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Effects of monoculture and polyculture difference stocking density of Nile tilapia *Oreochromis niloticus* and African catfish *Clarias gariepinus* fingerlings on water quality of fish culture in concrete ponds

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Abstract
This study was conducted to evaluate the effect of monoculture and polyculture systems; (1 tilapia *O. niloticus*: 0 catfish *C. gariepinus*, 0 tilapia *O. niloticus*: 1 catfish *C. gariepinus*, 1 tilapia *O. niloticus*: 1 catfish *C. gariepinus*, 2 tilapia *O. niloticus*: 1 catfish *C. gariepinus*, 3 tilapia *O. niloticus*: 1 catfish *C. gariepinus*, 1 tilapia *O. niloticus*: 2 catfish *C. gariepinus* and 1 tilapia *O. niloticus*: 3 catfish *C. gariepinus*) at different stocking density (12, 24, 36 and 48 fish/m^{-3}) on fish culture environment in concrete ponds. Fingerlings cultured for sixteen weeks. Water parameters monitored and mustered biweekly using handheld refractometers; and some water characteristics (NO_2, NO_3, electrical conductivity, total alkalinity and total hardness) were analysis in laboratory. Data were statistically analysed using one-way (ANOVA) analysis of variance; and (LSD) made the Comparisons among means. The results of physio-chemical water quality parameters (DO, NH_4, PH, NO_3 and total dissolved solid) ranged from 3.47 to 3.90, 0.22 to 0.35, 7.3 to 7.6, 2.33 to 3.13 mg/L^{-1} and 101.7 to 124 ppm, respectively showed significant difference ($p<0.05$); and (temperature, NH_3, NO_2, electrical conductivity, total alkalinity and total hardness) with 24.50 ^{O}C, 0.01 mg/L^{-1}, 0.02 mg/L^{-1}, 1977.83 µs/cm, 161.3 ppm and 316.3 ppm respectively, there was no significant difference ($p>0.05$). Generally, the results of study within the acceptable range of water quality of fish culture environment.

Keywords: Monoculture and polyculture, stocking density, Nile tilapia (oreochromis niloticus), African catfish (clarias gariepinus), water quality parameters

Introduction
Aquaculture is one of the fastest emerging food-producing sectors globally and is flourishing day-by-day (Habib *et al*., 2020) [1]. Tilapia is one of the popular aquaculture species known as ‘‘aquatic chicken” due to its rapid growth, great adaptability to survive even in harsh environmental conditions, more resistance against a specific disease, high protein composition in meat (El-Sayed, 2006 [2]; Abdel-Aziz *et al*., 2021) [3]. More recently, tilapia production has been sharing up to 75% of total aquaculture production globally due to its ability to tolerate a wide range of several environmental factors. Tilapia can tolerate a wide range of temperatures; even can survive for few days in temperature below 10 °C and increases up to 40 °C. Nile tilapia is multiple spanners that is reproduced throughout the year, and gonads mature even during early life stages, which also depend upon the availability of food rich protein and lipid contents. Among 70 aquaculture tilapia species, nine species are widely used for aquaculture purposes, including i.e. Tilapia *zillii* and *Oreochromis niloticus.* The African catfish (*Clarias gariepinus*) is one of the major fish species cultured in Africa. It has also been introduced into aquaculture in different parts of the world, including the Netherlands, Hungary, much of South-East Asia, and East Asia (M. Feroz Khan and P. Panikkar, 2009) [4]. The species is also one of the most important individual commercial freshwater fish in many parts of Africa (E. Dadebo, *et al*, 2000) [5]. This species can be cultivated in areas with a tropical climate, areas with access to geothermal waters, or with the use of heated recirculating water systems. It is considered a very hardy fish in aquaculture terms and can be densely stocked in low-oxygen waters, making it ideal for culture in areas with a limited water supply. In sustainable aquaculture practice, the management of fish culture system is necessary to minimize costs and maximize growth performance is needed to handle fish culture for the best possible growth performance and fish health (Hassan *et al*., 2021a [6], 2021b) [36]. water is the physical support in which they carry out their life functions such as feeding, swimming, breeding, digestion and excretion (Bronmark and Hansson, 2005) [7]. Water quality is determined by various physico-chemical and biological factors, as they may directly or indirectly affect its quality and consequently its suitability for the distribution and production of fish (Moses, 1983) [8]. A sharp drop or an increase within these limits has adverse effects on their body functions (Davenport, 1993 [9]; Kiran, 2010) [10]. Therefore, Water quality management in fishponds is a necessary step that is required to be taken up. In most of the countries, fishes are cultivated in ponds (lentic water) but unfortunately, such culturists are not so aware of importance of water quality management in fishponds. If The role of various factors like temperature, transparency, turbidity, watercolour, carbon dioxide, pH, alkalinity, hardness, ammonia, nitrite, nitrate, primary productivity, biochemical oxygen demand (BOD), plankton population etc. can’t be overlooked for maintaining a healthy aquatic environment and for the production of sufficient fish food organisms in ponds for increasing fish production. Therefore, there is the need to ensure that, these environmental factors are properly managed and regulated for good survival and optimum growth of fish. Therefore, the current study objective to

