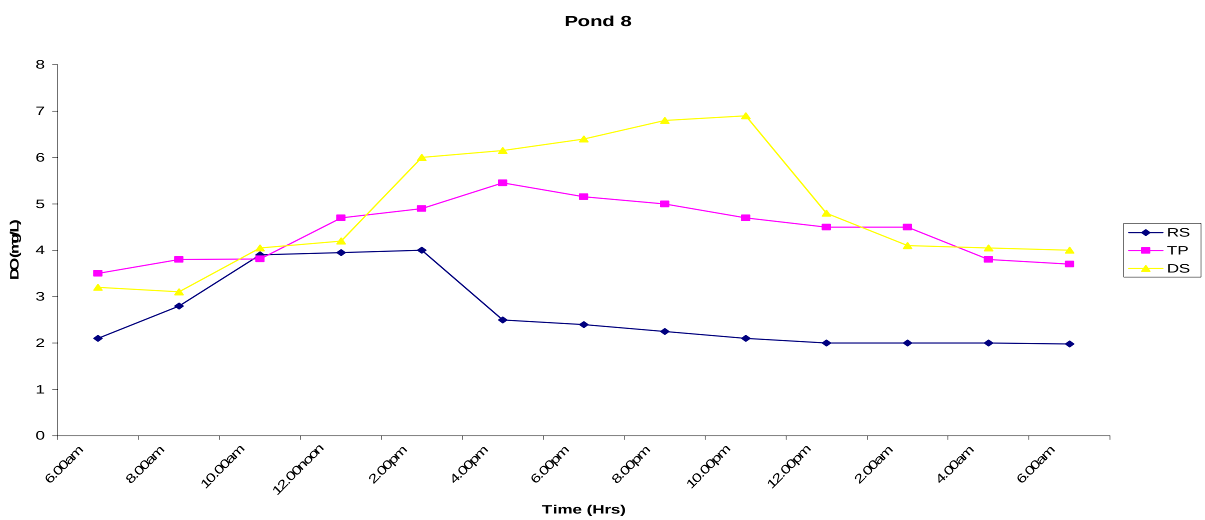
Fig. 1: Lagos lagoon and its enviorns; ××: Institute's experimental fish farm at lkoyi; ⇄ Tidal flow of water

Table 1: Mean Dissolved Oxygen Fluctuation in Ponds 6, 8 and 9

	Pond 6			Pond 8			Pond 9		
Time	RS	TP	DS	RS	TP	DS	RS	TP	DS
6.00 am	2.1	3.5	3.2	2.15	3.25	5.1	0.45	1.3	2.2
8.00 am	2.8	3.8	3.1	2.8	3.6	5	0.7	1.6	1.95
10.00am	3.9	3.81	4.05	2.9	3.8	5.45	0.8	1.7	2.6
12.00 noon	3.95	4.7	4.2	3.9	4.8	6	2.5	2.4	3.7
2.00 pm	4	4.9	6	4	5.2	6.3	2.6	2.9	3.7
4.00 pm	2.5	5.45	6.15	3.95	5.95	6.8	2.15	3.5	3.9
6.00 pm	2.4	5.15	6.4	3.45	5.8	7	1.2	3.3	3.8
8.00 pm	2.25	5	6.8	3.5	5.3	5.95	0.7	2.8	2.95
10.00 pm	2.1	4.7	6.9	3.49	5.1	5.01	0.8	2.4	2.7
12.00 pm	2	4.5	4.8	3.15	4.8	4.5	0.85	2.15	2.3
2.00 am	2	4.5	4.1	3.1	4.2	4.4	0.3	1.8	2
4.00 am	2	3.8	4.05	3.05	3.5	4.1	0.25	1.5	1.8
6.00 am	1.98	3.7	4	3	3.3	3.5	0.2	1.35	1.2

