Ethiopian Journal of Environmental Studies & Management 10(9): 1193 – 1199, 2017.
ISSN:1998-0507 doi: https://ejesm.org/doi/v10i9.7
Submitted:July 28, 2017 Accepted: November 21, 2017

GROUNDWATER SUITABILITY FOR AQUACULTURE: A CASE STUDY OF AGBOR, DELTA STATE, NIGERIA

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Abstract
The increasing practice of aquaculture to meet the market demand for fish and the use of groundwater for freshwater aquaculture, has necessitated the need for the screening of source water for its physico-chemical properties to ascertain its suitability for efficient fish production. The study was aimed at assessing the groundwater in Agbor Delta State for its suitability in aquaculture. Water samples were collected from selected boreholes and physico - chemical parameters were analysed according to standard methods. Results showed that with the exception of pH, Chlorine and Copper; all other physico-chemical parameters considered were within the recommended permissible limits, and requisite water treatments should be carried out to improve the water quality with reference to the low pH, low Chlorine concentration and high Copper concentration in the groundwater, in order to make the groundwater holistically suitable for aquaculture.

Key Words: *Groundwater, Aquaculture, Physico-chemical Parameters, Agbor Delta State*

Introduction

The increasing demand for fish and fish products as sources of animal protein, has created a gap between demand and supply which has necessitated the increase in aquaculture production. According to the United Nations Food and Agriculture Organization (FAO), most species subject to capture fishing are over exploited and the potential for increasing yield in long term is extremely limited (FAO, 1996). Aquaculture has emerged as an attractive, irrepressible alternative to capture fisheries due to its potential for production expansion, effective use of processing facilities, and adaptability of production – to – market requirements (Zweig *et al.*, 1999).

Fishes are totally dependent on water and so information on the quality (physico-chemical) and availability of source water for fish production is indispensable. Water quality in aquaculture refers to anything in the water, be it physical, chemical or biological that affects the fish normal health and production performance (Balogun, 2015). Its quality directly affects feed efficiency, growth rates, the fish's health and survival. According to the University of Florida (2005), most fish kills, disease outbreaks, poor growth, poor feed conversion efficiency and similar management problems are directly related to poor water quality. To a great extent the success of an aquaculture operation is dependent on water quality, as such water sources should be selected based on its suitability for efficient production of high quality aquaculture products.

In general, for fresh water aquaculture, groundwater sources are preferred as they maintain a constant temperature, free of parasites and larvae of predatory insects, and are usually less contaminated than surface water sources, but may contain high or reduced iron concentrations, high chemical hardness and typically lacking oxygen (Lawson, 1995). For many of these physico – chemical properties of natural waters such as temperature, pH, turbidity, salinity, hardness, dissolved oxygen, nitrogen compounds, iron etc. that affect the growth and health of fishes; fishes have a limited range of concentration values in which they can grow optimally. Hence the screening of source water for its physico – chemical properties is an important initial step in assessing the source water suitability for aquaculture (Zweig *et al.,* 1999).

Agbor town is situated in Delta State, Nigeria. It lies within longitudes 6° 05’ E and 6° 20’ E; and latitudes 6° 07’ N and 6° 25’ N, and covers an area of about 650 km^2 rainforest vegetation. It has two distinct seasonal climate comprising of the wet and dry seasons with high humidity. Groundwater occurs at a depth generally greater than 60 metres, predominantly under unconfined aquifer (Olobaniyi *et al.,* 2007; Odjugo, 2008). Previous studies carried out on groundwater in this locality include; hydrogeochemical and bacteriological investigation of groundwater (Olobaniyi *et al.,* 2007), determination of heavy metals in groundwater (Oyem *et al.,* 2015), and the vulnerability of groundwater to dumpsite leachate pollution (Oboh and Egun, 2017). However, the aim of this work is to assess the groundwater suitability for aquaculture practices, especially for *Clarias garepinus*, the most common fresh water fish species cultivated in the study area.

