WATER QUALITY AND ITS IMPACT ON PRODUCTIVITY OF CULTURED OREOCHROMIS NILOTICUS

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ABSTRACT

The physical, chemical and bacteriological parameters of ponds water were studied in order to optimize the conditions of fish productivity. Four fish ponds in Abbassa farm supplied from agriculture drainage water; were used. Water and fish samples were collected equally from the hatchery, fingerlings and two raising ponds each pond over a period of twenty months. fish samples were examined for their bacterial content, growth and survival rates Results indicates that raising P2 had the highest average values of NH_3-N, NO_2-N, Total coliform (TC), Fecal coliform (FC), faecal streptococci (FS) & Salmonella species were 0.27 ± 0.024,0.99 ± 0.12,27.7 ± 1.9,14.0 ±1.8,31.0 ± 2.4 & positive resp., followed by pond (I) were 0.173±0.012,0.084 ± 0.008, 20.6 ±1.6 , 10.8 ± 24.0 ± 2.8 & positive respectively compared with the lowest values estimated in the hatchery were 0.084 ± 0.007, 0.068 ±, 9.6 ±1.0, 4.1 ± 0.6 ,4.0 ± 0.7 & ND resp.. Correspondingly, fish samples from P2 had the highest percentages of TC, FC, FS and Salmonella species were 37.6 ± 4.2, 15.6 ± 2.0, 5.7± 0.5 & 3.62 ± 0.28 resp., followed by pond (I) were 26.7 ± 1.7, 10.6 ± 0.9, 6.8 ± 1.1, 2.02 ± 0.4 resp., This explain that impairing of physical-chemical of P2 followed by P1 provide optimal conditions for multiplication and survival of coliform and Salmonella spp., in both pond's water and fishes. Moreover, growth rate; body weight gain & survival rates were higher in P1 32.88 ± 4.2g & 96.0 ± 1.7% as compared with P2; 27.60 ± 3.0g & 93.0 ± 1.2%. Therefore, fish productivity can be enhanced if the water quality in the ponds were maintained at optimum levels. On the other hard, the public health significance of Salmonella in fish as well as the potential environmental health impact of pond water with exceedingly high coliform counts released to water sources cannot be ignored.

INTRODUCTION

Aquaculture has been vigorously developed in recent years to achieve two major purposes of food security and income generation; the vast majority of this is conducted in ponds **(Okonji and Akolisa, 2005)**. The total Egyptian fish production reached about 960 thousand tons in 2006, of which more than 61 % was from aquaculture, **(GAFRD, 2007)**. Tilapia is the most popular fish in Egypt for their favorable characteristics and production **(Yang et al., 2003)**. Good fish management begins with an understanding of the physical, chemical and biological characteristics of the ponds. These characteristics determine the quality of fish the ponds can produce and the problems that may be encountered **(Ntengwe and Edema, 2008)**. Water quality parameters such as ammonia and nitrite in ponds may affect the level of bacterial contamination of fish, **(Saeed and Sakr, 2009)**; this is probably due to the effect of water quality on the fish immune response, so profitable fishing can result from proper management of fish and ponds. The type and level of bacterial populations associated with farmed fish are useful indicators of quality and safety of fish for consumers, of much concern in ponds is the contamination of fishes by fecal coliform, **(Kapetanovic et al., 2005)**, and their presence in fish may cause a potential danger for human health **(Jha, et al., 2008)**. Therefore, the aim of the present study was to establish the levels of physico-chemical and biological characteristics of the ponds with a view for optimizing the conditions of water for optimum fish productivity.

MATERIAL AND METHODS

1. Study Site :

This field study was carried out during the period from April 2008 till December 2009 at the central laboratory for aquaculture research, El- Abbassa, Sharkia governorate, Egypt. It conducted on different production units belonged to the farm besides their water supply including:

1-The hatchery: it consists of circular tanks with average size 8 m3 for each, made from fiberglass and supplied with agricultural drainage water after filtration. The fry of Oreochromis niloticus were reared in the hatchery for one week and fed on pelleted ration contained 40% protein.

