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Differences in Physicochemical Properties of Water from Neighbourhood Boreholes and Their Usefulness in *Clarias gariepinus* Egg Hatching

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ABSTRACT: Water parameters and egg hatching success in water from three boreholes within close proximity were investigated. The studies were conducted to ascertain differences in their quality and ability to support *Clarias gariepinus* egg hatching. The boreholes were tagged 300m, 400m and 330m in relation to their distances from a perennial stream within the vicinity. Temperature and pH were investigated using digital metres. Dissolved oxygen, alkalinity and total hardness were determined using titration method. The water parameters were measured twice a week for 5 weeks. Percentage egg hatching, time to commencement and termination of egg hatching were studied in triplicates. The results obtained showed that pH, Dissolve oxygen (DO), Alkalinity and total hardness were significantly different (P<0.05) among the boreholes, while temperature was not significantly different (P>0.05). Total hardness fluctuated most at 21% coefficient of variation (CV). Egg fertilization success was not significantly different (P>0.05). Percentage egg hatching (68.8%, 92.8% and 87.3% for 300m, 400m and 330m) respectively was significantly different (P<0.05). Higher coefficient of variation in hardness enhanced egg hatching. It could be induced in hatchery operations. Time to commencement (1443, 1453 and 1517) minutes and termination of hatching (1962, 1957 and 2037) minutes were significantly different (P<0.05). Larval survival by day-3 post hatch was significant[y different (P<0.05). The study provided evidence of disparity in water quality among the boreholes and revealed differences in their ability to support *Clarias gariepinus* egg hatching. These suggest carefulness in choice of borehole water for fish egg hatching regardless of proximity of boreholes.

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The gap between demand and supply of fish in Nigeria has continued to widen, making fish unaffordable to most Nigerians (Olayinka, 2013). The annual fish demand in Nigeria as at 2012 was 2,656,739 tonnes when the domestic production was reported at 700,739 tonnes (Ayinla, 2012). Ekeleme, (2013) reported that the country spends a whooping sum of one hundred and fifteen million, nine hundred and eight four thousand, eight hundred US dollars (115,984,800$) annually to make up for the short fall in fish production. The current fish production in the country is a far cry from her potential being a coastal state. Nigeria is bordered in the south by the Atlantic Ocean with about 1.8 million hectares of fresh and brackish water swamps site suitable for aquaculture production (FAO, 1994). The country is therefore, endowed with extensive inland water systems - lakes, reservoirs, lagoons, creeks and floodplains all of high potential for fish production. Ayoade and Oyebande (1983) posited that Nigeria has extensive lake and reservoir systems covering about 300,000 hectares. This reveals a tremendous aquaculture potential of the geographic Nigeria. Major constraints to aquaculture development and by extension fish production in Nigeria include scarcity of fish seeds and fish food as well as inadequate database on the biology and ecological requirement of endemic fish species with aquaculture potentials which hampers rational aquaculture development plan (Olayinka, 2013). Fish seeds are very expensive in Nigeria. It constitutes a major operational cost of about 20% (Abiodun, 1986). Therefore adequate fish seeds are unavailable to most farmers in Nigeria. Orji (1997) traced scarcity of fish seeds in Nigeria to the fact that fish spawning is affected greatly by the physico-chemical parameters of the water used in most hatcheries in the country. Several other authorities also reported physicochemical qualities of water to influence egg hatching and subsequent development of hatched fish egg after breeding (Meador and Goldstein 2003, Allen 2001, Giller and Malmqrisit 2002). Water is considered as a material in which dissolved gases, inorganic substances (minerals) as well as organic matter are abundant. In addition to dissolved

