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POTENTIAL OF MARINE GASTROPOD (*Thais coronata*) SHELLS AS ALTERNATIVE BUFFER TO CALCIUM CARBONATE FOR FISH FARMING IN THE NIGER DELTA, NIGERIA

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ABSTRACT

A study was conducted to evaluate buffering potency of rock shells (Thais coronata) on acidic borehole water for aquaculture. Eighteen (18), 100-litre plastic tanks placed on shaded outdoor concrete tanks and three-quarter filled with acidic borehole water (pH 4.0) of three replicates per treatment of 270 g buffer agent were used. The treatments (T) namely control (C) [T1], calcium carbonate (CA) [T2], crushed burnt rock shells (CBRS) [T3], uncrushed burnt rock shells (UBRS) [T4], crushed unburnt rock shells (CURS) [T5] and uncrushed unburnt rock shells (UURS) [T6] were used for four trials. Temperature and pH were monitored morning, afternoon and night while dissolved oxygen, calcium and alkalinity were measured once for duration of study using standard methods. Data were analyzed using Microsoft Excel for analysis of variance and descriptive statistics. pH steadily increased from 4.0 to acceptable range of 6.5-9.0 in all treatments except T1 at the end of trials. All shell forms buffered the acidic water but crushed burnt rock shells are preferable to others in terms of fish health and food safety. Dissolved oxygen, calcium and alkalinity values were within acceptable limit. The study therefore suggests at least 270 g shell of any form as organic buffer for aquaculture.

Keywords: Fish production, low pH, organic buffer, *Thais coronata* shells, whelk, Niger Delta

INTRODUCTION

Nigeria is blessed with diverse quantities of seashells. Seashells are hard coated coverings of small to medium size soft-bodied, invertebrate sea animals that are found mostly on shores of coastal waters. They are shells or exoskeleton of marine molluscs that protect the sea animals from environmental hazards. *Thais coronata* (Lamarck, 1816) commonly known as rock shell is a mollusc with a humped or spined, thick-walled shell, mostly with short whorls with the shell closed by a honey operculum. Rock shells are up to 5 cm in length and are dirty grey to brown in colour with red aperture and lip toothed (Avil and Ross, 1999). They are salt water molluscs, found on rocks and mussel banks and demonstrate both restricted geographical and local distribution (Davis and Fitzgerald, 2004).

The rock shell is an important source of cheap protein for the coastal people of Southern Nigeria and its fisheries supports a thriving, but subsistence economic activity. The empty shells of rock shell are usually thrown away as waste after consuming the soft-flesh but these shells contain high amount of calcium oxide (CaO) (95.54%), 2.52% of magnesium oxide (MgO) and trace amount of other oxides which make them good and acceptable source of raw materials for the production of calcium supplements by indigenous food industry (Malu *et al.*, 2009).The basic building blocks of the living organisms such as proteins, carbohydrates and fats are changed completely during metabolisms by living organisms, forming clearly defined synthetic products, which contribute to meat yield and condition index of shellfish. The extraction or processing of seashells for calcium carbonate is somehow environmental friendly than that of quarrying or mining of limestone deposit which causes environmental pollution and soil erosion (Barefoot *et al.*, 2002 and Donatelle, 2005). The bubbling (electrolysis) of carbon dioxide into calcium hydroxide solution in which calcium carbonate is precipitate out is another source of obtaining calcium carbonate but this process is expensive (Browne, 1993; Frank and Greer, 2006).

Profitability and productivity of aquaculture in the Niger Delta region of Nigeria is limited by low water and sediment pH. Estim (2009) recommended ground water (for example, borehole) as a more preferable source of water for fish farming because it has more consistent water quality than surface water, and is less likely to contain pathogens or fish but pH is low. The growth of fish is affected by acidic water hence the low hatchery, nursery, grow-outs and broodstock productions, and profitability of aquaculture in this region (Davies, 2014). The studies of Davies *et al*. (2012), Davies and Jaja (2014), Davies and Ansa (2015) and, Davies and Ogidiaka (2015) have greatly contributed to reduce cost of and boost production, and to stop the use of synthetic chemicals in fish farming for healthy and safe food. Organic materials are cheap, abundant and easily available and can be used as an alternative to using chemicals. The introduction of whole and/or parts of plants and animals as organic (natural) buffer is a new technology in fish farming in the Niger Delta region of Nigeria.

The aim of this study therefore was to assess the buffering efficiency of marine gastropod (*T. coronata*) shells of different types (crushed burnt, uncrushed burnt, crushed unburnt and uncrushed unburnt) as organic buffer for the first used and reused and compare its potency with that of calcium carbonate (conventional buffer) for fish farming in the Niger Delta region of Nigeria.

MATERIALS AND METHODS

Study area, source of marine gastropod (*T. coronata*) shells, experimental tanks, source and volume of water

The study was carried out in Roone Fish Farm, Abuloma, Port Harcourt, Nigeria. Marine gastropod (*T. coronata*) shells were collected from Azubiae Creek (at Okujagu-ama). A total of eighteen (18) 100-litres shaded plastic tanks of three replicates per treatment were used for each trial. There were six (6) treatments (TRA) namely: control (C) [T1], calcium carbonate (CA) [T2], crushed burnt rock shells (CBRS) [T3], uncrushed burnt rock shells (UBRS) [T4], crushed unburnt rock shells (CURS) [T5] and uncrushed unburnt rock shells (UURS) [T6]. There were four trials (TR) namely; TRA, TRB, TRC and TRD. Duration of the trials varied; four days for TRA, TRB and eight days for TRC and TRD. The tanks were placed on outdoor concrete tanks and three-quarter (3/4) filled with acidic borehole water (pH 4.0). They were kept open throughout the study.

