Journal of Natural Sciences Research
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.3, No.12, 2013

Physico-chemical Characteristics of the Andoni River and its potentials for production of the Giant Tiger Prawn (*Penaeus monodon*) in Nigeria

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Abstract
The physico-chemical characteristics of Andoni River and its potentials for production of *Penaeus monodon* (Fabricius 1798), an exotic species whose occurrence in Nigerian coastal waters was first reported in 1999 was investigated from March 2012 to February, 2013. Physico-chemical properties of the River were determined from water samples collected at Kaa water front on a monthly basis. Temperature was determined using Mercury-in-glass Thermometer. A Pocket-sized pH meter Hanna Instruments (pHep) was used *in situ* to determine the pH of the River water. Dissolved oxygen was determined using modified Winkler's Method. Temperature ranged from 27.00± 0.32^{0}C to 31.00± 0.89^{0}C, pH varied between 5.64±0.02 to 6.92± 0.04. Salinity varied from 11.60± 0.51ppt in November to 22.80± 0.37ppt in May. Dissolved oxygen ranged from 3.86±0.37mg/l to 8.00±0.00mg/l. The values recorded were within FAO recommended range (temperature 25^{0}C - 30^{0}C, Salinity 5ppt - 40ppt and Dissolved oxygen 0.5mg/L – 8.6mg/L) for growth and development of Penaeid shrimps except for pH values which was lower than the recommended 7.5 - 9.0. The low pH was attributed to the time of sampling which for logistic reasons were carried out in the morning hours. Based on the results, it is concluded that the Andoni River is suitable for the production of the giant tiger prawn (*Penaeus monodon*).
Keywords: Water quality, Shrimp, Niger Delta.

1.0 Introduction

The giant tiger prawn, *Penaeus monodon*, although a marine species spends part of its life cycle in brackish waters where conditions are highly variable. For example, salinity values may be very high during the flow tide and reduced during the low tide. It may also show seasonal variation with higher values in dry season and lower values in rainy season. Ikusemiju (1973) and Ezenwa *et al*., (1987) reported fresh water salinity to be <0.5ppt, estuarine salinity >0.5ppt <30.0ppt while the ocean salinity is >30.0ppt. Salinity however, influences the distribution of aquatic plants and animals. Edokpayi (2005) reported that Benin River whose salinity ranged from 8.8ppt to 24.1ppt support the growth and production of prawn. Salinity values are low during the rainy season. This is due to the dilution effect of increased river inflow through rain waters. This observation is common to most Nigerian rivers and creeks (Courant *et al*., 1987). The months of April to October in West Africa record higher rainfall resulting in increased discharge of fresh water into estuary and oceans thereby reducing salinity (Abowei 2010) while heat generated by sunlight in dry season months would cause evaporation of the surface water making it saltier and more saline (McLusky, 1989, Ansa, *et al*., 2007, Oyewo *et al*., 1982).Salinity affects Osmoregulation and development of fish eggs (Ibe 1985)

Most aquatic organisms including the giant tiger prawn are exothermic and are not able to control body temperature except by behaviourial means. Increased metabolic rate leads to higher oxygen consumption and waste production. Metabolic rate is known to increase 2-or 3-fold for every 10^{0}C increase in temperature. On the other hand, the amount of oxygen that will dissolve in water increases as temperature decreases. Waterwatch/Namoi CMA, (2013) revealed that water at 0^{0}C will hold up to 14.6mg/litre while at 30^{0}C it will hold only up to 7.6 mg/L of dissolved oxygen.

Temperature equally influences the rates of development, timing and success of reproduction, mobility, migration patterns and the sensitivity of organisms to toxins, parasites and diseases. The Life cycles of many aquatic organisms are often related to changes in temperature (Water watch/Namoi CMA, 2013). Many factors influence the temperature of pond and lake including seasonal air temperature, water depth (Abowei 2010), ground water inflow, stream flow, mixing due to wind and water currents, and the amount of sunlight and shade (Kelly and Linda 1997). Abowei (2010) reported the temperature of Nkoro River to range from 24.0^{0}C – 33.7^{0}C.

