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STUDY OF INTERRELATIONSHIP AMONG WATER QUALITY PARAMETERS IN EARTHEN POND AND CONCRETE TANK

A MASTER DEGREE RESEARCH CONDUCTED BY

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ABSTRACT

One of the major limiting factors in aquaculture production is poor water quality which can negatively affect the yield from aquaculture venture. There is therefore the need to study the rate of interrelationship among key water quality parameters in relation to water quality management and productivity. The level of interaction among dissolved oxygen, ammonia, pH, and temperature in two culturing facilities (Earthen and Concrete ponds) was therefore investigated. Water samples were collected from concrete and earthen fish ponds in a commercial fish farm in Ibadan. The concrete tanks and earthen ponds used for the experiment have the same stocking rate; number of stocked fish; water source and feeding rate and frequency. Water samples were collected randomly from 4 different points in each of the rearing facilities with a sampling bottle in the morning (8.00-8.30am) and evening (5.00-5.30pm) immediately after feeding; this is done weekly for 6weeks. Also the mortality of fish in the studied facilities was recorded. Four different physico-chemical parameters (Temperature, pH, Dissolved oxygen and Ammonia) were analyzed and measured using HATCH analysis water testing kit model FF-1A immediately after water sample collection. Data collected were analysed using ANOVA and correlation and were test for significance at p=0.05. The result showed that, the

mean values of pH was (8.15±0.17; 8.69±0.17); temperature (27.95±1.88; 30.21±1.880C) and dissolved oxygen (4.79±3.98; 11.38±3.98mg/l) were obtained in the morning and evening respectively. Mean dissolved oxygen was (7.04±3.98; 9.12±3.98mg/l); pH (7.9±0.17; 8.9±0.17mg/l); and ammonia (0.5±0.24; 2.09±0.24) in concrete tanks and earthen ponds respectively. The highest values of temperature (33.000C); dissolved oxygen (13.00mg/l) were obtained in the evening. The values obtained for dissolved oxygen and temperatures showed significant variations between the time of the day. Mean mortality recorded was (1.2±1.07); (2.6±1.07) in concrete and earthen ponds respectively. Mortality recorded shows positive correlation with temperature and ammonia with correlation coefficient (r=0.18) and (r=0.54) respectively, however, ammonia level had direct significant relationship with mortality. It is concluded that there exist interrelationship among the key water quality parameters examined, and there values varies with time of the day and between different culture facilities.

Keywords: Physiochemical parameters, fish production, Water quality

INTRODUCTION

In the growing aquaculture industry, it is accepted that good water quality is needed to maintain viable aquaculture production (King, 1998). Poor water quality can result in low profit, low product quality and potential human health risks. Production is reduced when the water contain contaminants that can impair development, growth, reproduction, or even cause mortality to the cultured species (Stone and Thormforde, 2003). Some contaminants can accumulate to the point where it threatens human health even in low quantities and cause no obvious adverse effects (King, 1998).

Efficient feed conversion, growth and marketability of the final product cannot occur unless the pond system is balanced or in harmony with nature. Therefore the overriding concern of the fish culturist is to maintain, 'balance' or 'equilibrium conditions' with respect to water chemistry and its natural consequence (Wurts, 2000). Water quality for aquaculturists refers to the quality of water that enables successful propagation of the desired organisms (Boyd, 1995). The required water quality is determined by the specific organisms to be cultured and has many components that are interwoven. Sometimes a component can be dealt with separately, but because of the complex interaction between components, the composition of the total array must be addressed (ICLARM, 2006).

Growth and survival, which together determine the ultimate yield, are influenced by a number of ecological parameters and managerial practices (Boyd and Tucker, 1998). High stocking density of fish or crustaceans in ponds usually exacerbates problems with water quality and sediment deterioration. Wastes generated by aquaculture activity (faeces and unconsumed feed) first settle in the bottom, as a consequence of organic waste and metabolite of degraded organic matter is accumulated in sediment and water. Part of the waste is flushed out of the ponds immediately or later, after the organic matter has been degraded (Boyd, 1990).

Low dissolved oxygen level is the major limiting water quality parameter in aquaculture systems (Boyd, 1995). A critically low dissolved oxygen level occurs in ponds particularly when algal blooms die-off and subsequent decomposition of algal blooms and can cause stress or mortality of prawns in ponds. Chronically low dissolved oxygen levels can reduce growth, feeding and moulting frequency (Boyd, 1990).

Another major consequence of aquaculture production is a high degree of variability in the concentration of dissolved nitrates, nitrites and ammonia (Schwartz and Boyd, 1994). The environmental conditions that create high ammonia concentrations may also cause increase in nitrite concentration. Both ammonia and nitrite can be directly toxic to culture organisms or can induce to sub lethal stress in culture populations that results in lowered resistance to diseases (Boyd, 1998).