Preparation of rock shells as organic buffer

Manually harvested rock shells were cleaned of foreign matters (stones, dust and other materials). Cleaned rock shells were divided into four groups namely: crushed burnt rock shells (CBRS), uncrushed burnt rock shells (UBRS), crushed unburnt rock shells (CURS) and uncrushed unburnt rock shells (UURS). Crushing was done by use of a hammer mill. The rock shells were burnt by use of naked fire. A stainless steel plate containing the shells was placed over the naked fire. Another stainless steel plate was used to cover it so as to retain the heat and prevent the shells from dropping on the floor. The different forms of rock shells were reused three times. Two hundred and seventy grammes (270 g) (dosage) of each form of rock shells were used as shown in the calculation below.

Calculation for amount of rock shells used

Following the modified Viveen *et al*. (1986) guidelines for application of liming material in kg/hectare (Davies, 2012) (Table 1).7200 kg of organic buffer=1 × 10^7 litres (10,000 m^3)of water with pH 3.6-4.0 10,000,000 L= one hectare0.072 kg (72 g) of organic buffer =100 L of water with pH 3.6-4.Therefore, 72 g × 3.75 (factor) =270 g was used for 100 L of water with pH 3.6-4.0. 3.75 times of the normal dosage was used to speed up the process of buffering (from acidic to alkaline).

Measurements of relevant water quality parameters

Temperature and pH were taken in-situ using Kedid pH meter, B-Bran Scientific and Instrument Company, England three times [7.00 am (morning), 1.00 pm (afternoon) and 7.00 pm (night)] daily. The meter was agitated slightly at interval so that the probe (electrode) could read the pH. Reading was taken once the displayed value was stable for few seconds. Dissolved oxygen, total alkalinity and calcium were measured using test kit, Freshwater Aquaculture Testing (Aquacare 2000.6 Para test, Aquacare 2000.3 Para test and Aquacare 2000.10 Para test correspondingly) at the beginning and ending of the study.

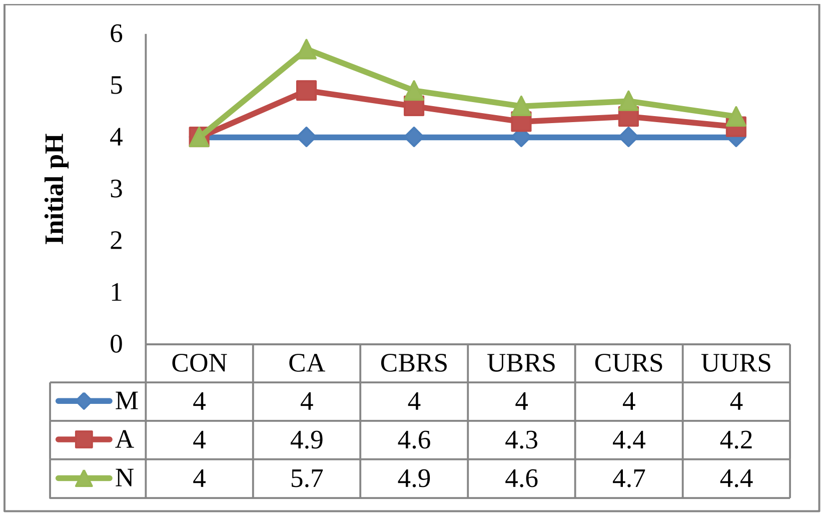
Statistical analyses

Data was analyzed for means, standard error of means, analysis of variance (ANOVA) and descriptive statistics (bar charts) using Microsoft Excel (2007).

RESULTS

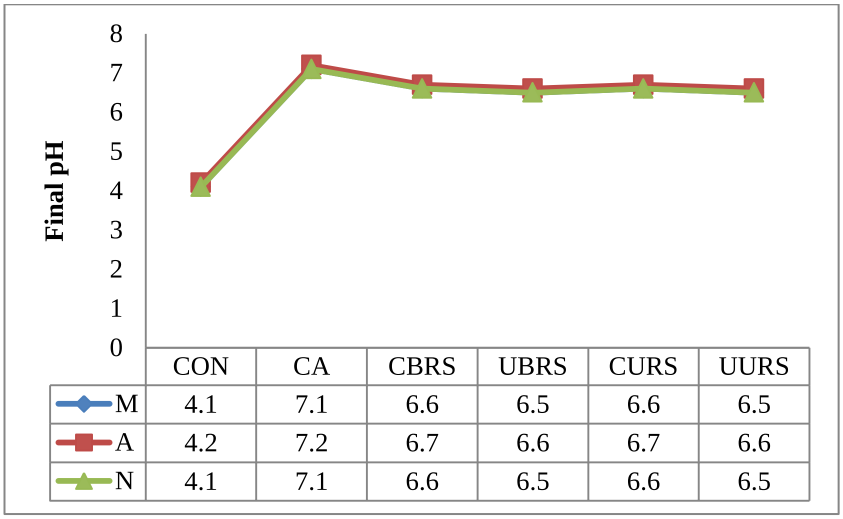
The initial and final pH values increased progressively in all treatments (TRA, TRB, TRC and TRD). The initial pH values at afternoon and night were higher than that of the morning in all the trials (Figs. 1 to Fig. 4). There were significant temporal (time) fluctuations between the initial and final pH values of all the trials ($P<0.05$).The final pH values at afternoon [4.2 (T1), 7.2 (T2), 6.7 (T3), 6.6 (T4), 6.7 (T5) and 6.6 (T6)] were not significantly ($P<0.05$)

higher than that of the morning and night (Fig.1b). However, the morning and night pH values were the same (Fig.1b).The final morning, afternoon and night pH values increased in all treatments. The final pH values at morning, afternoon and night in TRA and TRB (Fig. 1b and Fig.2b) were significantly higher than those of TRC and TRD (Fig. 3b and Fig. 4b). The increase in pH values took longer days in TRC and TRD as the shells were reused