Key: RS-Dry Season; TP-Transition Period; DS-Dry Season





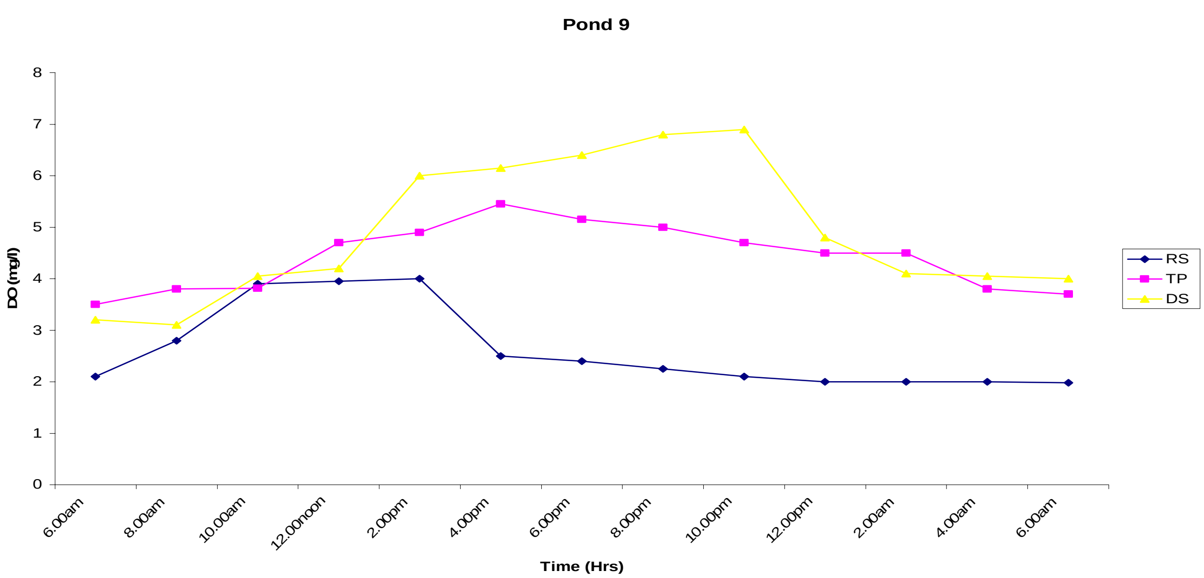


Fig. 2: Mean dissolved oxygen fluctuation in pond

and then declined to 4.00 mg/1 at 6.00 am next morning. In pond 8, the mean DO fluctuation increased from 5.10 mg/1 at 6.00 am to a maximum value of 7.00 mg/1 at 6.00 pm and then declined to a lowest value of 3.50 mg/1 at 6.00 am next morning. In pond 9, the mean DO fluctuation increased from 2.20 mg/1 at 6.00 am to a maximum value of 3.90 mg/1 at 4.00 pm, before declining to a lowest value of 1.20 mg/1 at 6.00 am next morning.

The mean DO values over the twenty-four hour period during the transition between rainy and dry seasons more or less toed the middle course (Fig. 1).

DISCUSSION

The lowest DO fluctuations occurred in each pond during the peak wet season while the lowest DO values occurred during the period of cloudy weather, high relative humidity (85.00-87.00%) and heavy rainfall which ranged from 118.70-703.00 mm (MMS, 1988). On the other hand the highest DO values were recorded during very sunny months with low relative humidity (74.00-78.00). The relatively low quantum of DO fluctuation in pond 9 may be attributed to low phytoplankton population since it s sluice gate was closed to tidal nutrient influx. On the other hand, the high amplitude of DO fluctuations in ponds 6 and 8 is attributable to increased nutrients brought by tidal water from the lagoon. This view is supported by Ezenwa *et al.* (1994) who reported similar observation in the ponds.

The result of the Analysis of Variance (ANOVA) and Duncan multiple range test showed that mean DO values recorded in the ponds during the peak dry season were significantly higher ($p \leq 0.05$) than those of the peak wet season. Whereas during the transition months (October to December) the DO levels were not found significantly ($p \geq 0.05$) different from that of peak dry season. Significant DO fluctuation ($p \leq 0.05$) observed in the ponds may be due to the availability of sunlight the day for photosynthetic activities of phytoplankton. At night photosynthesis stops and oxygen production ceases. Meanwhile respiration by the biota continued to use up available oxygen thereby causing DO decline at night (Lackey, 1938).

The relatively low mean DO values recorded during the rainy season (pond 6:4.10 mg/l; pond 8:4. 20 mg/l; pond 9: 2.70 mg/l) may be attributed to the effect of cloudy weather on oxygen generating capacity of phytoplankton population. On the other hand, the highest mean DO values recorded during the dry season (pond 6:6.80 mg/1; pond 8:7.60 mg/1; pond 9:3.90 mg/1) is attributable to increased light penetration for the photosynthetic activities of phytoplankton. Ezenwa *et al*. (1994) reported similar observation for primary productivity values in the ponds. It has further been reported that extended periods of cloudy weather may result in dangerously low dissolved oxygen concentrations even in ponds with moderately heavy plankton blooms (Ezenwa *et al*., 1994).