Development of aquaculture activities at a particular site cannot be carried out only by considering planned facilities and the quality of water on the site at its origin but also on the aspects of water quality management (Boyd, 1990).

There is a strong relationship between the quality of the water in the pond and that in the water-surrounding environment as cited by (Boyd, 1995). Degradation of surrounding water quality will be faster unless proper water quality management techniques are not implemented in the ever-increasing aquaculture system (Boyd, 1995).

The fish perform all its physiological activities in the water – breathing, excretion of waste, feeding, maintaining salt balance and reproduction. Thus, water quality is the determining factor on the success or failure of an aquaculture operation. The continued degradation of water resources due to anthropogenic sources necessitates a guideline in selecting sites for aquaculture using water quality as a basis (Boyd, 1998).

THE STUDY AREA

The experiment was conducted in a commercial fish farm-Nazarene Fish Farm, Challenge, Ibadan, Oyo state. The farm is one hectare in size with ten concrete tanks and fourteen earthen ponds. The farm has a water channel constructed through it which serves the purpose of controlling flood and depends largely on water from reservoir for fish production. Water sample used for this study were collected from concrete and earthen ponds on the farm.

EXPERIMENTAL PROCEDURES

Water samples were collected from concrete and earthen fish ponds on the farm .The concrete tank and earthen ponds used for the experiment have the same; stocking rate (15 fish/m^3); the fish stocked are of the same parent stock; water source (reservoir); feeding rate and frequency(3% fish body weight and twice daily respectively).Water samples were collected randomly at 10cm below the surface and from 4 different points in each of the rearing facilities with a sampling bottle in the morning (8.00-8.30am) and evening (5.00-5.30pm) immediately after feeding, this is done every week for 6weeks. Four different physico-chemical parameters (Temperature, pH, dissolved oxygen and Ammonia) were analyzed using HATCH analysis water testing kit model FF-1A following method described by (Boyd and Tucker, 1998), the analysis were done immediately after water samples collection. Mortality was recorded from the culture systems used for the experiment.

TESTING PROCEDURE AND METHOD

AMMONIA

The Nessler method for ammonia testing is used; the Nessler testing is a sensitive single reagent test. Interference due to high water hardness is eliminated by adding Rochelle salt solution to the sample (APHA, 1980). The standard procedure follows the method as described by the manual of HATCH analysis water testing kit model FF-1A.

(1) One of the viewing tubes of the water quality testing kit was filled to the 5ml mark with deionised water; this will be the reagent blank.

(2) The second viewing tube was filled to the 5ml mark with water sample to analyze; this was the prepared sample.

(3) 1 drop of Rochelle salt solution was added to each viewing tube and they were swirl to mix.

(4) 3 drops of Nessler Reagent was added to each viewing tube, they will then be swirl to mix. It is allowed to stay for 10 minutes for colour development

(5) The prepared sample was put in the right hand side of the comparator, while the reagent blank was put in the left hand opening.

(6) The comparator was held up to a light source and disc in the comparator was rotated until the colour in the left and right windows matches. The concentration of ammonia was determined in mg/l through the scale window.

TEMPERATURE

Temperature of the water was determined with the use of simple mercury in glass thermometer, the thermometer was dipped into the water at consistent surface depth 10cm throughout the period of the experiment, the temperature of the water was determined in situ.

DISSOLVED OXYGEN

Dissolved oxygen level was determined titrimetrically using method as described by the manual of HATCH analysis water testing kit model FF-1A.The standard procedure for dissolved oxygen determination would be as follows;

(1) The glass stoppered dissolved oxygen bottle was submerged into water in the pond and allowed to fill to the top

(2) Air bubbles are prevented by inclining the bottle slightly and inserting the stopper with a thrust, this forces air bubbles out of the sample.

(3) The stopper was carefully removed from the bottle and the content of dissolved oxygen 1and dissolved oxygen 2 reagent powder were emptied into the glass, the stopper is placed again and the bottle was shaken vigorously, a flocculent precipitate was formed, if oxygen is present the precipitate would be brownish orange

(4) The sample was then allowed to stand until the floc has settled half way and the upper half of the bottle is clear.

(5) The bottle was shaken again and the floc is allowed to settle again

(6) The stopper was removed and the content of the dissolve oxygen 3powder pillow was added to the sample in the bottle

(7) The stopper was replaced and the bottle is shaken, the floc at this time would dissolve in the presence of oxygen, this was the prepared sample.

(8) A plastic measuring tube was filled to the top with the prepared sample; the content in the tube was then poured into mixing bottle.

(9) Sodium thiosulphate standard solution was added drop by drop, the bottle was swirled after each drop, the drop would continue until colour changes from yellow to colourless. Each drops represent 1mg/l dissolved oxygen

pH

pH level was determined using method as described by the manual of HATCH analysis water testing kit model FF-1A

(1)The viewing tubes were thoroughly rinsed and fill to the 5-ml marks

(2) 6 drops of wide range 4 pH indicator solutions was added to one of the tube and swirled to mix

(3)The tube containing the indicator was inserted into the right hand opening of the colour comparator, while the tube of untreated sample was inserted into the left hand opening of the comparator.