evaluate the effect of monoculture and polyculture systems at different stocking density of Nile tilapia *O. niloticus* and catfish *C. gariepinus* on water quality in concrete ponds.

Materials and Methods

1. Study Area

The experimental work was conducted in College of Animal Production Science and Technology (CAPST), and at Laboratory of Department of Fisheries and Wildlife Science (DFWS), and Hatchery of Freshwater Aquaculture Research Centre (FARC), Kuku Camp. The culturing of Nile Tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*) fingerlings were done at the (FARC) centre in Kuku Camp.

2. Experimental ponds setup and fish

The experimental fish of the two species were adapted in Hapas for two weeks. The hapas were made of nylon mosquito netting with mesh size 0.5× 0.5 mm. After the adaptation period, each fish species was weighed, then randomly distributed, and stocked in each Hapa (1 m^2 height × 1 m^2 width × 2 m^2 length) at different stocking ratios of fish species. Hapas were constructed and implanted in inside of the concrete ponds (1.2 m^2 height and 2 m^2 diameter., total volume 3.8 m^3) containing proximately 3700L of water., Figure 3.2. Used completely randomised block design (CRBD) according to (Ali *et al.,* 2006) [11] and (Khattab *et al.,* 2004) [12] to reduce any large variation (i.e. pond effect) among experimental units since it is a field experiment. Three replicated per each treatment (Yakubu *et al*., 2012) [13]. The experiment was conducted on concrete ponds in which are in indoor a building covered on the sides with Expenda and on top with zinc sheets.

3. Water Quality Parameters.

The physical and chemical qualities of water are essential for optimum fish production. The quality of water in the experimental ponds (tables 2, 3 and 4) were monitored and analysed throughout the culture period to ensure that conducive environmental conditions were maintained: Dissolved oxygen mg/ L^{-1} using mobile digital DO-meter (Yellow Springs OH, USA), Salinity was measured by a Handheld refractometer (MSI 5509, OH, USA). The pH measurement was read using a portable pH meter Model: Mi105. The temperature and total dissolve substances (TDS) were measured using portable TDS and TSS Model: Mi 306, Martini Instrument (YSI 556 MPS), while Electrical conductivity *µs*/cm, Total alkalinity (mg/l), Ammonia Nitrite, and nitrate (mg/l) were determined with the chemical methods according to (APHA, 1995) [35]. Three readings per parameter were taken in each of the sevens experimental ponds. The probe was immersed in the pond at different depths and at different sections of the ponds. Samples were taken biweekly at 09:00

The optimum range of various water quality parameters are summarised in Table 2.1.