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substances, water matrix gives buoyance and other supports to microorganisms, plants and animals and provides a medium of exchange for these populations (Boyd and Tucker, 1992). Water quality can be broadly defined as the physical, chemical and biological composition of water as related to its intended use. A good water quality for aquaculture must satisfy the minimum requirement for the survival, reproduction and growth of cultivable fish species (Onuoha, 2009). Quality of water is influenced by the source of the water. According to Lee (1973), good quality water is free of pesticides, has a suitable pH and is free of harmful elements, such as pollution or excessive mineral content. The sources of water may be surface water such as river, rain or settled run-offs or underground water such as borehole and well. Underground water is usually pollution free, although some underground waters contain noxious gases that can be toxic to aquatic organisms. Hydrogen sulphide and methane are the most common undesirable gases (Wheaton 1977). Tucker (1991) reported that the underground water is the best water for hatcheries because they are usually free of pollutants, suspended solids and diseases. The major disadvantage of underground water is its low oxygen content. All surface water suffers the disadvantage of being exposed to sources of pollution (Wheaton 1977). Factors that could bring about differences in water quality among neighbourhood boreholes includes (i) disparity in distance to the aquifer even within near locations. This makes it very difficult to have a standard distance to drill a borehole. Some Engineers do not get to the right aquifer while drilling a borehole. (ii) Difference in soil contaminants. Soil that has lots of iron (ferrous soil) will contaminate the water with iron. (iii) Anthropogenic activities of farming, waste dump and mining. Some soils were used for farming, whereas some were used as a dump site, others were used for mining of different minerals. The type of contaminants seen on the mining site is different from the one seen on the dump site likewise the one seen on a farmland (Shiklomanov, 2000). All these contaminants create disparity in the physico-chemical properties of water from different boreholes. *Clarias gariepinus* is one of the most important tropical catfish species for Aquaculture. Its distribution ranges from Nile to West Africa and from Algeria to South Africa (Emmanuel and Solomon, 2011). The fertilized eggs of *C. gariepinus* will hatch within 24 – 28 hours when placed in conducive environment (Piper *et al.,* 1982). The study reported here compared some water quality parameters among three bore holes in Michael Okpara University of Agriculture and assessed their suitability for use in hatchery propagation of *Clarias gariepinus* in the University.

MATERIALS AND METHODS

Studied borehole waters: Water parameters and egg hatching success in water from three neighbourhood boreholes within the premises of Michael Okpara University of Agriculture, Umudike (5.467^0N,7.489^0E) were studied. The three boreholes were tagged FARM-200m (5.481^0N,7.537^0E), CNREM-300m (5.477^0N,7.539^0E) and HOSTEL-230m (5.495^0N,7.548^0E) in relation to their exact location and distances from a perennial stream (Anya stream) within the vicinity. The three boreholes (FARM-300m, CNREM-400m and HOSTEL-330m) were simply reported in this document as 300m, 400m and 330m respectively.

Sample collection and analysis: Sample bottles of 120cl (individual capacity) were used for the study. The sample bottles were sterilized with 70% alcohol and were flushed for 2minutes to ensure thorough washing. The samples were transported to laboratory for analysis in an ice-packed cooler. The physicochemical properties analysed in the laboratory included Dissolved Oxygen (DO), Total alkalinity and total hardness. Temperature and pH were measured *in-situ* using mercury in glass thermometer and pH metre (Hanna equipment) respectively.

Dissolved oxygen (DO): The dissolved oxygen was measured following Winkler titration method. 25 ml of water sample was added into 100ml beaker and 2 ml Magnesium sulphate ($MnSO_4$) was then added followed with the addition of 2 ml of alkaline potassium iodide. The bottle was immediately covered with a stopper resulting in formation of brown precipitate. The stopper was removed and 2.0ml of concentrated sulphuric acid (H_2SO_4) was added. The acid was allowed to run down the neck of the bottle and a golden yellow solution was obtained. A freshly prepared starch was added and a bluish black solution was obtained. The bluish black colour solution was titrated with 0.025N sodium thiosulphate until solution turns to a pale straw to colourless end point at the first disappearance of the blue colour. Dissolved Oxygen was then estimated using the formula:

$$\mathrm{DO} = \frac{\mathrm{A}}{\mathrm{B}} \mathrm{x} \frac{C}{\mathrm{D}}$$

A =Mliliter of titrant x 0.025N x 8 x 100mg/1; B = vol. g water sample; C = mole of water sample − 4; D = vol of bottle; N = Normality of $Na_2S_20_3$; 8 = Oxygen cone equivalent to 1 ml of I N; 1000 = conversion factor to 1 litre

Determination of total hardness: The total hardness was measured using the Winklers titration method.