The optimum range of Dissolved Oxygen (DO) for profitable fish cultivation is 5 .0 mg/1 to 9.50 mg/1 (Boyd, 1979). Several studies have shown that fish eat and grow be\st at DO concentrations near air saturation (Boyd, 1979; Boyd and Lichtkopper 1979; Masser *et al*., 1999). It is the feeing of most workers that if DO does not drop below about 25% saturation during the night; adequate level of fish production may be achieved. This, however, is usually difficult to achieve at night in ponds. In this study, DO concentrations were predominantly much below saturation, especially in pond 9 (closed). It has been reported that pond annual production of 4,000 to 5,000 pounds have been sustained through maintenance of optimal level of DO in ponds particularly during early morning hours, using mechanical method such as paddle wheels and air compressors (Brune *at al*., 2004). However, the most cost effective method would be to maintain regulated gravity flow through system at night from an aerated reservoir. The highest mean DO values recorded in this study (pond 6:6.80 mg/l; pond 8:7.00 mg/l; pond 9:3.90 mg/l) indicated that the photosynthetic capacity of the phytoplankton was more pronounced during the dry season. The ponds with open sluice gates (6 and 8), recorded higher mean DO values than the pond with closed sluice gate (9).

This may be due to a combination of many factors: increased nutrients brought by tidal water from the lagoon, increased photosynthetic capacity of the phytoplankton population and low relative humidity. Figure 2 illustrates the prediction of early morning DO deficiency in fish ponds using linear extrapolation.

The deduction from this study is that tidal brackish water ponds with access to lagoon and estuarine systems exhibit dual diel oxygen regimes: high DO levels and fluctuations during the dry season and relatively low DO levels and fluctuations during the rainy season. The dual regimes could be exploited in:

- Effective prediction of early morning DO deficiency in ponds during dry and rainy seasons (Fig. 2) and
- Cost-effective utilization and application of fertilizers, lime and feeds for the culture of both carnivorous fish like the catfish and phytoplankton feeders such as mullets, tilapia, shrimps and prawns.

CONCLUSION

This study has provided additional baseline data on diel oxygen fluctuations for typical tidal brackish water fish farms in the West African sub-region. It also confirmed the existence of season dependent dual diel dissolved oxygen regimes that could be exploited in cost-effective management of brackish water ponds, particularly prediction and control of early morning DO deficiency.

REFERENCES

Ali, T.A., 1986. Oxygen regime and productivity in fish ponds. M. Tech. Thesis, Rivers State University of Science and Tech, Port Harcourt, Nigeria, pp: 85.

Boyd, C.E., 1979. Water Quality in Warm Water Fish Ponds. Agri. Exp. Stat. Auburn Univ. Auburn, Alabama, pp: 359.

Boyd, C.E. and F. Lichtkoppler, 1979. Water Quality Management in Pond Fish Culture. Research and Development Series No. 22, Auburn Univ., Auburn, Alabama, AID/DSAN, pp: 30.

Boyd, C.E., R.P. Romaire and E. Johnston, 1978. Predicting early morning dissolved oxygen concentration in channel catfish pond. Trans. Am. Fish. Soc., 107: 484-492.

Brune, D.E., G. Schusartz, A.G. Eversole, J.A. Collier and T.E. Schwedler, 2004. Partitioned Aquaculture Systems, Southern Regional Aquaculture Centre Publication No. 4500, pp: 7.

Ezenwa, B., P. Uzukwu and P. Anyanwu, 1994. Studies on primary productivity in a tidal fish farm at Ikoyi, Lagos. J. Aqua. Trop., 9: 1-7.

Fry, F.E.J., 1971. The Effects of Environmental Factors on the Physiology of Fish. In: Hoar W.S. and J.D. Randall (Eds.), Fish Physiology. Academic Press, London, 6: 1-98.

Kutty, M.N., 1981. PH regulation during long-term swimming in the mullet *Phinomugil corsula*. Proc. India Acad. Anim. Sci., 90(3): 303-305.

Lackey, J.B., 1938. The manipulation and counting of river plankton and changes in some organisms due to formalin preservation. U.S. Public Health Reports, 53: 2080-2093.

MMS (Marine Meteorological Service), 1988. Rainfall Data and Relative Humidity (1986-1989). Marine Meteorological Services, Lagos, pp: 150.

Masser, M.P., J. Rakocy and T.M. Losordo, 1999. Recirculating Aquaculture Tank Production Systems. Management of Recirculating Systems, Southern Regional Aquaculture Centre Publication No. 452.

Nwadukwe, F.O., P. Uzukwu, M.B. Hamzat and C.B. Okoro, 2006. Studies on water, soil and macro-invertebrates in a brackish water habitat in the Lagos Lagoon. Afr. J. Appl. Zool. Environ. Biol., 8: 1-5.

World Resources, 1990. A Report by World Resources Institute in Collaboration with UNEP and UNDP. Oxford University Press, New York, pp: 383.