Table 1: Suggested water-quality criteria for pond water fishes for getting high yield via applying minimum input.

Parameter	Acceptable range	Desirable range	Stress
Temperature (0C)	15-35	20-30	<12, >35
Turbidity (cm)		30-80	<12, >80
Water colour	Pale to light green	Light green to light brown	Clear water, Dark green &Brown
Dissolved oxygen (mg L^{-1})	3-5	5	<5, >8
BOD (mg L-1)	3-6	1-2	>10
CO2 (mg L-1)	0-10	<5,5-8	>12
PH	7-9.5	6.5-9	<4, >11
Alkalinity (mg L-1)	50-200	25-100	<20, >300
Hardness (mg L-1)	>20	75-150	<20, >300
Calcium (mg L-1)	4-160	25-100	<10, >250
Ammonia (mg L-1)	0-0.05	0-<0.025	>0.3
Nitrite (mg L-1)	0.02-2	<0.02	>0.2
Nitrate (mg L-1)	0-100	0.1-4.5	>100, <0.01
Phosphorus (mg L-1)	0.03-2	0.01-3	>3
H2S (mg L-1)	0-0.02	0.002	Any detectable level
Primary productivity (C L-1 D-1)	1-15	0.1-4.5	<1.6, >20.3
Plankton (No. L-1)	2000-6000	3000-4500	<3000, >7000

4. Statistical analysis

Data were analysed using SPSS (version 26) One-way (ANOVA) and Microsoft Excel (2013). Results were compared with Analysis of variance and considered significant at $p<0.05$. LSD test was used to identify statistically significant differences among treatment means.

Results

1. Water Quality Parameters

The physic-chemical qualities of water are essential for optimum fish production. Results of water quality parameters for the treatments (1Tilapia *O. niloticus*: 0 *C. gariepinus*, 0 *O. niloticus*: 1 *C. gariepinus*, 1 *O. niloticus*: 1 *C. gariepinus*, 2 *O. niloticus*: 1 *C. gariepinus*, 3 *O. niloticus*: 1 *C. gariepinus*, 1 *O. niloticus*: 2 *C. gariepinus* and 1 *O. niloticus*: 3 *C. gariepinus*) are presented in tables 2, 3 and 4.

Table 2: Effect of fish species (*O. niloticus* and *C. gariepinus*) on physio-chemical of water quality reared in concrete ponds (means ± SD)

Fish species Parameters	*O. niloticus*	*C. gariepinus*	Sg.
Temperature (^{o}c)	24.50±0.20^{a}	24.50±0.35^{a}	Ns
Dissolved Oxygen (DO mg /L^{-1})	3.90±0.06^{a}	3.80±0.06^{a}	Ns
PH (mg /L^{-1})	7.4±0.15^{a}	7.6±0.15^{a}	Ns
Total Ammonia (NH_4 mg /L^{-1})	0.22±0.02^{a}	0.27±0.02^{a}	Ns
Ammonia (NH_3-N mg /L^{-1})	0.01±0.01^{a}	0.01±0.0^{a}	Ns
Nitrite (NO_2–N mg /L^{-1})	0.01±0.00^{a}	0.02±0.0^{a}	Ns
Nitrate (NO_3 mg /L^{-1})	2.70±0.49^{b}	2.60±0.31^{a}	Ns
Salinity ppt/L^{-1}	1.10±0.04^{a}	1.10±0.03^{a}	Ns
Electrical conductivity (EC µs/cm)	1976.7±6.11^{a}	1977.0±8.0^{a}	Ns
Total Alkalinity ppm/L^{-1}	161.3±1.53^{a}	162.7±3.79^{a}	Ns
Total hardness ppm/L^{-1}	315.0±2.65^{a}	316.3±22.86^{a}	Ns
Total Dissolved Solid (TDS ppm/L^{-1})	101.7±0.58^{a}	109.0±8.54^{a}	Ns

Means with similar superscripts in a row are statistically insignificantly different (p>0.05); Values are mean ± standard division for the three replicates.