25ml of water sample was placed in 250 ml clean conical flask and 3 ml of Ammonium chloride was added followed with addition of 2 drops of Eriochrome Black T indicator. This was titrated against 0.01M EDTA solution until there was a colour change from violet to blue. Hardness was then estimated from the formula:

$$\mathrm{H} = \frac{V\ x\ M\ x\ 1000}{ml\ of\ sample\ used}$$

Where H = Hardness in mg/l $CaCO_3$; V = Volume of EDTA used and M = Molarity of EDTA used

Alkalinity: The reagents used were concentrated sulphuric acid (H_2SO4), Distilled water and Phenolphthalin indicator. 30 ml of conc. H_2SO_4 was mixed with 1 litre of distilled water to obtain the stock solution. 20 ml of the stock solution was diluted and thoroughly mixed in I litre of distilled water to have 0.02N H_2SO_4. The 0.02N H_2SO_4 was poured into a burette for titration against 100ml of sample water in a conical flask. 10 drops of phenolphthalein indicator was added to the sample water and a pink solution was obtained. Titration was until colourless end point was achieved. Phenophthalein alkalinity was estimated from titration volume x 10 as ppm $CaCO_3$.

Egg hatching in water from different boreholes: Eggs from a female *C. gariepinus* were fertilized with milt from single male of the same species and incubated in triplicate water from three different boreholes. Percentage egg hatching, time to commencement and time to termination of egg hatching were investigated. Egg fertilization was recognized from the distinct green colour of the fertilized egg against the white colouration of the un-fertilized eggs while hatching was recognized on observation of shaking and tail wagging of hatchling as against non-movement of the un-hatched eggs (Uka and Sikoki, 2011).

RESULT AND DISCUSSION

The temperature of water (28, 28.5 and 28.56) ºC from the three boreholes (300m, 400m and 330m respectively) and their corresponding fluctuation (9.1%, 8.8% and 8.8% within the boreholes) were not significantly different (P>0.05) (tables 1 and 2). This could be attributed to the relative uniform environment of the boreholes. The environment of the boreholes consisted of sparse vegetation and objects that occasionally cast their shadow on the overhead tanks. There was no permanent artificial object to prevent exposure of the overhead tanks to sunray source of heat. The slight differences observed could come from irregular shading offered by vegetation for different duration depending on the direction of wind and position of the sun. Bhatnagar and Devi (2013) recognised the role of providing shades in preventing heat-up of borehole water.

Table 1: Water Quality Parameters of three neighbourhood boreholes

	Boreholes			
Parameters	300m	400m	330m	ST
Temperature .(ºC)	28.00	28.50	28.56	ns
pH	6.06^a	6.34^a	5.39^b	*
Dissolved Oxygen (mg/l)	7.71^a	6.34^b	4.23^c	*
Alkalinity (mg/l)	136.60^a	52.40^b	50.53^b	*
Total hardness (mg/l)	60	150.40^a	115.2^b	*
Egg fertilization (%)	95.67	95.22	97.56	ns
Egg hatching (%)	92.8^a	87.3^b	68.8^c	*
Survival rate (%)	89.89^a	50.22^c	64.44^b	*
Time to commencement of egg hatching (minutes	1443^b	1453^b	1517^a	*
Time to termination of egg hatching (minutes)	1962^b	1957^b	2037^a	*

*ST = Statistical test; ns= Not significant, *=Significant at 5% level*

Table 2: Coefficient of variation in water quality parameters within three neighbourhood boreholes

Boreholes Parameters	300m	400m	330m	Test	Mean CV (%)
Temperature.(ºC)	0.091	0.088	0.088	ns	8.9
pH	0.081^a	0.060c	0.072^b	*	7.1
Dissolved Oxygen (mg/l)	0.062^c	0.175^a	0.139^b	*	12.5
Alkalinity (mg/l)	0.021^c	0.104^a	0.089^b	*	7.1
Total hardness (mg/l)	0.425^a	0.115^b	0.089^c	*	21

*ns= Not significant, *=Significant at 5% level*

The dissolved oxygen (7.71, 6.34 and 4.23) mg/l of the water from the boreholes: 300m, 400m and 330m in that order and their respective degree of fluctuation measured as coefficient of variations (6.2%, 1.8% and 1.4% within the boreholes) were significantly different (P<0.05) among the boreholes. These could be traced to the slight differences observed in temperature among the boreholes and implies that slight change in water temperature could trigger significant change in level of dissolved oxygen in water. Boyd and Tucker