Materials and Methods

Groundwater was sampled from four (4) selected boreholes across the study area, as shown in Figure 1. Water samples were collected in pre–washed 1 litre plastic containers and analysed *in-situ* for pH and transported in ice chests for further analysis. The sampling, preservation, transportation and physico – chemical analysis of groundwater samples was carried out according to outlined procedures in the Standard Methods for the Examination of Water and Wastewater (Ademoroti, 1996; APHA, 1998). The water samples were analysed for fourteen (14) physico-chemical parameters namely pH, Turbidity, Total suspended Solids (TSS), Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Sulphate, Nitrate, Phosphate, Chloride, Copper, Lead, Iron and Zinc.

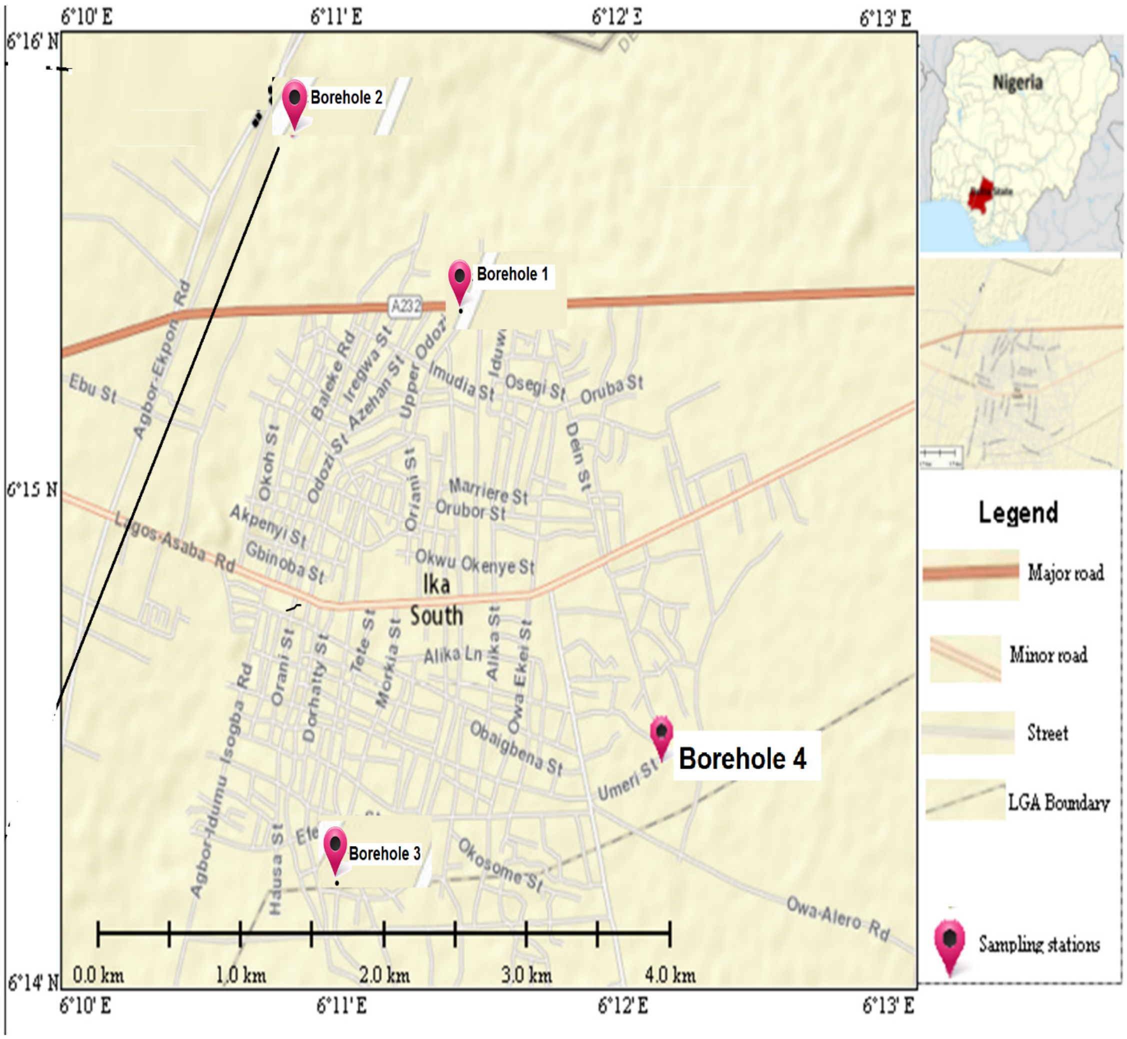

Fig. 1: Map of study area showing borehole locations in Agbor, Delta State, Nigeria.