The pH of water varies naturally within streams due to photosynthesis (Water watch/Namoi CMA, 2013). pH range of 5.5 to 10 (Moyle 1993) was considered adequate to support growth of aquatic organisms. Acid soils and rocks such as basalt, granite and sandstone contribute to lower pH in water. Oxidized or uncovered acid sulphate soil releases sulfuric acid into surrounding water ways. Basic rocks including limestone contribute to higher pH values. Eroded fertilizers and detergent also cause increase in alkalinity. A pH range of 6.5 to 8.0 is optimal for fresh water while a range of 8-9 is optimal for estuary and sea waters (water watch/Nomoi CMA, 2013). Matthews (1998) reported that water with pH less than 6 may result in reduced egg fertility, hatchability and growth. Water with low pH imposes stress on fish. Most fish thrive in pH range of 5.5 to 10 (Matthews ,1998). Abowei (2010) reported the pH of Nkoro River of Niger Delta to range from 6.1 to 8.5. Lower pH of 6.68 ±0.07 to 6.81 ±0.05 at upstream was attributed to decay of domestic and other wastes littered in the upstream section. Tannic acids (tannins) which are found naturally in leaves are responsible for giving water a tea-like colour. Extreme acidic or alkaline water results in death of most aquatic fauna (Water watch/Namoi CMA, 2013).

Seasonal variation of pH was observed by Dublin-Green (1990) in Bonny River, Ekeh and Sikoki (2003) in the New Calabar River, Abowei (2010) in Nkoro River, Ansa (2004) in Andoni flats of Niger Delta, all indicating high pH during dry season and lower in the rainy season. However, Yakubu *et al.,* (1998), and Francis *et al*., (2007), observed higher pH in rainy season which was attributed to increased inflow of runoff water which could have washed in fertilizers and other inorganic chemicals from the environment.

The amount of Dissolved oxygen in water shows the overall health of a water body. High dissolved oxygen indicates low level of pollution. Conversely, low dissolved oxygen indicates high oxygen demand depicting that the water is not of optimal health (Water watch/Namoi CMA, 2013). Ambient oxygen acts as a limiting factor of metabolism and growth (Francis *et al*., 2007). Though oxygen level in a water body may be quite above the lethal point, oxygen may be restricting activity and growth (FAO, 2013) shrimps consume as low as 0.5% and as high as 8.6% of oxygen, whereas bacteria/organic matter may consume as high as 69.4% of the dissolved oxygen present in the water (FAO,2013). Dissolved oxygen is not a limiting factor in most running waters (Hynes, 1970). Edokpayi (2005) attributed the low dissolved oxygen recorded at some stations in the Benin River to high oxygen demand caused by microbial break down of allochthonous input mainly fallen leaves. However, Caduto (1990) observed that productive lakes have large populations of aquatic plants or algae and experience greatest fluctuation of its dissolved oxygen. Dissolved oxygen concentration is lowest before sunrise and highest late at noon. For optimum ecosystem function and high carrying capacity, coastal waters require minimum dissolved oxygen of 4 to 5mg/l (UNESCO/WHO, 1978).

Clark (1996) observed that depletion of dissolved oxygen could lead to suffocation, fish kills, loss of appetite which could affect embryonic development, hatching success, reproductive success, recruitment pattern, and change in abundance and diversity of species.

This study of some key physical and chemical characteristics of the Andoni River was necessary to ascertain the suitability of the River for production of Penaeid shrimps.

2.0 Materials and Methods.

2.1 The Study Area

The Andoni River is located between latitudes $4^0$28' to $4^0$45' N and longitudes $7^0$45' E. It is a major fish breeding and nursery area in the Niger Delta region of Nigeria on the West coast of Africa. (fig 1).

2.2 Location of Sampling Stations

Five sampling stations were established at the Kaa water front for the purpose of determining the physico-chemical properties of the River.

2.3 Determination of Physico-chemical Variables.

Salinity was measured in parts per thousand (ppt) using a hand-held Refractometer, Model NEW S-100.Temperature was determined using Mercury-in-glass Thermometer with the probe inserted into the water and the value read off and recorded in degree Celsius (^{o}C). A Pocket-sized pH meter, Hanna Instruments (pHep) was used *in situ* to determine the pH.