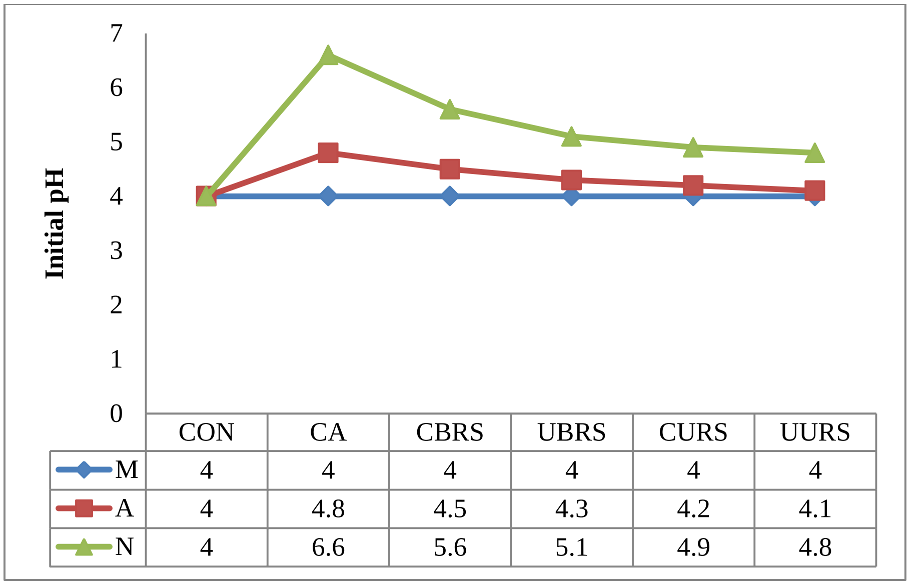
	CON	CA	CBRS	UBRS	CURS	UURS
◆ M	4	4	4	4	4	4
■ A	4	4.9	4.6	4.3	4.4	4.2
▲ N	4	5.7	4.9	4.6	4.7	4.4

Fig. 1a: Initial pH of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRA (first use)



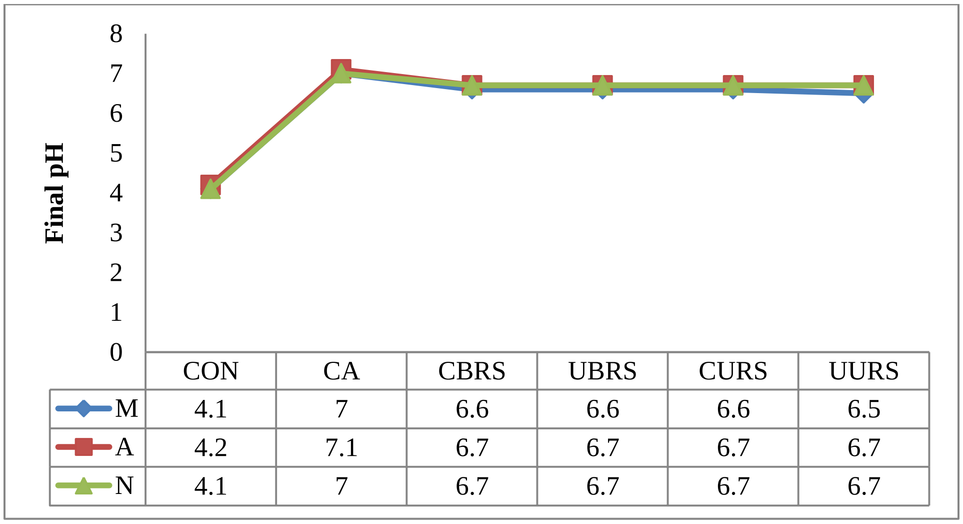
	CON	CA	CBRS	UBRS	CURS	UURS
◆ M	4.1	7.1	6.6	6.5	6.6	6.5
■ A	4.2	7.2	6.7	6.6	6.7	6.6
▲ N	4.1	7.1	6.6	6.5	6.6	6.5

Fig. 1b: Final pH of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRA (first use)



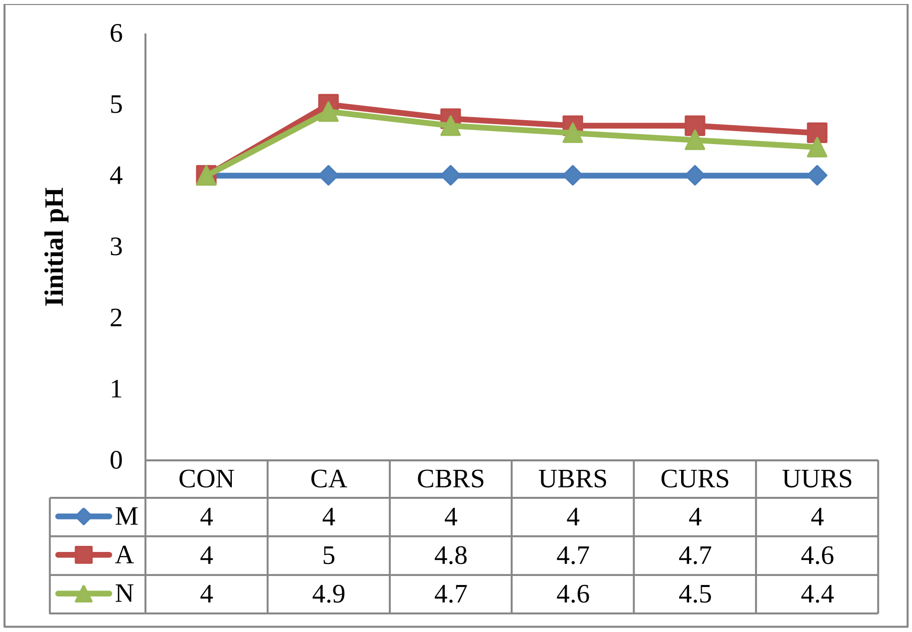
	CON	CA	CBRS	UBRS	CURS	UURS
◆ M	4	4	4	4	4	4
■ A	4	4.8	4.5	4.3	4.2	4.1
▲ N	4	6.6	5.6	5.1	4.9	4.8