(4)The comparator was held to light and viewed through the opening; the colour disc was rotated until colour match is obtained.

MORTALITY

Mortality record were kept for the earthen pond and concrete structure separately, this is done in the morning and evening.

DATA ANALYSIS

The data obtained were subjected to one way analysis of variance and the difference between means were tested for significance ($p<0.05$).Regression analysis was carried out to give prediction of equations and reveal correlation between treatments and response parameters. This is done using STATISTICA software version 10.0,based on the description of (King, 1998)

RESULTS

Water quality study is essential for setting base line conditions and standards. Against these standards results of further studies can be evaluated. The results of this study are presented in Tables 2 and 3. Four different physiochemical parameters (Temperature, Ammonia, pH and Temperature) were analyzed. The analysis was based on the samples taken from concrete and earthen fish ponds.

WATER QUALITY PARAMETERS

Temperature

Temperature value recorded ranges from 27.9 to 30.3 with the lowest value 27.9 recorded in the morning, the mean temperature is (27.95±1.88; 30.21±1.88^{0}C) in morning and evening respectively as shown in Table 1; Figure 1.Temperature recorded in the morning throughout the period of the experiment shows a mark significant difference ($p<0.05$) from that recorded in the evening, while no significant difference of temperature value among the rearing facilities used. Figure 1 shows the graphical representation of this variation.

Dissolved Oxygen

This is a measure of amount of gaseous oxygen dissolved in an aqueous solution that plays a vital role in the biology of cultured organisms (Thunjai *et.al*, 2001). The mean dissolved oxygen calculated from the results of analysis presented in Appendices 1 and 2 ranges between 4.78±3.98 and 11.38±3.98 in the morning and evening as shown in Table 2, and between 9.11±3.98 and 7.05±3.98 in earthen pond and concrete tank respectively as recorded in Table 1; Figure 2 Dissolved oxygen value in the morning shows that there is significant

TABLE 1: Variation of parameters in relation to culture medium

	Culture medium	
Parameters	Concrete tank	Earthen pond
Dissolved Oxygen	9.11±3.98	7.05±3.98
pH	8.90±0.17	7.94±0.17
Ammonia	0.5±0.24	2.09±0.24
Temperature	29±1.88	29.05±1.88
Mortality	1.2±1.07	2.6±1.07

TABLE 2: Variation of parameters in relation to time of the day

	Time of the day	
Parameters	Morning	Evening
Dissolved Oxygen	4.78±3.9	11.38±3.9
pH	8.15±0.17	8.69±0.17
Ammonia	0.5±0.24	2.09±0.24
Temperature	27.95±1.88	30.21±1.88

different ($p<0.05$) with that recorded in the evening period, and there is significant difference ($p<0.05$) in value of dissolved oxygen recorded in concrete and earthen facilities, The pattern of fluctuation of dissolved oxygen does not follow that of temperature; it was significantly ($P<0.05$) lower in the afternoon and significantly ($P<0.05$) higher during the morning and evening sessions as seen on Figure 2.

pH value

Mean pH value varies between 8.15±0.17 and 8.69±0.17 with the value 8.15 recorded in the morning and also ranges between 7.94±0.17 and 8.90±0.17 in earthen pond and concrete tank with value 7.9mg/l recorded in the earthen pond as shown in Table 1 and 2; figure 3. There is a significant different ($p<0.05$) in pH recorded in the morning and in the evening, this is shown in Figure 3, Figure 3, also pH recorded in earthen and concrete structures shows mark significant difference ($p<0.05$).

Ammonia

Mean ammonia level ranges between 0.0.5±0.24 and 2.09±0.24 shown on Table 1 with concrete tank having the value 0.5mg/l,The Ammonia level in the concrete tank is significantly different ($p<0.05$) from the value recorded in the earthen structure, this is shown on Figure 4.

The ammonia level recorded ranges between 0.5 to 2 mg/l, figure 4, this high value of ammonia recorded contributed to high mortality recorded during the period of the experiment.