Table 2. Shows the Effect of fish species (*O. niloticus* and *C. gariepinus*) reared in concrete ponds on physio-chemical of water quality parameters (temperature, DO, NH_4, NH_3, NO_3, NO_2, Electrical conductivity µs/cm, Total Alkalinity, Total hardness and Total Dissolved Solid) There was no significant difference (p>0.05) in all parameters monitored and measured at the throughput of the growth study.

Table 3: Effect of mono and polyculture system on physio-chemical water quality of *O. niloticus and C. gariepinus* reared in concrete ponds (means ± SD)

Treatments Parameter	1T:0C (N=12)	0T:1C (N=12)	1T:1C (N=12:12)	2T:1C (N=24:1)	3T:1C (N=36:12)	1T:2C (N=12:24)	1T:3C (N=12:36)	Sg.
Temp. ^{o}c	24.50±0.2^{a}	24.47±0.4^{a}	24.77±0.2^{a}	24.60±0.2^{a}	24.50±0.3^{a}	24.50±0.2^{a}	24.37±0.4^{a}	NS
DO2 mg/L^{-1}	3.87±0.1^{a}	3.77±0.1^{a}	3.70±0.2^{a}	3.80±0.1^{a}	3.60±0.3^{a}	3.70±0.2^{a}	3.47±0.1^{b}	*
PH	7.4±0.15^{b}	7.6±0.15^{a}	7.4±0.35^{b}	7.5±0.06^{b}	7.3±0.06^{b}	7.3±0.15^{b}	7.3±0.12^{b}	*
NH_4 mg/L^{-1}	0.22±0.02^{c}	0.27±0.02^{b}	0.26±0.02^{b}	0.26±0.01^{b}	0.35±0.02^{a}	0.28±0.01^{b}	0.29±0.02^{b}	**
NH_3 mg/L^{-1}	0.01±0.0^{a}	0.01±0.0^{a}	0.01±0.0^{a}	0.02±0.0^{a}	0.01±0.0^{a}	0.02±0.0^{a}	0.02±0.0^{a}	NS
NO_2 mg/L^{-1}	0.01±0.0^{a}	0.02±0.0^{a}	0.02±0.0^{a}	0.04±0.0^{a}	0.02±0.0^{a}	0.02±0.0^{a}	0.02±0.0^{a}	NS
NO_3 mg/L^{-1}	2.67±0.5^{b}	2.57±0.3^{b}	2.33±0.2^{b}	3.13±0.7^{a}	2.83±0.4^{b}	3.03±0.6^{b}	2.80±0.3^{b}	*
Salinity ppt	1.06±0.0^{a}	1.05±0.0^{a}	1.05±0.0^{a}	1.05±0.0^{a}	1.05±0.0^{a}	1.05±0.0^{a}	1.05±0.0^{a}	NS
EC µs/cm	1976.67 ±6.1^{a}	1977.00 ±8.0^{a}	1982.33 ±3.1^{a}	1979.67 ±1.5^{a}	1979.00 ±2.7^{a}	1978.67 ±3.1^{a}	1976.67 ±2.1^{a}	NS
Total Alkalinity ppm	161.33±1.5^{a}	162.67±3.8^{a}	162.33±3.2^{a}	162.00±1.7^{a}	161.00±2.7^{a}	161.67±2.1^{a}	159.00±2.7^{a}	NS
Total hardness ppm	315.00 ±2.7^{a}	316.33 ±22.9^{a}	318.67 ±8.4^{a}	321.33 ±3.2^{a}	318.00 ±17.6^{a}	322.00 ±4.6^{a}	323.00 ±4.0^{a}	NS
TDS ppm	101.67±0.6^{b}	109.00±8.5^{b}	116.00±13.0^{b}	118.67±5.5^{a}	124.00±7.0^{a}	113.00±11.0^{b}	122.33±8.5^{a}	*

Temp, temperature., DO2, Dissolved Oxygen., NH4- N, Ammonal Nitrogen., NH3 – N, Ammonia., NO3-N, Nitrate., NO2 –N, Nitrite., Electrical conductivity µs/cm., TA, Total Alkalinity ppm, THN, Total hardness ppm and TDS, Total Dissolved Solid ppm. Means with similar superscripts in a row are statistically insignificantly different (p>0.05); those with different superscripts are statistically significantly different (p>0.05).