Fig. 2a: Initial pH of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRB (first reuse)



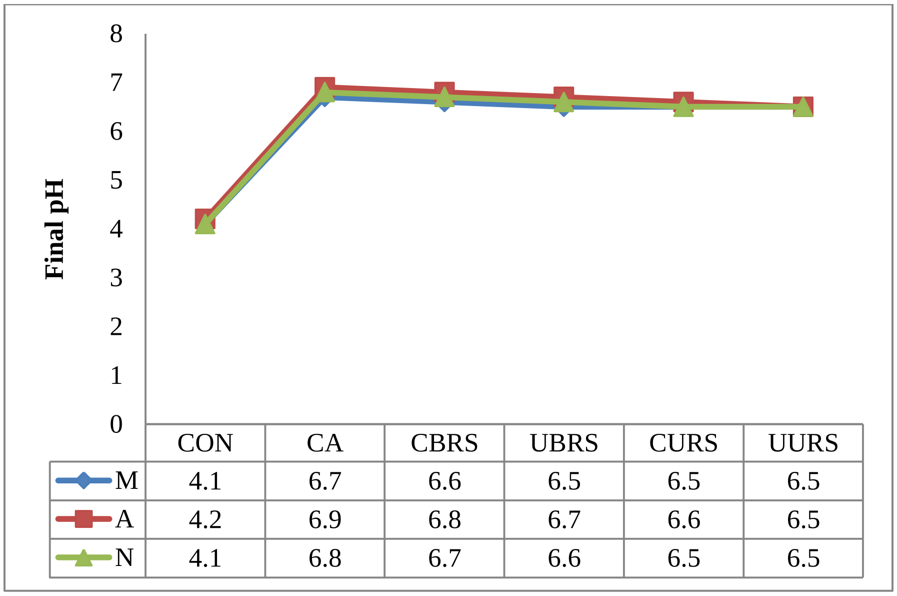
	CON	CA	CBRS	UBRS	CURS	UURS
◆ M	4.1	7	6.6	6.6	6.6	6.5
■ A	4.2	7.1	6.7	6.7	6.7	6.7
▲ N	4.1	7	6.7	6.7	6.7	6.7

Fig. 2b: Final pH of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRB (first reuse)



	CON	CA	CBRS	UBRS	CURS	UURS
◆ M	4	4	4	4	4	4
■ A	4	5	4.8	4.7	4.7	4.6
▲ N	4	4.9	4.7	4.6	4.5	4.4

Fig. 3a: Initial pH of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRC (second reuse)



	CON	CA	CBRS	UBRS	CURS	UURS
◆ M	4.1	6.7	6.6	6.5	6.5	6.5
■ A	4.2	6.9	6.8	6.7	6.6	6.5
▲ N	4.1	6.8	6.7	6.6	6.5	6.5

Fig. 3b: Final pH of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRC (second reuse)

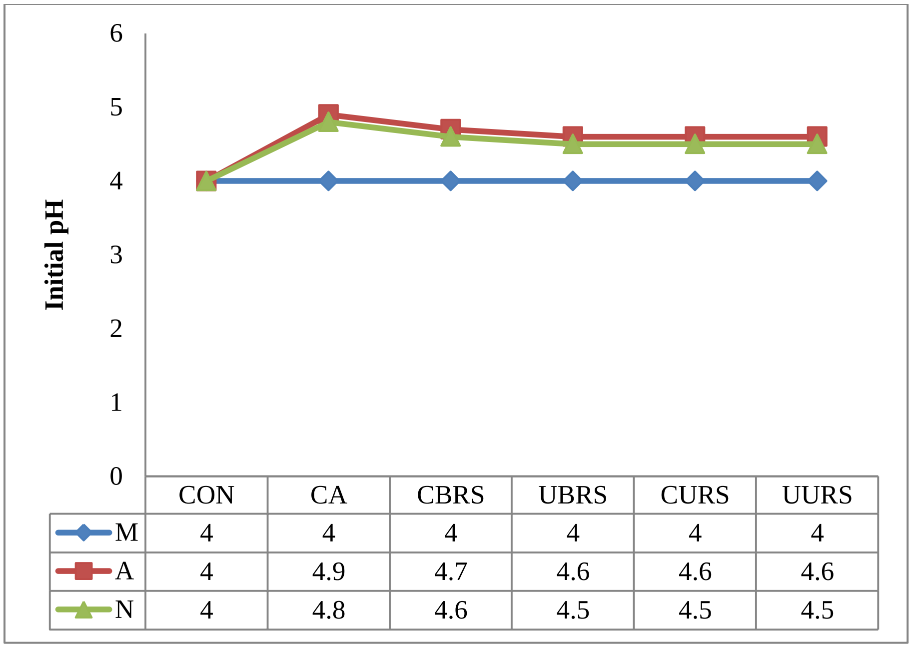


Fig. 4a: Initial pH of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRD (third reuse)