Dissolved oxygen was measured by the Alkaline-Azide modification method of Winkler (APHA, 1998) where 200ml amber sample bottles were used to collect water sample at each of the stations. The bottles were corked in such a manner that air bubbles are not trapped. Thereafter, the cork on each bottle was removed and 0.5ml of $MnS0_4$ $4H_20$ solution and 0.5 ml KOH/ KI solution added. The bottles were then re-corked and inverted severally (this is to fix the dissolved oxygen). The samples were transported to the laboratory for further analysis. In the laboratory, the Corks were removed and concentrated H_2SO_4 added (acidifying), re-corked and inverted to mix the content and 25ml of this solution was titrated with standard Na_2 S_2O_3 to a pale yellow coloration.2 drops of starch was added and titrated to a colourless solution. The titre value was recorded. Calculation: Dissolved Oxygen = titre value × 200/25 (titre value × 8)

2.4 Statistical Analysis

Descriptive statistics as well as two-way ANOVA was employed in the Physico-Chemical data analysis.

3.0 Results and Discussion

Data on temperature profile are presented in Fig.2. The data revealed that temperature varied between 27± 0.32^0C and 31± 0.89^0C. The temperature range was within acceptable WHO (2006) and FEPA (1991) limits for warm water fish production. The profiles of pH in the river are presented in Fig. 3. The data showed that mean pH ranged from 5.34± 0.11 in June to 6.92±0.04 in October. Similarly, salinity values recorded during the study are presented in figure 4. The Salinity ranged from 11.6 ±0.51 ppt to 22.8 ±0.37 and was relatively higher during the dry season.

The variations in Dissolved Oxygen content are summarized in figure 5. Its values ranged from 3.85 ± 0.37mg/l in January to 8.0 ± 0.00 mg/l in April. The highest dissolved oxygen value was recorded in April while the lowest value was recorded in January. The water quality (Table 1) of Andoni River does not only show the suitability of production of the giant tiger prawn but also the aquaculture potentials of the River. This is so because its physico – chemical properties are within FAO recommended limits.

The physico-chemical properties of the Andoni River estuary are suitable for the production of *P. monodon* as compared in Table1. The Salinity levels though relatively lower during the rainy season and higher in the dry season were attributed to the dilution effect of increased river inflow through rain waters (Edokpayi, 2005, Courant *et al.,* 1987, Abowei, 2010). In Andoni River, salinity appears to be influenced naturally by fresh water inflow, tidal stage, stratification of estuarine water and rainfall. The Salinity range recorded during this study (11.6 ± 0.51 ppt to 22.8 ± 0.37 ppt) differed slightly from those of Ansa *et al.*, (2007) who reported a range of 8ppt to 21ppt. However, result agrees with that of Francis *et al.,* (2007) who reported a range of 12 ppt to 22 ppt. Earlier work by Yoloye (1976) recorded the salinity of the same water body to range from 10 to 25 ppt. *P. monodon*, although marine, is known to tolerate low salinity conditions as low as 1 to 2% ppt (FAO 2011), accounting for why they are found in estuaries including the Andoni River estuary.

The temperature range of 27±0.3°C to 31.8±0.95°C, recorded in this river is typical of tropical estuarine waters. However earlier researchers had reported values of 26.2°C to 32.4°C (Ansa *et al.,* 2007) and 26.05°C to 32.1°C on the same Andoni River. Temperature influences migration, spawning, egg incubation, growth and metabolism of aquatic organisms (Kelly and Linda 1997). The temperature of Andoni River system is favourable to the growth and metabolism of *P.monodon*, hence the suitability of the new environment.

The mean p^H ranged from 5.34 ± 0.11 to 6.92 ± 0.04. Moyle (1993) reported that p^H range of 5.5 to 10 will support aquatic growth adequately. Andoni River system exhibits seasonal variation as value becomes lower during rainy season especially from July to November and higher in the dry season especially from December to March. Other factors such as photosynthesis and nature of substratum affect the P^H of any water body (Water Watch/NamoiCMA,2013). Edokpayi (2005) reported p^H range of 6.70 to 2.8 for Benin River and suggested seasonality of p^H. Water tends to be acidic when p^H is lower and alkaline when p^H value is higher. During rainy season the estuarine water becomes more alkaline due to dilution but acidic during dry season.