It's apparent from Table 3.3. That: The analysis of variance of the water of polyculture system showed there was no significance differences (p>0.05) was optioned in temperature, nitrite, salinity, electrical conductivity, alkalinity, hardness and total dissolved solid between the seven polyculture systems, While the result showed differences in dissolved oxygen, pH and nitrate was significantly (p<0.05); and extremely highly significantly different (p<0.01) in total ammonia

Table 4: Effect of stocking densities on physio-chemical of water quality of *O. niloticus and C. gariepinus* reared in concrete ponds (means ± SD)

Parameters	12	24	36	48	Sg.
Temp. ^{o}c	24.48±0.3^{a}	24.77±0.2^{a}	24.55±0.2^{a}	24.43±0.3^{a}	Ns
DO2 mg /L^{-1}	3.82±0.1^{a}	3.70±0.02^{ab}	3.75±0.2^{a}	3.53±0.2^{b}	*
PH	7.47±0.2^{a}	7.43±0.4^{a}	7.38±0.2^{a}	7.25±0.1^{a}	Ns
NH_4 mg /L^{-1}	0.25±0.03^{b}	0.26±0.02^{b}	0.27±0.02^{b}	0.32±0.04^{a}	*
NH_3 mg /L^{-1}	0.01±0.01^{a}	0.01±0.00^{a}	0.02±0.01^{a}	0.01±0.01^{a}	Ns
NO_2 mg /L^{-1}	0.01±0.00^{a}	0.02±0.00^{a}	0.03±0.03^{a}	0.02±0.01^{a}	Ns
NO_3 mg /L^{-1}	2.33±0.23^{b}	3.08±0.56^{a}	2.82±0.31^{b}	2.77±0.46^{b}	*
Salinity ppt	1.05±0.03^{a}	1.05±0.0--4^{a}	1.05±0.02^{a}	1.05±0.01^{a}	Ns
EC µs/cm	1976.83±6.37^{a}	1982.33±3.06^{a}	1979.17±2.23^{a}	1977.83±2.48^{a}	Ns
TA ppm	162.00±2.68^{a}	162.33±3.22^{a}	161.83±1.72^{a}	160.00±2.61^{a}	Ns
THN ppm	315.67±14.57^{a}	318.67±8.39^{a}	321.67±3.56^{a}	320.50±11.73^{a}	Ns
TDS ppm	105.33±6.7^{b}	116.00±13.0^{ab}	115.83±8.4^{a}	123.17±7.0^{a}	*

Temp, temperature., DO, Dissolved Oxygen., NH4- N, Ammonical Nitrogen., NH3 – N, Ammonia., NO3-N, Nitrate., NO2 –N, Nitrite., Electrical conductivity µs/cm., TA, Total Alkalinity ppm, THN, Total hardness ppm and TDS, Total Dissolved Solid ppm. Means with similar superscripts in a row are statistically insignificantly different (p>0.05).

Table 3.4. Shows summary of the effect of stocking density on physio-chemical of water quality of *Oreochromis niloticus* and *Clarias gariepinus* reared in concrete ponds showed; there was no significance differences ($p>0.05$) was optioned in temperature, pH, ammonia, Nitrite, salinity, electrical conductivity, alkalinity and hardness between the seven polyculture systems, While the result showed differences in dissolved oxygen, total ammonia, nitrate and total dissolved solid was significantly ($p<0.05$).