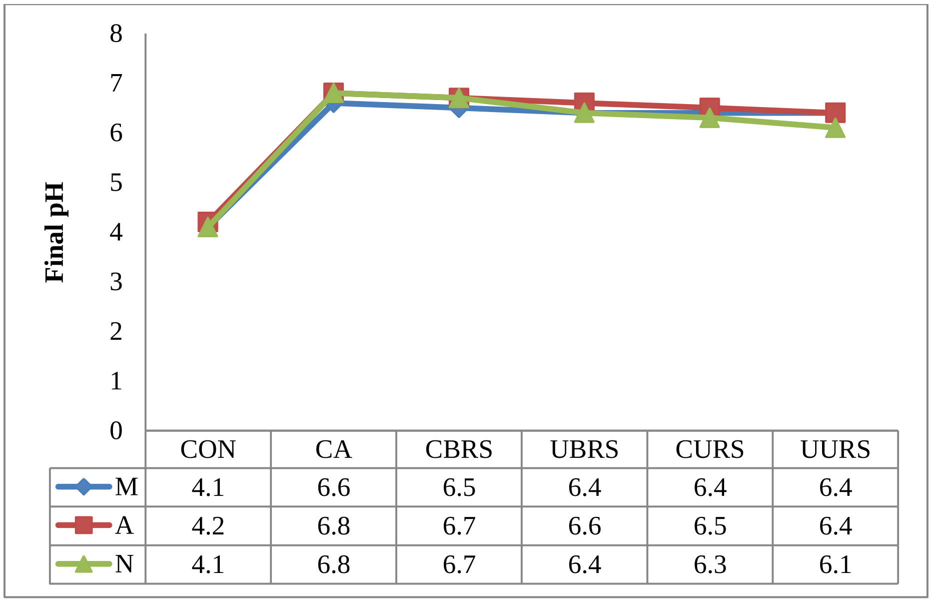


Fig. 4b: Final pH of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRD (third reuse)

There were no significant diurnal variations in the temperature values of all treatments in all the trials (Tables 1 to 4). From Table 5, TA values increased significantly (P< 0.05) between initial and final in TRA. The final TA values in TRB,TRC and TRD were the same (Tables 6 to8). TA values in TRA were higher than those of TRB, TRC and TRD. The calcium content increased significantly (P<0.05) in all the trials (TRA, TRB, TRC and TRD)and treatments except CON as shown in Tables 9 to12. The DO values in the four trials were the same as presented in Tables13, 14, 15 and 16. There were no significant differences in the DO values (P>0.05).

Table 1: Temperature of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRA (first use)

Treatment (T)	Initial temperature (ºC)			Final temperature (ºC)		
	M	**A**	**N**	**M**	**A**	**N**
CON (T1)	26.4±0.02a	28.9±0.01a	27.7±0.02a	27.7±0.02a	29.0±0.02a	28.3±0.02a
CA (T2)	26.4±0.02a	28.9±0.01a	27.7±0.02a	27.6±0.02a	29.0±0.02a	28.3±0.02a
CBRS (T3)	26.4±0.02a	28.9±0.01a	27.7±0.02a	27.8±0.02a	29.0±0.02a	28.3±0.02a
UBRS (T4)	26.4±0.02a	28.9±0.01a	27.7±0.02a	27.7±0.02a	29.0±0.02a	28.3±0.02a
CURS (T5)	26.4±0.02a	28.9±0.01a	27.7±0.02a	27.8±0.02a	29.0±0.02a	28.3±0.02a
UURS (T6)	26.4±0.02a	28.9±0.01a	27.7±0.02a	27.2±0.02a	29.0±0.02a	28.3±0.02a

Means with different letters on same column are significantly different (P<0.05)
CON-Control; CA-Calcium carbonate; CBRS-Crushed burnt rock shells; UBRS-Uncrushed burnt rock shells; CURS-Crushed unburnt rock shells; UURS-Uncrushed unburnt rock shells; M-Morning; A-Afternoon; N-Night

Table 2: Temperature of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRB (first reuse)

Treatment (T)	Initial temperature			Final temperature		
	M	**A**	**N**	**M**	**A**	**N**
CON (T1)	26.9±0.02a	30.1±0.03a	29.2±0.01a	27.1±0.02a	30.2±0.03a	29.4±0.01a
CA (T2)	26.9±0.02a	30.1±0.03a	29.8±0.01a	27.1±0.02a	30.2±0.03a	29.9±0.01a
CBRS (T3)	26.9±0.02a	30.1±0.03a	29.5±0.01a	27.1±0.02a	30.2±0.03a	29.6±0.01a
UBRS (T4)	26.9±0.02a	30.1±0.03a	29.3±0.01a	27.1±0.02a	30.2±0.03a	29.4±0.01a
CURS (T5)	26.9±0.02a	30.1±0.03a	29.4±0.01a	27.1±0.02a	30.2±0.03a	29.5±0.01a
UURS (T6)	26.9±0.02a	30.1±0.03a	29.2±0.01a	27.1±0.02a	30.2±0.03a	29.3±0.01a

Means with different letters on same column are significantly different (P<0.05)
CON-Control; CA-Calcium carbonate; CBRS-Crushed burnt rock shells; UBRS-Uncrushed burnt rock shells; CURS-Crushed unburnt rock shells; UURS-Uncrushed unburnt rock shells; M-Morning; A-Afternoon; N-Night

Table 3: Temperature of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRC (second reuse)

Treatment (T)	Initial temperature (ºC)			Final temperature (ºC)		
	M	**A**	**N**	**M**	**A**	**N**
CON (T1)	27.5±0.01a	28.8±0.02a	27.6±0.01a	27.7±0.01a	29.5±0.02a	28.5±0.02a
CA (T2)	27.5±0.01a	28.8±0.02a	27.6±0.01a	27.8±0.01a	29.5±0.02a	28.5±0.02a
CBRS (T3)	27.5±0.01a	28.8±0.02a	27. 2±0.01a	27.8±0.01a	29.5±0.02a	28.5±0.02a
UBRS (T4)	27.5±0.01a	28.8±0.02a	27.6±0.01a	27.8±0.01a	29.5±0.02a	28.5±0.02a
CURS (T5)	27.5±0.01a	28.8±0.02a	27.6±0.01a	27.8±0.01a	29.5±0.02a	28.5±0.02a
UURS (T6)	27.5±0.01a	28.8±0.02a	27.6±0.01a	27.7±0.01a	29.5±0.02a	28.5±0.02a