Dissolved Oxygen in the Andoni River system varies from 3.85 ± 0.37 mgl^{-1} to 8.0 ± 0.00mgl^{-1}. These values are lower compared to those of Francis *et al* (2007) who recorded 5 to 12.30mgl^{-1} in Andoni River system. The Dissolved Oxygen is however, similar to those of Nkoro River which varied from 3.2 ± 0.1 to 7.3 ± 0.16mgl^{-1} (Abowei 2010). Fish kills may occur if dissolved oxygen falls below 2 mgl^{-1}. Though dissolved oxygen is not a limiting factor in most running water (Hynes, 1970), ambient oxygen act as a limiting factor of metabolism and growth (Francis *et al.*, 2007).

The dissolved oxygen of Andoni River system exceeds FEPA (1991) and WHO (2006) minimum limits implying that the River can support fish growth and metabolism. Diffusion of oxygen into the Andoni River system would have occurred through water turbulence and strong wind blow. Phytoplanktons and macrophytes exposed to sun light could have generated oxygen into the water. Shrimps consume as low as 0.5mgl^{-1} to as high as 8.6mgl^{-1} of oxygen (FAO 2013). This oxygen requirement makes it very possible for *P. monodon* to invade, adapt and sustainably grow in the Andoni River system. The physico-Chemical parameters of Andoni River showed marked variation across sampling months unlike in pond culture where temperature and dissolved oxygen can be easily moderated (Woke *et al.,* 2013).

4.0 Conclusion

The physico-chemical parameters of the surface water of the Andoni River system fall within acceptable range for production of shrimps in a brackish water ecosystem. The physico-chemical qualities of the Andoni River are therefore suitable for the production of this alien species (*P.monodon*). The sustained proliferation of the species not only serves as source of livelihood for shrimp fishers but also create avenue for self employment making them self reliant. The government and private sectors are therefore encouraged to invest in this fishery especially in aquaculture.

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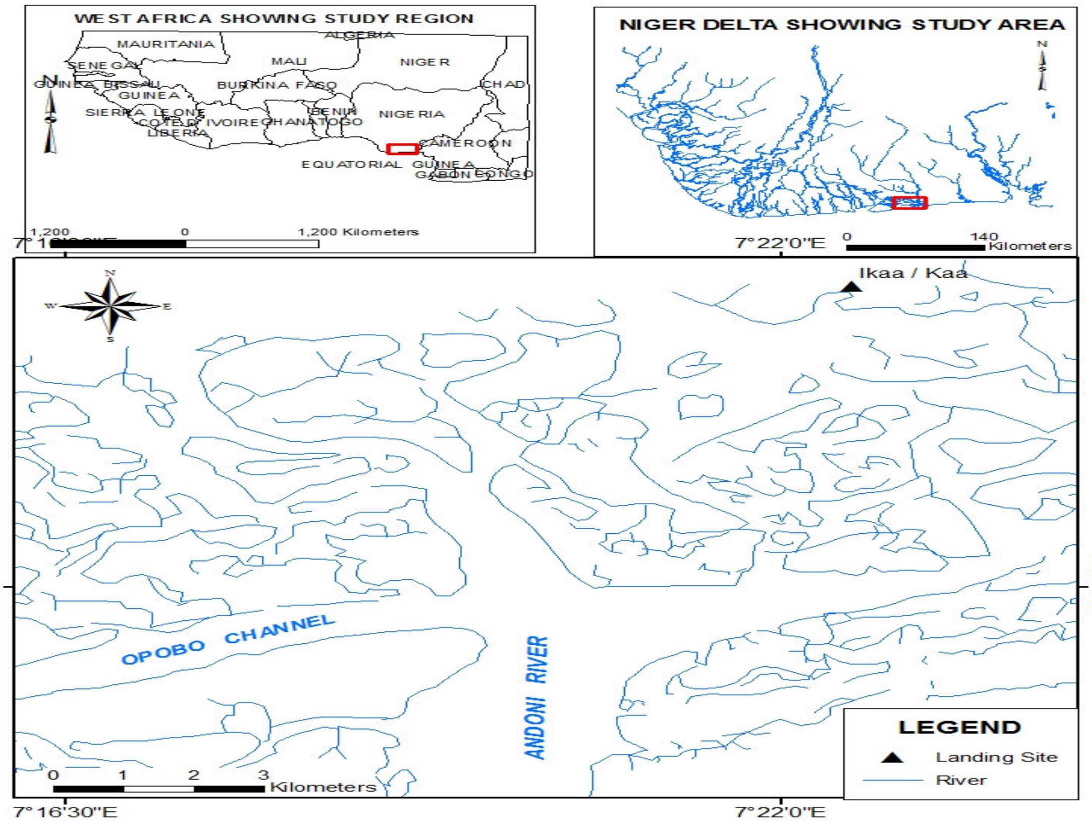