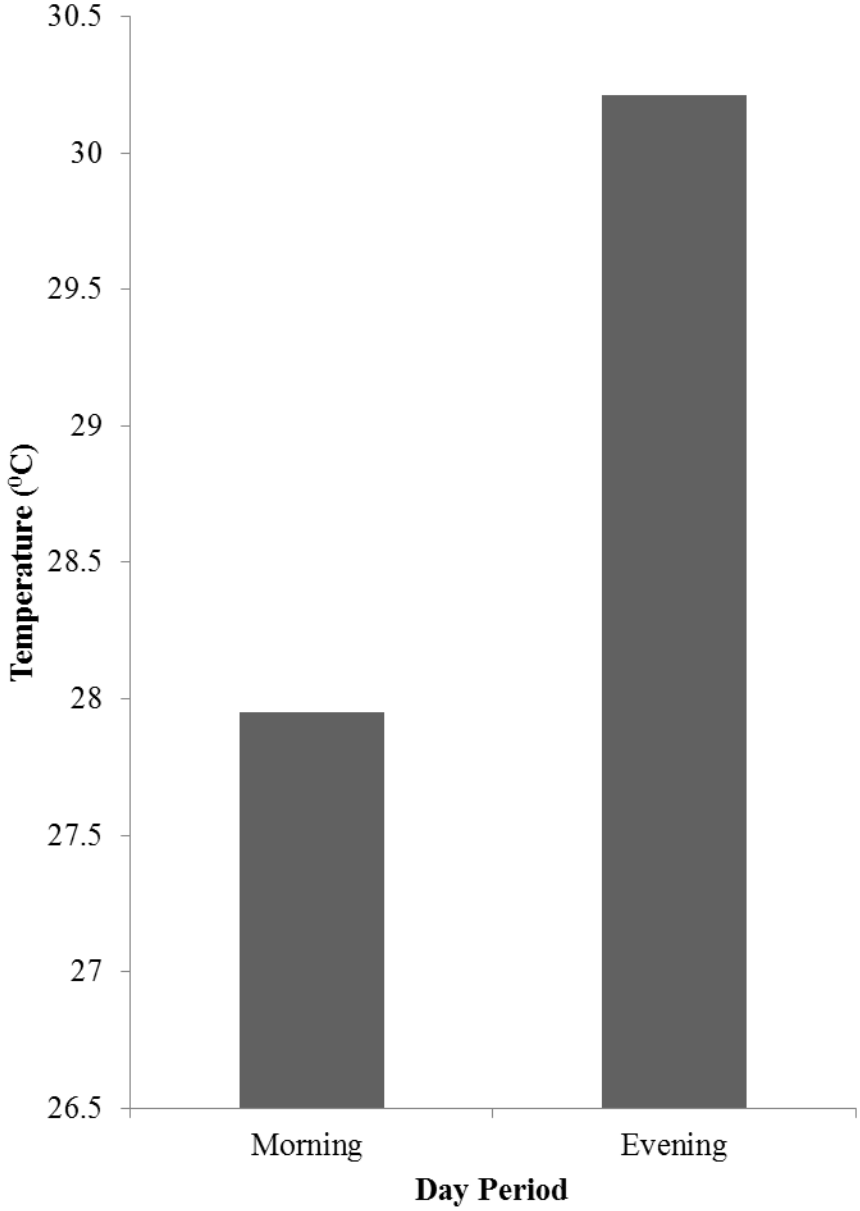

Fig 1 : Mean Temperature values under different day period

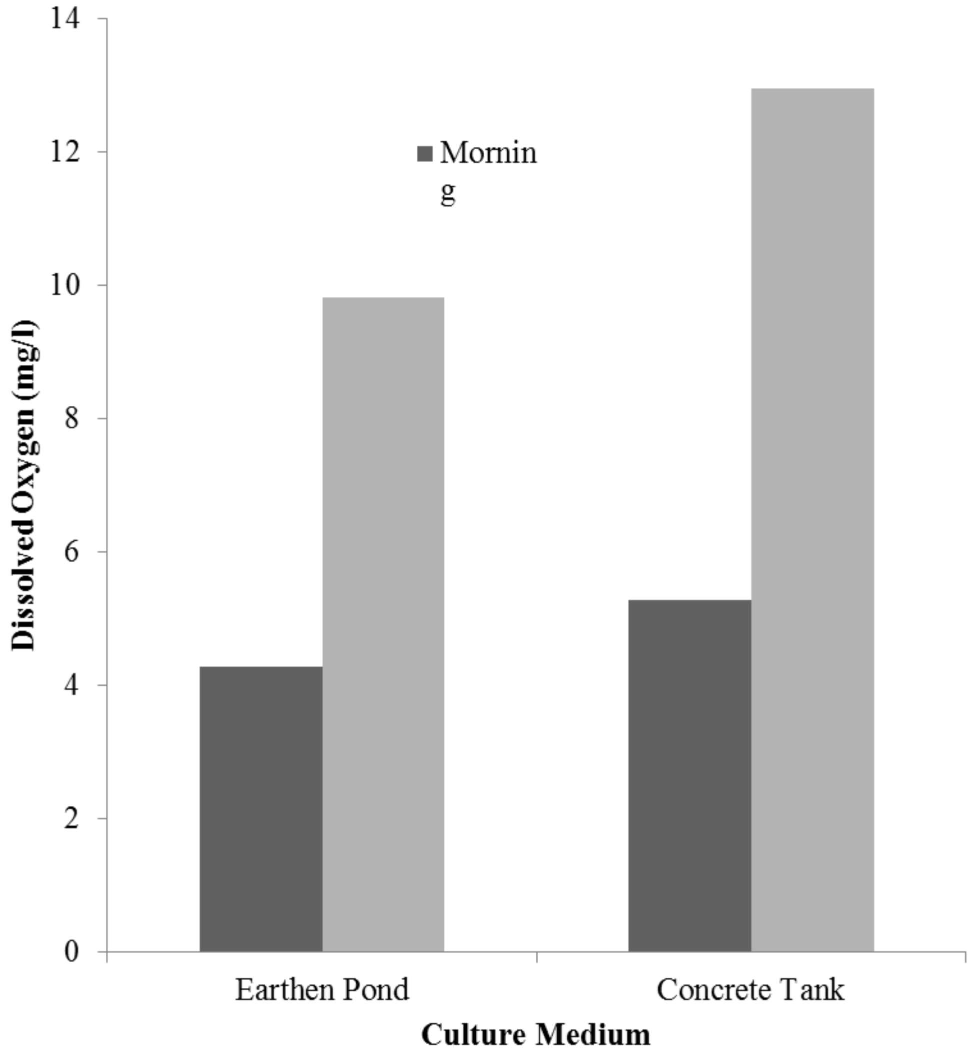

Fig 2: Mean Dissolved Oxygen