Means with different letters on same column are significantly different (P<0.05)
CON-Control; CA-Calcium carbonate; CBRS-Crushed burnt rock shells; UBRS-Uncrushed burnt rock shells; CURS-Crushed unburnt rock shells; UURS-Uncrushed unburnt rock shells; M-Morning; A-Afternoon; N-Night

Table 4: Temperature of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRD (third reuse)

Treatment (T)	Initial temperature (ºC)			Final temperature (ºC)		
	M	A	N	M	A	N
CON (T1)	26.6±0.02a	28.2±0.01a	27.5±0.01a	27.5±0.01a	29.4±0.02a	28.4±0.01a
CA (T2)	26.6±0.02a	28.2±0.01a	27.5±0.01a	27.5±0.01a	29.4±0.02a	28.4±0.01a
CBRS (T3)	26.6±0.02a	28.2±0.01a	27.5±0.01a	27.5±0.01a	29.4±0.02a	28.4±0.01a
UBRS (T4)	26.6±0.02a	28.2±0.01a	27.5±0.01a	27.5±0.01a	29.4±0.02a	28.4±0.01a
CURS (T5)	26.6±0.02a	28.2±0.01a	27.5±0.01a	27.5±0.01a	29.4±0.02a	28.4±0.01a
UURS (T6)	26.6±0.02a	28.2±0.01a	27.5±0.01a	27.5±0.01a	29.4±0.02a	28.4±0.01a

Means with different letters on same column are significantly different ($P < 0.05$)
CON-Control; CA-Calcium carbonate; CBRS-Crushed burnt rock shells; UBRS-Uncrushed burnt rock shells; CURS-Crushed unburnt rock shells; UURS-Uncrushed unburnt rock shells; M-Morning; A-Afternoon; N-Night

Table 5: Total alkalinity (TA) of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRA (first use)

Treatment	Initial TA (mg/L)	Final TA (mg/L)	Mean ± SEM
CON (T1)	0	0	0 ± 0.00c
CA (T2)	0	85	51 ± 0.01a
CBRS (T3)	0	68	42.5 ± 0.05a
UBRS (T4)	0	34	25 ± 0.02b
CURS (T5)	0	51	34 ± 0.03a
UURS (T6)	0	17	17 ± 0.01b

Means with different letters on same column are significantly different ($P < 0.05$)
CON-Control; CA-Calcium carbonate; CBRS-Crushed burnt rock shells; UBRS-Uncrushed burnt rock shells; CURS-Crushed unburnt rock shells; UURS-Uncrushed unburnt rock shells

Table 6: Total alkalinity (TA) of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRB (first reuse)

Treatment	Initial TA (mg/L)	Final TA (mg/L)	Mean ± SEM
CON (T1)	0	0	0 ± 0.00c
CA (T2)	0	68	42.5 ± 0.05a
CBRS (T3)	0	51	34 ± 0.03a
UBRS (T4)	0	17	17 ± 0.01b
CURS (T5)	0	34	25 ± 0.02a
UURS (T6)	0	17	17 ± 0.01b

Means with different letters on same column are significantly different ($P < 0.05$)
CON-Control; CA-Calcium carbonate; CBRS-Crushed burnt rock shells; UBRS-Uncrushed burnt rock shells; CURS-Crushed unburnt rock shells; UURS-Uncrushed unburnt rock shells

Table 7: Total alkalinity (TA) of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRC (second reuse)

Treatment	Initial TA (mg/L)	Final TA (mg/L)	Mean ± SEM
CON (T1)	0	0	0 ± 0.00c
CA (T2)	0	68	42.5 ± 0.05a
CBRS (T3)	0	51	34 ± 0.03a
UBRS (T4)	0	17	17 ± 0.01b
CURS (T5)	0	34	25 ± 0.02a
UURS (T6)	0	17	17 ± 0.01b

Means with different letters on same column are significantly different ($P<0.05$)
CON-Control; CA-Calcium carbonate; CBRS-Crushed burnt rock shells; UBRS-Uncrushed burnt rock shells; CURS-Crushed unburnt rock shells; UURS-Uncrushed unburnt rock shells

Table 8: Total alkalinity (TA) of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRD (third reuse)

Treatment	Initial TA (mg/L)	Final TA (mg/L)	Mean ± SEM
CON (T1)	0	0	0 ± 0.00c
CA (T2)	0	68	42.5 ± 0.05a
CBRS (T3)	0	51	34 ± 0.03a
UBRS (T4)	0	17	17 ± 0.01b
CURS (T5)	0	34	25 ± 0.02a
UURS (T6)	0	17	17 ± 0.01b

Means with different letters on same column are significantly different ($P<0.05$)
CON-Control; CA-Calcium carbonate; CBRS-Crushed burnt rock shells; UBRS-Uncrushed burnt rock shells; CURS-Crushed unburnt rock shells; UURS-Uncrushed unburnt rock shells

Table 9: Calcium concentration of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRA (first use)

Treatment	Initial calcium (mg/L)	Final calcium (mg/L)	Mean ± SEM
CON (T1)	20	20	20 ± 0.02c
CA (T2)	20	80	50 ± 0.20a
CBRS (T3)	20	80	50 ± 0.20a
UBRS (T4)	20	60	45 ± 0.25a
CURS (T5)	20	60	45 ± 0.25a
UURS (T6)	20	40	30 ± 0.20b

Means with different letters on same column are significantly different ($P < 0.05$)
CON-Control; CA-Calcium carbonate; CBRS-Crushed burnt rock shells; UBRS-Uncrushed burnt rock shells; CURS-Crushed unburnt rock shells; UURS-Uncrushed unburnt rock shells

Table 10: Calcium concentration of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRB (first reuse)

Treatment	Initial calcium (mg/L)	Final calcium (mg/L)	Mean ± SEM
CON (T1)	20	20	20 ± 0.02c
CA (T2)	20	80	50 ± 0.20a
CBRS (T3)	20	80	50 ± 0.20a
UBRS (T4)	20	60	45 ± 0.25a
CURS (T5)	20	60	45 ± 0.25a
UURS (T6)	20	40	30 ± 0.20b