Fig. 1 Map of Andoni River

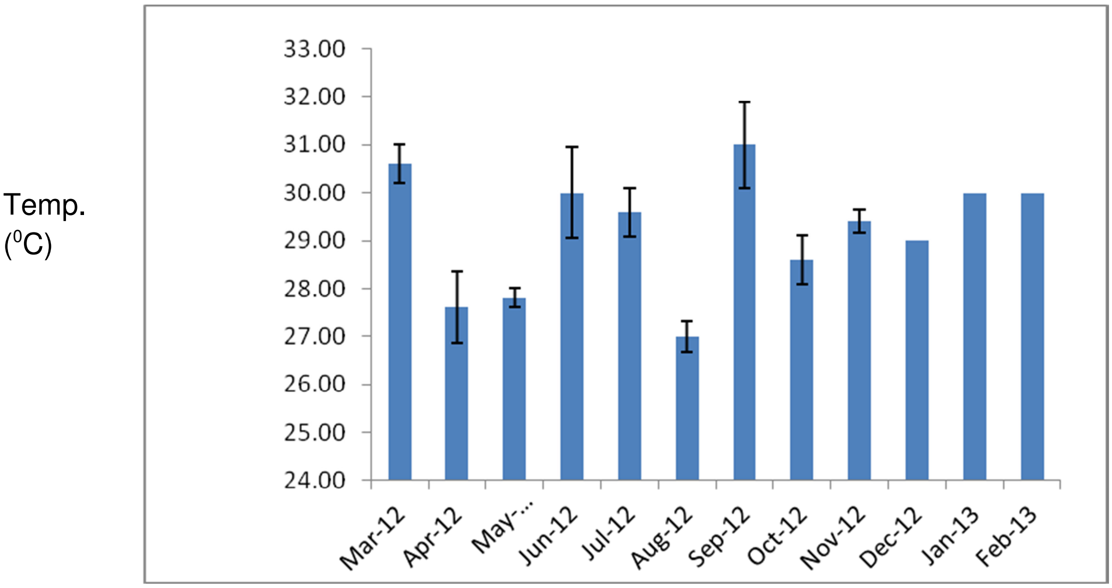

Fig.2: Mean Temperature values of the Andoni River System from March 2012 to Feb.2013