content under different culture media and day period

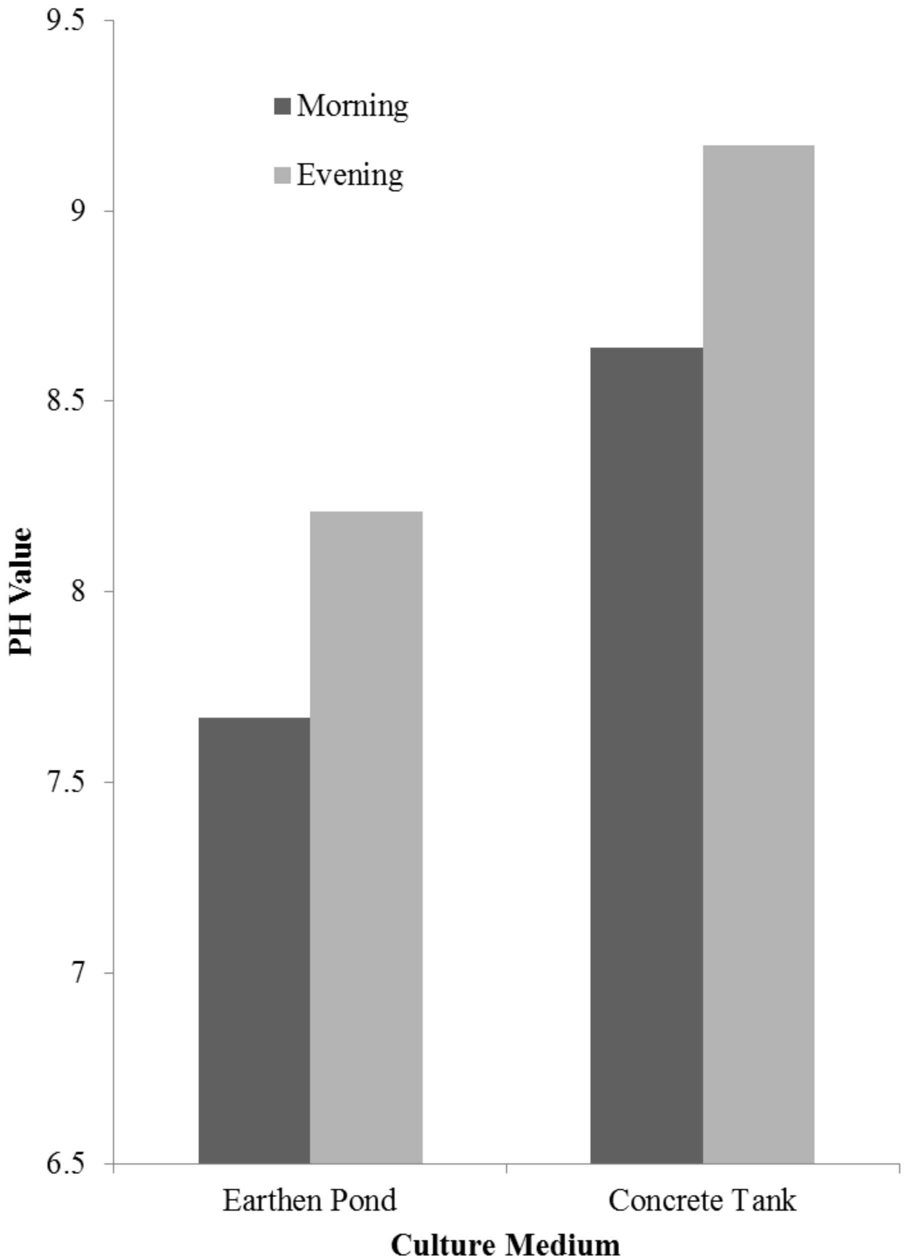

Figure 3 : Mean PH values under different culture media and day period.