Means with different letters on same column are significantly different ($P < 0.05$)
CON-Control; CA-Calcium carbonate; CBRS-Crushed burnt rock shells; UBRS-Uncrushed burnt rock shells; CURS-Crushed unburnt rock shells; UURS-Uncrushed unburnt rock shells

Table 11: Calcium concentration of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRC (second reuse)

Treatment	Initial calcium (mg/L)	Final calcium (mg/L)	Mean ± SEM
CON (T1)	20	20	20 ± 0.02c
CA (T2)	20	80	50 ± 0.20a
CBRS (T3)	20	80	50 ± 0.20a
UBRS (T4)	20	60	45 ± 0.25a
CURS (T5)	20	60	45 ± 0.25a
UURS (T6)	20	40	30 ± 0.20b

Means with different letters on same column are significantly different ($P < 0.05$)
CON-Control; CA-Calcium carbonate; CBRS-Crushed burnt rock shells; UBRS-Uncrushed burnt rock shells; CURS-Crushed unburnt rock shells; UURS-Uncrushed unburnt rock shells

Table 12: Calcium concentration of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRD (third reuse)

Treatment	Initial calcium (mg/L)	Final calcium (mg/L)	Mean ± SEM
CON (T1)	20	20	20 ± 0.02c
CA (T2)	20	80	50 ± 0.20a
CBRS (T3)	20	80	50 ± 0.20a
UBRS (T4)	20	60	45 ± 0.25a
CURS (T5)	20	60	45 ± 0.25a
UURS (T6)	20	40	30 ± 0.20b

Means with different letters on same column are significantly different ($P < 0.05$)
CON-Control; CA-Calcium carbonate; CBRS-Crushed burnt rock shells; UBRS-Uncrushed burnt rock shells; CURS-Crushed unburnt rock shells; UURS-Uncrushed unburnt rock shells

Table 13: Dissolved oxygen concentration of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRA (first use)

Treatment	Initial DO (mg/L)	Final DO (mg/L)	Mean ± SEM
CON (T1)	7	8	7.5 ± 0.66b
CA (T2)	7	13.5	10.5 ± 0.50a
CBRS (T3)	7	13	10 ± 0.50a
UBRS (T4)	7	12.5	9.5 ± 0.50a
CURS (T5)	7	13	10 ± 0.50a
UURS (T6)	7	10	8.5 ± 0.50a

Means with different letters on same column are significantly different ($P < 0.05$)
CON-Control; CA-Calcium carbonate; CBRS-Crushed burnt rock shells; UBRS-Uncrushed burnt rock shells; CURS-Crushed unburnt rock shells; UURS-Uncrushed unburnt rock shells

Table 14: Dissolved oxygen concentration of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRB (first reuse)

Treatment	Initial DO (mg/L)	Final DO(mg/L)	Mean ± SEM
CON (T1)	7	8	7.5 ± 0.66b
CA (T2)	7	13.5	10.5 ± 0.50a
CBRS (T3)	7	13	10 ± 0.50a
UBRS (T4)	7	12.5	9.5 ± 0.50a
CURS (T5)	7	13	10 ± 0.50a
UURS (T6)	7	10	8.5 ± 0.50a

Means with different letters on same column are significantly different ($P<0.05$)
CON-Control; CA-Calcium carbonate; CBRS-Crushed burnt rock shells; UBRS-Uncrushed burnt rock shells; CURS-Crushed unburnt rock shells; UURS-Uncrushed unburnt rock shells

Table 15: Dissolved oxygen concentration of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRC (second reuse)

Treatment	Initial DO (mg/L)	Final DO(mg/L)	Mean ± SEM
CON (T1)	7	8	7.5 ± 0.66b
CA (T2)	7	13.5	10.5 ± 0.50a
CBRS (T3)	7	13	10 ± 0.50a
UBRS (T4)	7	12.5	9.5 ± 0.50a
CURS (T5)	7	13	10 ± 0.50a
UURS (T6)	7	10	8.5 ± 0.50a

Means with different letters on same column are significantly different ($P < 0.05$)
CON-Control; CA-Calcium carbonate; CBRS-Crushed burnt rock shells; UBRS-Uncrushed burnt rock shells; CURS-Crushed unburnt rock shells; UURS-Uncrushed unburnt rock shells

Table 16: Dissolved oxygen concentration of acidic borehole water treated with different forms of rock shells and calcium carbonate in TRD (third reuse)

Treatment	Initial DO (mg/L)	Final DO(mg/L)	Mean ± SEM
CON (T1)	7	8	7.5 ± 0.66b
CA (T2)	7	13.5	10.5 ± 0.50a
CBRS (T3)	7	13	10 ± 0.50a
UBRS (T4)	7	12.5	9.5 ± 0.50a
CURS (T5)	7	13	10 ± 0.50a
UURS (T6)	7	10	8.5 ± 0.50a

Means with different letters on same column are significantly different ($P < 0.05$)

CON-Control; CA-Calcium carbonate; CBRS-Crushed burnt rock shells; UBRS-Uncrushed burnt rock shells; CURS-Crushed unburnt rock shells; UURS-Uncrushed unburnt rock shells

DISCUSSION

Water quality is the condition/state of the physical, biological and chemical parameters that affect the growth and well being of cultured organisms. The success of a commercial aquaculture business depends on providing the best environment for rapid growth at the minimum cost of resources and capital. The quality of water has effects on the condition factor index of aquaculture-raised animals and plants as it determines the general well-being and growth of cultured life. It is therefore an important factor to be looked into when planning for high aquaculture production. Water quality in fish ponds is affected by the interactions of several chemical such as ccarbon dioxide, pH, alkalinity hardness and others.This interaction can have profound effects on pond productivity. Water is said to be acidic when pH is below 7 and basic when pH is above 7. The pH values usually fall between 0 and 14.The average value of the water pH in this study was 4.0, this implies an acidic water and fresh water fish can hardly survive in it and if the adult can, the fry might die or the hatchery process might be alter. The recommended pH range for aquaculture is 6.5 to 9.0 (William and Robert, 1992).The recorded increasing pH from Day1 to Day 4 in all treatments in the four trials at morning; afternoon and night might be attributed to the very high quality calcium carbonate of rock shells. Rock shells contain 95.54% of calcium oxide (CaO), 2.52% of magnesium oxide (MgO) and trace amount of other oxides which make them good and desirable source raw materials for the production of calcium supplements by indigenous food industry (Malu *et al*., 2009).