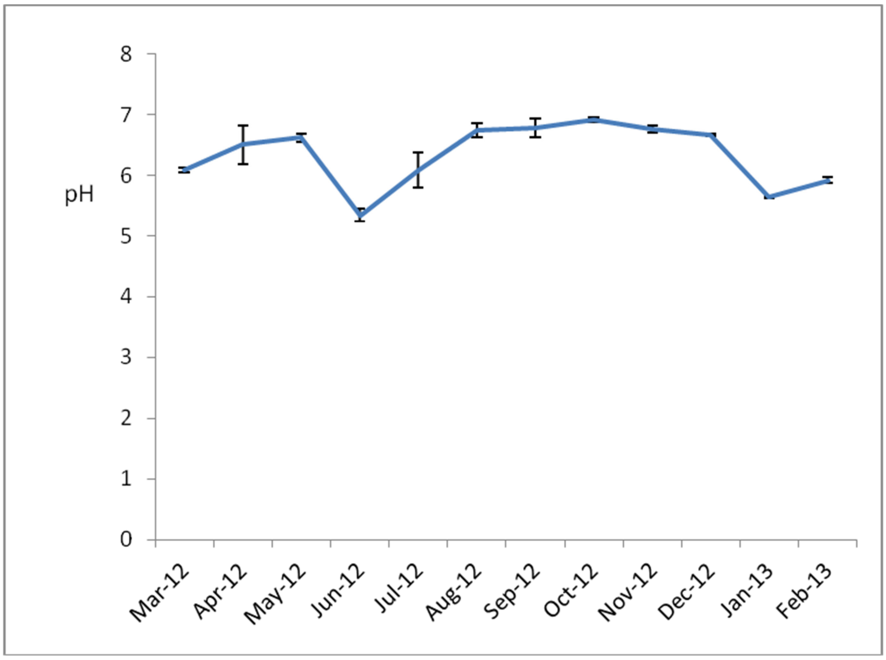

Fig.3: Mean pH values of the Andoni River System from March 2012 to Feb.2013

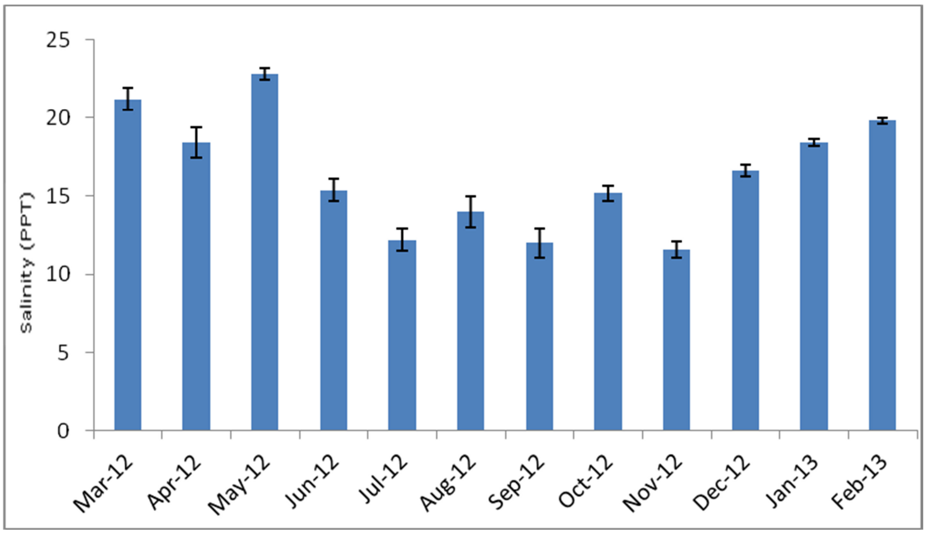

Fig. 4: Mean Salinity values of the Andoni River System from March 2012 to Feb.2013

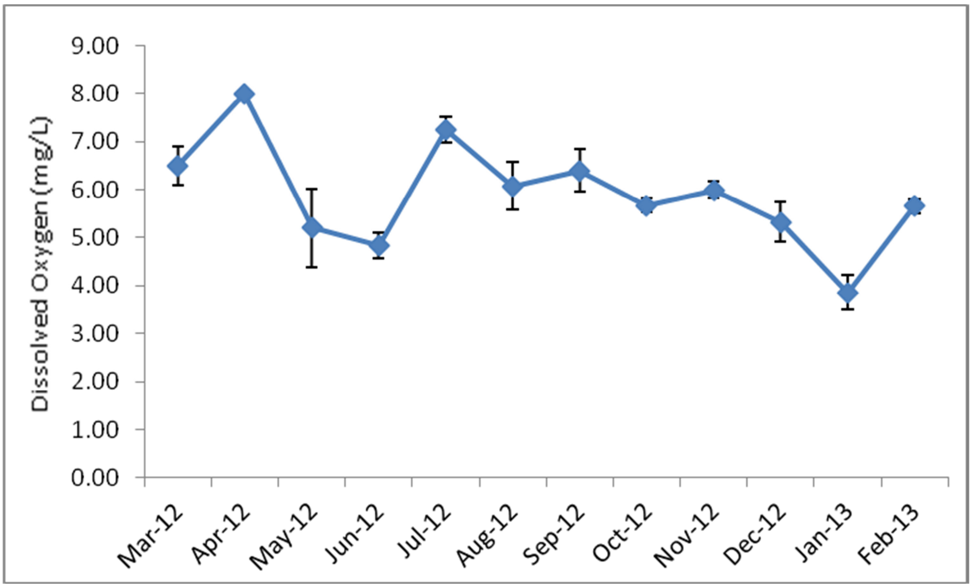

Fig. 5: Mean Dissolved Oxygen values of the Andoni River System from March 2012 to Feb.2013

Table 1: Water Quality Management

Parameters	FAO (1986) recommended range	Observed range from Andoni River
Temperature(^{0}C)	25 – 30	27 – 31
Salinity(PPT)	5 – 40	11.60 – 22.80
pH	7.5 – 9.0	5.64 – 6.92
Dissolved Oxygen(mg/L)	0.5 – 8.6	3.86 – 8.00