Discussion

Water is the source of life for fish and has certain requirements. In the aquaculture business, water quality must be monitored properly. Each parameter is important to be managed and monitored because it can affect the growth rate and fish health. Data of the experiment of physio-chemical water quality for mono and polyculture treatments at different stocking density in tables (2, 3 and 4) revealed that table 2 (effect of fish species) gave no significantly different ($p>0.05$) in all parameters result whereas table 3 and 4 (effect of treatments and different stocking density) gave not significantly different ($p>0.05$) in temperature, pH, ammonia, Nitrite, salinity, electrical conductivity, alkalinity and hardness between the polyculture systems, While the result showed differences in dissolved oxygen, total ammonia, nitrate and total dissolved solid was significantly ($p<0.05$); The water quality parameters were within desirable range for survival and growth of fishes suggested by Haylor (1992) [14], who recommended that temperatures of 25°-30°C was adequate for freshwater fish rearing. Temperature one of the most important external factors which influence fish production. It has considerable influence on vial activities of fish such as breathing, feeding, growth and reproduction. The results of treatments of present study for monoculture, polyculture and different stocking density has shown a temperature monitored and recorded a proximately similar value 24.60 oc within the range of (NAER, 1996) [15] reported that the temperature range between 23 to 32 oc is very suitable for fish culture in freshwater and brackish water. The experiment was current out in winter season therefore; the results of temperature has shown values less than level suggested of Bhatnagar *et al* (2004) [16]., and Delince (1992) [17] 30-35 0C is tolerable to fish, suggested the levels of temperature as 28-32 0C good for tropical major carps; < 20 0C – sub lethal for growth and survival for fishes and > 35 0C- lethal to maximum number of fish species. On the other hand, the results of present study agree with Santhosh and Singh (2007) [18] suggested suitable water temperature for carp culture is between 24 and 30 0C. The results of Dissolved Oxygen (DO mg /L-1) of present study ranged from 3.47 to 3.90, the result of this study within the range of Banerjea (1967) [19] who reported DO between 3.0-5.0 ppm in ponds is unproductive and for average or good production it should be above 5.0 ppm. Also the present results agrees with Tropical fishes have more tolerance to low DO than temperate fishes Bhatnagar and Singh (2010) [20] and Bhatnagar *et al*. (2004) [16] DO level >5ppm is essential to support good fish production. Bhatnagar *et al*. (2004) [16] also suggested that 1-3 ppm has sub lethal effect on growth and feed utilization; 0.3-0.8 ppm is lethal to fishes and >14 ppm is lethal to fish fry, and gas bubble disease may occur. DO less than 1- Death of Fish, Less than 5 -Fish survive but grow slowly and will be sluggish, 5 and above- Desirable. The results of this study similar to Santhosh and Singh (2007) [18] Catfishes and other air breathing fishes can survive in low oxygen concentration of 4 mg L-1. Ekubo and Abowei (2011) [21] recommended that fish can die if exposed to less than 0.3 mg L-1 of DO for a long period, minimum concentration of 1.0 mg L-1 DO is essential to sustain fish for long period and 5.0 mg L-1 are adequate in fishponds. The results of present study renege 0.01- 0.02 within the acceptable range of Ammonia (NH3) between 0.6 and mg L-1 for pond fish, and sub lethal effects may occur at 0.1 to 0.3 mg L-1 (EIFAC, 1973 [22]; Robinette, 1976) [23]. Maximum limit of ammonia concentration for aquatic organisms is 0.1 mg L-1 (Meade, 1985 [24]; Santhosh and Singh, 2007) [18], Swann (1997) [25] and OATA (2008) [26], the levels below 0.02 ppm were considered safe. Stone and Thomforde (2004) [27] stated the desirable range as Total NH3 N: 0-2 mg L-1 and Un-ionized NH3-N: 0 mg L-1 and acceptable range as Total NH3-N: Less than 4 mg L-1 and