The diffusion of air containing oxygen gas into the experimental water could also be the reason for the increased pH in all treatments in the four trials. Dissolved oxygen is directly proportionate to pH: DO increase as pH increased. However, this treatment type cannot be depended upon for fish production (because it takes more time to increase the pH) especially intensive and large scale production as recommended by Viveen *et al*. (1986) who suggested the use of liming materials or buffer agents to increase water pH. The dosage of rock shells used in these trials was adequate (Viveen *et al*., 1986) as the different duration regimes were within the minimum duration of 14 days. Therefore, the quantity of the organic buffer in this study was sufficient to raise pH of T3 to T6 to desirable range of 6.5-9.0 recommended by Boyd (1981) and Wurts and Durborow (1992), suitable for buffering acidic water for fish production.T3 (crushed burnt rock shell) obtained pH result is almost the same with T2, which implies that T3 is a perfect substitute for T2 in improving pond water pH

The various water temperatures recorded for the four trials were favourable for fish culture and they fell within the standard range already documented. Mean surface water temperature of 26 °C to 30 °C recorded agreed with the ranges recorded by Hassan (1974), Ugwumba and Ugwumba (1993) and ranges earlier documented by Boyd (1979) for freshwaters. Therewasno significant difference in the values of temperature recorded for morning, afternoon and night for each trial, but the afternoon temperature wasa bit higher in all the trials which might be responsible for the slight higher level of afternoon pH values in all the trials. In fish farming, heating of the water might become necessary if the temperature of the water is below the recommended range in order to increase the fish metabolic rate so that they can consume well but a very high temperature might make the fish very uncomfortable. Each species of fish has a range in temperature where it grows best. At temperatures above or below optimum fish growth can be impaired. Mortality may occur at extreme temperatures (Piper *et al.*, 1982).

The recorded maximum alkalinity values for T2 and T4 were within the permissible limit of 50 mg/L and above for aquaculture species. Rock shells exhibit filter quality and help improve alkalinity. pH and alkalinity can influence fish, but often not directly toxic (Stevens, 2007). Huet (1972), Meade (1989) and USDA (1996) reported that each water quality property correlates with and affects other factors in complex ways although in rare cases. The most suitable and desirable water for fish culture is that which is neutral or slightly alkaline with a pH range of 7 to 8 (Robert, 2007). Robert (2007) also observed that fish can die from pH shock, a consequence of a sudden change in the pH. The total alkalinity concentration should not be lower than 20 mg/LCaCO3 in production ponds. It has been reported that water pH changes widely at day, with values ranging from 6 to 10, when alkalinity concentrations are less than this level. Great fluctuations in daily pH can cause stress, poor growth and even death of thefish. Many aquatic organisms can adjust to a broad range of alkalinity concentrations. The suitable total alkalinity level for most cultured fish species lies between 50 and 150 mg/LCaCO3, but above 20 mg/L (Wurts and Durborow, 1992). T2 and T3 showed a very good alkalinity level than others. This implies that crushed burnt rock shell can serve as substitutes to replace calcium carbonate in improving pond water alkalinity level to a good range.

The increased calcium concentrations in rock shells treated water could be linked to the calcium content (calcium oxide, 95.54%) of the *T. coronata* shells. The recorded initial calcium level was not suitable for fish farming. Tucker (1991) suggested more than 20 mg/L of calcium for aquaculture. The non-significant difference (P>0.05) in calcium levels of T2 to T5 might be attributed higher (95.54%) calcium oxide in rock shells (Malu *et al.*, 2009).

The dissolved oxygen requirement for fish varies from species to species. Robert (2007) recommended a dissolved oxygen concentration of 3 mg/L and above for any cultured fish in tropical region. The recorded DO values were within the acceptable range (5 mg/L and above) for fish production according to Boyd (1985; Robert, 2007). The observed increases in DO values of the experimental water from the beginning to the end of the experiment could be the reason for the recorded increases in the pH with day. As the dissolved oxygen concentration decreases, respiration and feeding activities also decrease. As a result, the growth rate is reduced and the possibility of a disease attack is increased. However, fish is not able to assimilate the food consumed when DO is low (Tom, 1998).

The dissolved oxygen requirement for fish varies from species to species. Generally, the water quality for any fish cultured in tropical region must be such that the dissolved oxygen concentration must not be less than 3 mg/L (Robert, 2007).The recorded DO values were within the acceptable range (5 mg/L and above) for fish production according to Boyd (1985).The observed increases in DO values of the experimental water from the beginning to the end of the experiment could be the reason for the recorded increases in the pH with day. As the dissolved oxygen concentration decreases, respiration and feeding activities also decrease. As a result, the growth rate is reduced and the possibility of a disease attack is increased. However, fish is not able to assimilate the food consumed when DO is low (Tom 1998).

CONCLUSION

The use of rock shells as a buffer agent in replacing calcium oxide in aquaculture is due to its high concentration (95.54%) of $CaCO_3$ which tend to be more efficient and effective when the shell is crushed and burnt before used. This study therefore recommends at least 270 g of the different shell types preferable the crushed burnt shells as organic buffer for fish production for cheaper and more efficient pond management.

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