Results and Discussion

The results of the physico-chemical parameters of the studied groundwater from selected boreholes are presented in Table 1.

Table 1: Summary of the Physico - Chemical Parameters of Selected Borehole water in Agbor, Delta State

Parameter	Test Result (Min – Max)	Mean ± SD	Permissible Limits
pH	5.0 – 6.50	5.75 ± 0.36	6.5 – 9.5 (Lloyd, 1992; Lawson, 1995; Akintomide *et al.,* 2010; Balogun, 2015)
Turbidity (NTU)	0.00 – 4.00	2.00 ± 0.94	25 – 80 (Boyd, 1990) < 20 NTU (Akintomide *et al.,* 2010)
TSS (mg/l)	0.00 – 4.00	2.00 ± 1.47	
TDS (mg/l)	12.60 – 35.90	48.50 ± 4.66	
DO (mg/l)	5.40 – 6.20	5.80 ± 0.19	5.0 – 6.0 (Lawson, 1995; Akintomide *et al.,* 2010; Bichi *et al.,* 2014)
BOD (mg/l)	0.38 – 1.20	0.44 ± 0.31	
Sulphate (mg/l)	0.07 – 2.00	1.04 ± 0.16	
Nitrate (mg/l)	0.06 – 0.23	0.15 ± 0.04	< 3 mg/l (Meade, 1989; Zweig *et al.,* 1999; Akintomide *et al.,* 2010)
Phosphate (mg/l)	0.09 – 0.46	0.28 ± 0.08	
Chloride (mg/l)	6.50 – 15.60	11.05 ± 1.32	> 30 mg/l (Swann, 1993)
Copper (mg/l)	0.022 – 0.069	0.046 ± 0.01	0.001 – 0.01 (Svobodova, 1993; USEPA, 1993)
Lead (mg/l)	0.000 – 0.010	0.002 ± 0.03	< 0.0032 mg/l (USEPA, 1993)
Iron (mg/l)	0.080 – 0.29	0.173 ± 0.05	< 0.05 mg/l (Zweig *et al.,* 1999; Akintomide *et al.,* 2010)
Zinc(mg/l)	0.005 – 0.05	0.025 ± 0.01	< 0.11 mg/l (USEPA, 1993)

Table 2: pH levels and effects for Aquaculture (Warm water)

pH Levels	Effect
< 4.0	Acid death point
4.0 – 5.0	No reproduction
4.0 – 6.5	Slow growth
6.5 – 9.0	Desirable range for fish production
9.0 – 11.0	Slow growth
> 11.0	Alkaline death point

Source: Lawson (1995)

Water is always a limiting factor in commercial fish production, as many of the negative chemical and environmental factors associated with most operations have their origins in the source of water selected (Swann, 1993).

pH is the hydrogen ion concentration present in a solution, and a measure of the acidity or alkalinity. Natural waters range between pH 5 and 10. For most fish species, a pH range of 6.5 - 9.5 is ideal, as species experience slow growth and inability to maintain salt balance at a pH below 6.5 (Lloyd, 1992; Akintomide *et al.,* 2010). Also, pH has been considered as one of the major factors affecting the hatchability and fertility of fish egg (Ukwe and Abu, 2016). Therefore, potential source water should be screened, since a proper pH is imperative. The observed pH values (6.5 – 9.5) in this study indicate that the water is acidic and requires treatment for its suitability for optimum fish production (Table 2). According to Boyd (1990)) low pH waters are often treated using lime.