(1998) reported that solubility of oxygen in water decreases with increase in water temperature. There was significant difference ($P<0.05$) in water pH (6.06, 6.34 and 5.39) among the boreholes and the fluctuation of pH (0.081, 0.060 and 0.072) within the boreholes was also significantly different ($P<0.05$) (tables 1 and 2). These findings suggest the existence of different carbonate system in the water from the boreholes which could be due to differences in soil and rock types that surround the neighbourhood boreholes or differences in the nature of discharge of pollutants that sip into the boreholes. Drainage water from forests and marshes could be acidic due to presence of acids produced by decaying vegetation (Exploring Environment, 2004). The concentration of carbonate CO_3^{2-} , HCO_3^- and carbon dioxide (CO_2 (aqua) are the main influence on pH of water. High concentration of carbonate CO_3^{2-} , HCO_3^- and carbon dioxide (CO_2 (aqua) produces alkaline water, while low concentration produces acidic water (low pH). The alkalinity (136.60, 52.40 and 50.53) mg/l and the total hardness (60, 150.40 and 115.20) mg/l of water from 300m, 400m and 330m respectively were significantly different ($P<0.05$). The coefficient of variation in alkalinity (0.021, 0.104 and 0.089) and total hardness (0.425, 0.115 and 0.089) in the same order were also significantly different among the treatments. Alkalinity differences among the boreholes suggest differences in presence of buffering materials principally the bases (HCO_3, CO_3 and OH^+ among the boreholes since bases neutralize acid. Natural buffering materials in water slow down the reduction of pH. A rapid pH drop follows gradual decline as the bicarbonate buffering capacity is used up. Differences in hardness among the boreholes similarly suggest differences in the geology of the earth and rocks around the boreholes as well as the history of human activities in the area. The most fluctuating water parameter among the boreholes was total hardness (21%). This was followed by dissolved oxygen (12.5%) and temperature (8.9%). The fluctuation in pH and alkalinity were of equal magnitude of 7.1% apart.

Clarias gariepinus egg hatching success (92.8%, 87.3% and 68.8% in water from 300m, 400m and 330m borehole respectively) was significantly different ($P<0.05$) among the boreholes (Table 3). Egg hatching and larval survival increased with increase in levels of dissolved oxygen and alkalinity. On the other hand, low total hardness as low as 60mg/l facilitated egg hatching and larval survival much higher than 150.40mg/l and 115.20mg/l. Optimal total hardness for egg hatching was not established in this study. However, it was observed that higher fluctuation in total hardness (42.5%) permitted higher egg hatching (92.8%) and larval survival (89.9%) than lower fluctuations 11.5% and 8.9% which gave 87.3%, 50.2% and 68.8%, 50.2% respectively. Therefore inducing fluctuation in total hardness could be employed for enhanced *Clarias gariepinus* egg hatching. Time to commencement of egg hatching (1443, 1453 and 1517) minutes in 300m, 400m and 330m waters respectively and time to termination of egg hatching (1962, 1957 and 2037) minutes in the same order were significantly different ($P<0.05$) among the treatments (Table 3).

Table 3: Hatching success of *C. gariepnus* egg in different boreholes

Boreholes Parameters	300m	400m	330m	ST
Egg fertilization (%)	95.67	95.22	97.56	ns
Egg hatching (%)	92.8^a	87.3^b	68.8^c	*
Survival rate (%)	89.89^a	50.22^c	64.44^b	*
Time to commencement of egg hatching (minutes	1443^b	1453^b	1517^a	*
Time to termination of egg hatching (minutes)	1962^b	1957^b	2037^a	*

*St = Statistical test; ns= Not significant, *=Significant at 5% level*

Conclusion: Disparity in water quality among neighbourhood boreholes and differences in their ability to support *Clarias gariepinus* egg hatching were observed. The document therefore recommended carefulness in choice of water for fish propagation. Moderately hard water (< 115mg/l) was more favourable to egg hatching and larval survival than harder (> 115mg/l) or soft (<60mg/l) waters. High coefficient of variation in hardness enhanced hatching and larval survival. Inducing fluctuation in total hardness could be employed for improved *Clarias gariepinus* egg hatching.

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