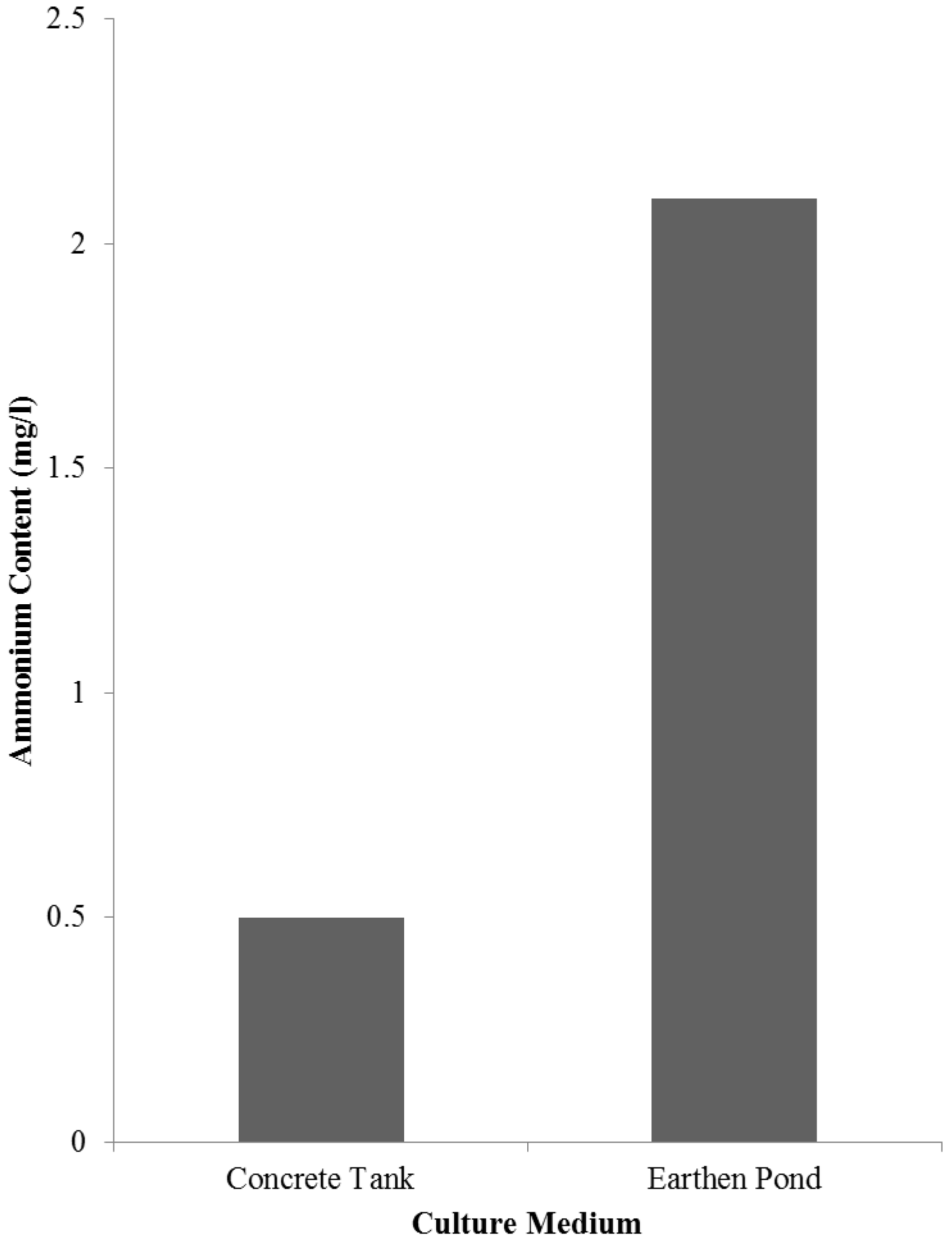

Figure 4 : Mean Ammonium content under different culture media

MORTALITY

The mortality in the culturing facilities used were recorded, it was observed that the highest mortality recorded was from the earthen pond, this could be linked to high ammonia build up in the pond which may be as a result of presence of pollutants like Chemical (pesticides), and organic run–off deposition into pond or as a result of poor pond preparation.Figure 5 shows variation in mortality across culturing facilities. Mean mortality recorded was (1.2±1.07); (2.6±1.07) in concrete and earthen ponds respectively.