Turbid conditions result from dissolved and suspended solids such as clay. High turbidity leads to a reduction in oxygen levels; causes gill damage and fish stress (Zweig *et al.,* 1999; Balogun, 2015). A mean concentration value of 2 mg/l observed for turbidity and total suspended solids in this study, is suitable for pisciculture (Akintomide *et al.,* 2010). According to Boyd (1990), no harmful effect on fisheries were observed at a turbidity of 25 NTU, and a suspended solids concentration range of 25 mg/l to 80 mg/l was acceptable for aquaculture.

Dissolved oxygen (DO) is a very basic requirement for aquaculture and the first limiting factor to occur in pond aquaculture. The most common cause of low dissolved oxygen in water is a high concentration of biological oxygen demand (BOD) in water. Biological oxygen demand is a measure of the amount of organic compounds that can be biologically oxidized by naturally occurring microorganisms in water (Tchobanoglous and Burton, 1991). As a general guideline, a dissolved oxygen range of 5.0 mg/l to 6.0 mg/l is recommended for aquaculture (Lawson, 1995; Akintomide *et al.,* 2010; Bichi *et al.,* 2014). Therefore, the observed dissolved oxygen levels (5.40 – 6.20 mg/l) in groundwater from Agbor metropolis is suitable for aquaculture.

Nitrate is found as the end product of the nitrification process, and high levels of nitrate affect osmoregulation and oxygen transport (Lawson, 1995). Observed mean nitrate concentration of 0.15 mg/l is suitable for aquaculture, as permissible concentration of nitrate in aquaculture is less than 3 mg/l (Meade, 1989; Zweig *et al.,* 1999; Akintomide *et al.,* 2010).

Chloride offers protection against nitrites and the winter kill of catfish is directly related to ponds with low chloride levels. According to Swann (1990), chloride concentrations less than 30 mg/l is not desirable for fish culture. Result of this study revealed low chloride concentration values of 6.50 mg/l to 15.60 mg/l in groundwater. However, this deficiency can be corrected by the addition of sodium chloride salt to enable the water confer protection on the fishes during aquaculture practice (Swann, 1993).

Copper is very toxic to aquatic animals and a maximum recommended concentration in source water range from 0.001 mg/l to 0.01 mg/l (Svobodova, 1993; USEPA, 1993). Results showed an elevated mean copper concentration of 0.046 mg/l. Chronic lead toxicity in aquatic organisms lead to nervous system damage while acute toxicity causes gill damage and suffocation (Svobodova *et al.,* 1993). The observed mean concentration of lead (0.002 mg/l) in source water was within the permissible lead concentration of 0.0032 mg/ 1 for fresh water fish species (USEPA, 1993).

Utilizing water with high iron concentration for holding fish causes stress and mortality as precipitated iron may occlude the gills of fish (Boyd, 1990). As a guideline, iron concentration less than 0.5 mg/l would be appropriate for warm water species (Zweig *et al.,* 1999; Akintomide *et al.,* 2010). Result showed that iron concentrations (0.08 mg/l – 0.29 mg/l) in groundwater were within the permissible limits, and as such suitable for fish culture.

According to the USEPA (1993), the general guideline for zinc concentration in fresh water for aquaculture is 0.11 mg/l. The observed groundwater zinc concentration in this study ranged from 0.005mg/ l to 0.05 mg/l, and is therefore suitable for use as source water in fish farming.

Conclusion

Water is a major limiting factor in commercial fish production, as its quality affects the growth and well – being of fishes. Water quality with reference to its physico – chemical parameters is of important to the fish farmer. Groundwater still remains the preferred source of water for fresh water aquaculture as it is free of parasites and usually less contaminated than surface water sources. This study on the suitability of the groundwater in Agbor, Delta State for aquaculture, revealed that with the exception of pH, Chlorine and Copper; all other physico – chemical parameters considered were within the recommended acceptable limits for fish culture. However, requisite water treatments should be carried out to improve the water quality with reference to the low pH, low Chlorine concentration and high Copper concentration in the groundwater, in order to make the groundwater holistically suitable for aquaculture.

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