Un-ionized NH3 N: Less than 0.4 mg L-1. Bhatnagar *et al*. (2004) [16] suggested >0.4 ppm is lethal to many fishes & prawn species. Bhatnagar and Singh (2010) [20] recommended the level of ammonia (<0.2 mg L-1) suitable for pond fish culture. This result renege between 2.33-3.13 mg L^{-1} of Nitrate (NO3) agreed with Meck (1996) [28] reported that its concentrations from 0 to 200 ppm are acceptable in a fish pond and is generally low toxic for some species whereas especially the marine species are sensitive to its presence. The result of nitrite renege from 0.01-0.02 mg L^{-1} with similar to Stone and Thomforde (2004) [27] they mention nitrite is relatively nontoxic to fish and not cause any health hazard except at exceedingly high levels (above 90 mg L^{-1}). Also, the results of study agrees with Santhosh and Singh (2007) [18] described the favourable range of 0.1 mg L^{-1} to 4.0 mg L^{-1} in fish culture water. However, OATA (2008) [26] recommends that nitrate levels in marine systems never exceed 100 mg L^{-1}. The present study results 1.05 ppt showed that salinity not influenced the water quality of Nile tilapia *O. niloticus* and Catfish *C. gariepinus* under mono, polyculture systems and different stocking density. According to the current experimental data of water quality parameters were within the desirable limits to tropical fish culture (Setiadi *et al*., 2018) [29]. Freshwater fish generally thrive over a wide range of electrical conductivity. Some minimum salt content is desirable to help fish maintain their osmotic balance. The current study value of electrical conductivity 1976 - 1982 µs/cm (tables 2, 3 and 4). Was in desirable range 100 - 2,000 mSiemens/cm consonance with what is recorded by Nathan M. Stone and Hugh K. Thomforde (2020) [30]. The results of the present study gave the range of total alkalinity ranged 37 to 57ppm this result within the range of Moyle (1964) [31] who reported the total alkalinity as 0.0 - 20.0 ppm for low production, 20.0-ppm low to medium, 40.0 - 90.0 ppm medium to high production and above 90.0 ppm productive. Boyd and Lichtkoppler (1979) [32] suggested that water with total alkalinities of 20 to 150 mg L^{-1} contain suitable quantities of carbon dioxide to permit plankton production for fish culture. The results renege between 159.0-162.7 of the current study agree with Wurts and Durborow (1992) [33] they reported the optimal alkalinity between 75 to 200 mg L^{-1}, and not less than 20 mg L^{-1}. The hardness resulted 312 ppm of present study within range of 30-300 mg L-1and, the recommended ideal value of hardness for fish culture is at least 20 ppm (Santhosh and Singh, 2007) [21], and Bhatnagar *et al*. (2004) [16] and Stone and Thomforde (2004) [28] they also pointed out that the desirable Range is 50-150 mg L-1 as CaCO3 and acceptable Range is above 10 mg L-1 as CaCO3. However, some euryhaline species may have high tolerance limits to hardness. The present study values of total dissolved solids of various in mono, polyculture systems and different stocking density was found to be is 101-124 ppm (tables 2, 3 and 4). This value is greater than the standard value of 0.13 mg/l recommended by Davis (1993) [34]. This implies the ground water should first be treated to the acceptable range it could be used as a source of water for fish farming, therefor the high TDS to effect on growth of fish cultured.

Conclusion

The study concluded that: There are precautions and guidelines related to the elements of the quality of the aquaculture water (temperature, Dissolved Oxygen, Ammonia, Nitrate, Nitrite, Electrical conductivity, Total Alkalinity, Total hardness, Total Dissolved Solid. … etc.) if taken according to optimum limits will not only raise productivity and economic benefits but will also help the farmers in maintaining eco-friendly ponds environment required for sustainable fish culture / aquaculture. Therefore, the results of current study significant affected of stocking density, monoculture and polyculture on water quality.

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