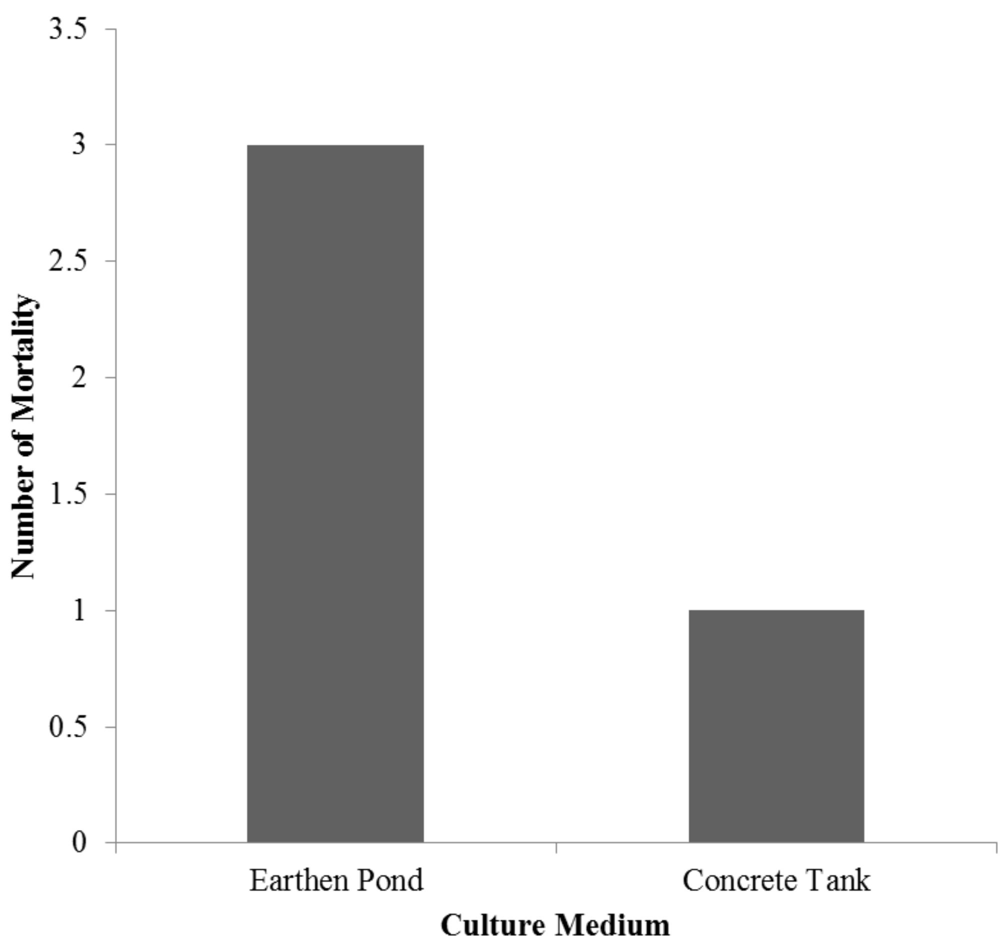

Fig. 5 : Number of mortality under different culture media

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CORRELATION AND REGRESSION

The result of correlation in Table 3 shows that there is positive correlation between mortality and ammonia level in the pond; temperature shows positive correlation and significant with level of dissolved oxygen with correlation coefficient (r= 0.62) dissolved oxygen, dissolved oxygen shows positive correlation and significance with temperature and pH with correlation coefficient (r = 0.62) and (r = 0.54) . Mortality also shows positive correlation with temperature and ammonia with correlation coefficient (r = 0.18) and (r = 0.54), however, ammonia level had direct significant relationship with mortality.

The record of mortality obtained were correlated against the water quality parameters examined, the result obtained is presented in Table 3.

TABLE 3: CORRELATION COEFFICIENT

Variable	Mortality	Temperature	pH	NH_3	D/ O
Mortality	1.00	0.18	-0.51*	0.54*	-0.11
Temperature	0.18	1.00	0.15	-0.03	0.62*
pH	-0.51*	0.15	1.00	-0.73*	0.54*
NH_3	0.54*	-0.03	-0.73*	1.00	-0.23*
DO	-0.11	0.62*	0.54*	-0.23*	1.00

DISCUSSION, RECOMMENDATIONS AND CONCLUSION

DISCUSSION

Generally, the parameters analysed fell within the desirable and acceptable limits. Although, there wasa value (Ammonia concentration) higher than the acceptable limit in the earthen ponds.

pH Value

The desirable range for pond pH is 6.5 - 9.5 and acceptable range is 5.5 - 10.0 (Stone and Thomforde, 2003). The range of the pH obtained from this study was (6.89 - 7.10), this agreed with Stone and Thomforde (2003). Thus, good pond productivity and fish health can be maintained. Furthermore, a similar range was obtained by Fafioye *et.al* (2005) who reported a range of 7.3 - 8.3. The optimum range recorded by (Boyd, 2005) was 6.5 - 8.5. Pond CO_2 concentrations and pH, are affected by respiration and photosynthesis. Carbon dioxide is released during respiration and consumed for photosynthesis. As a result, pond pH varies throughout the day, the plant members of the pond plankton community, phytoplankton, absorb CO_2 for photosynthetic production of sugar. As daylight progressively intensifies, the rate of photosynthesis increases and so does the uptake of CO_2. The removal of CO_2 reduces the concentration of carbonic acid, and pond pH rises.

Dissolved Oxygen

The dissolved oxygen (mg/l) obtained from this study was in the range of 4 - 11mg/l, these values agree with those of Saloom and Duncan, (2005),they also pointed out that the minimum dissolved oxygen should be 5 mg/l for tropical fish.The highest dissolved oxygen recorded was in the evening and was in consonance with what is recorded by Saloom and Duncan, (2005).

Fafioye *et.al*.,(2005) recorded ranges between 1.4 to 4.8mg/l, the dissolved oxygen recorded was also in agreement with the optimum range of dissolved oxygen document by Boyd,(1979); 4.0 to 6.0 mg/l, Boyd and Lichtkoppler,(1985) also record 5.68mg/l and 5.7mg/l. The higher level of dissolved oxygen recorded in the evening may be as a result of photosynthetic activities by primary producers during the day when light intensity is high, and probably the reason for low dissolved oxygen recorded in the morning may be due to respiratory activities aerobic organisms in the culture medium.

Temperature

The mean water temperature of (27.95±1.88; 30.21±1.88^{0}C) recorded in the morning and evening agreed with the ranges recorded by King (1998), Ugwumba and Ugwumba (1993) and ranges earlier documented by Boyd (1979) for freshwaters. Boyd and Lichtkoppler, (1985) also record temperature range of 26 – 28 ^{0}C. The reason for difference in temperature in temperature may be as a result of solar energy absorbed by the water surface. It was also observed that there is no significant difference in temperature in the culturing facilities used for the experiment; the reasons can be ascribe to the fact that the earthen and concrete facilities are subjected to the same light intensity and maybe the type of holding structure does not influence temperature change.

Ammonia Value

The ammonia level recorded ranges between 0.5 to 2 mg/l, this high value of ammonia recorded contributed to high mortality recorded during the period of the experiment,the desirable limit is 0 – 0.05 mg/l and acceptable limit less than 0.5mg/l (DWAMD, 1994). These desirable and acceptable limits are lower than those from previous study and therefore not in consonance with the result of this study. The high values suggested that there is the presence of pollutants like bacteria and pesticides; this can be remedied by water change. The range on ammonia recorded is not in consonance with 0.025mg/l recorded by (Boyd, 2005), (Fafioye *et. al.,* 2005) also describe a range of 0.025 to 0.035 mg/l. One of the other reasons for high ammonia recorded may be due to high level of pH because pH has a positive correlation with ammonia level, ammonia – nitrogen has more toxic form at high pH and less toxic at low pH (Wurts, 2000)

Mortality

The mortality in the culturing facilities used were recorded, it was observed that the highest mortality recorded was from the earthen pond, this could be linked to high ammonia build up in the pond which may be as a result of presence of pollutants like bacteria and pesticides; poor pond preparation and presence of decaying macrophyte. From the result gotten it shows that ammonia level is directly proportional to mortality; this is in consonance with Saloom and Duncan, (2005). Mortality was also recorded in the concrete structure but not as high as that recorded in the earthen facilities, this may be due to higher level of ammonia recordedwhich is higher than the optimum recorded by (DWAMD, 1994).

RECOMMENDATIONS AND CONCLUSION

Water quality influences the performance and survival of cultured organism. Some of the water quality factors are more likely to be involved with fish losses and are referred to as key water quality parameters, such as dissolved oxygen, temperature, and ammonia. Others, such as pH,alkalinity, hardness and clarity affect fish, but usually are not directly toxic.

Water quality factor interacts with and influence other parameters, sometimes in complex ways. The result of the experiment on water quality parameters showed that no single parameter can be singled out in relation to fish growth and health, that there exist strong interrelationship among

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key water quality parameters. However, five of these parameters (i.e. temperature, dissolved oxygen, ammonia, pH and alkalinity) must be kept at optimal level to guarantee high fish yield.

It was also observed that a significant variation exist in the value of physico - chemical parameters across culture facilities, changes in value of parameters can be sponteneous and can be greatly influenced by type and nature of culture system. In light of these, the determination method of water quality parameters and frequency of monitoringdepends upon the type and rearing intensity of theproduction system used.

Significant variations of some parameters (Temperature, Dissolved Oxygen and Ammonia) in relations to period of the day were also recorded; this may be due to the effect of biological activities like photosynthesis and respiration of organisms.

Therefore, it is concluded that all the listed physico-chemical parameters studied should be closely monitored and the optimal limit should at all time be provided to the cultured organism for optimum performance of the organism as well as profitability of fish production venture, also ,knowledge of testing procedures and interpretation of results are important to the fish farmer.

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