2- Fingerlings earthen pond of average size 50 x 40 m^2 were stocked with at a rate of 50,000 /feddan and reared for 40 day; fed on pelleted ration contained 40% protein. Water losses were replaced by agricultural water every 2-3 weeks interval. The average final weight of fingerlings was 7.6 ± 1.3 g.

3- Raising ponds (P1 & P2): Two rectangular shaped earthen ponds with different size; the first pond (P1) 170 x 50 m^2 with average stocking density 4 fish/ m2. Meanwhile, the second pond (P2) was 180 x 70 m^2 with stocking density 6 fish/ m^2. Fish in raising ponds were fed on a pelleted ration contain crude protein 25%. Superphosphate, urea and chicken manure were added as a fertilizer. Water losses from ponds were replaced from the water supply every 2-3 weeks. Plankton and weeds were pronounced in P2 than P1.

2. Sampling Program:

Three hundred water samples were collected from both water source & ponds besides 360 fish samples from each production units throughout the production period.

2.1. Sampling of Water :

Water samples were collected bi-weekly in sterilized glass bottles (250 ml) from three locations for each pond at a fixed hour of the day (9.0 hour) as described earlier by **Boyd, (1998)**. Results were averaged monthly.

2.1 A. Physico-chemical analyses of water samples

Routine water quality parameters for temperature, turbidity, DO, pH, NH_3-N, NO_2-N, NO_3-N, Alkalinity and some heavy metals (lead & cadmium) were estimated according to methods as described by APHA (1998). Temperature was recorded using a mercury thermometer. Turbidity (cm) was measured using a secchi disc according to **Boyd (1998)**. The pH was measured in situ using a portable pH meter (Hanna Instruments) The dissolved oxygen (DO) was determined using the YSI DO meter, NH_3-N, NO_2-N, NO_3-N and total alkalinity were estimated using commercial kits, while Pb & Cd were measured using atomic absorption spectrophotometer (thermo 6600, thermo electron corporation, Cambridge, UK).

2. 1. B. Bacteriological analysis of water samples :

Water samples were subjected for determination of total coliform, faecal coliform, faecal streptococci and Salmonella according to the protocol provided in standard method for the examination of water and waste water analysis by APHA (1998). Total coliform, faecal coliform and faecal streptococci were detected using three tubes method (MPN), as recommended by AOAC (1999). While Salmonella isolation according to **Harrigan (1998)**.

2.2. Sampling of Fish :

A cast net used to collect fish samples from the various ponds. Five live tilapia (Oreochromis niloticus) were randomly selected from the catch at each sampling time as method described by AOAC (1999). The fish were placed in labeled sterile polypropylene bags containing water from the pond and transported to the laboratory.

2.2. A. Determination of Lead and Cadmium level in Fish Samples :

Lead (Pb) and cadmium (Cd) were measured in the fish muscle samples according to the method of AOAC (1999), using atomic absorption spectrophotometer (Thermo 6600, thermo electron corporation, Cambridge, UK).

2.2. B. Bacteriological Examination of Fish Samples :

Fish surface swabs were used for total bacterial count, total coliform and faecal coliform and Salmonella spp. measurement according to the protocol provided by (A.P.H.A 1998).

2.2. C. Fish Performance :

The fish samples were weighted every month throughout the production period to calculate the following parameters:-

i. Body weight gain: Weight gain % = 100 [final weight (g) - initial weight (g)/initial weight (g)], according to **Likongwe et al. (1996)**.
ii. Specific growth rate (SGR): SGR = 100 [final weight (g) - initial weight (g) /t]; where (t) is the culture period in days, according to **Jha et al. (2008)**.
iii. Survival rate of examined fish: Survival % = (Nf / Ni) x 100. Where Nf and Ni are the number of fish harvested and stocked respectively, according to **Hargreaves and Semra (2001)**.

4. Statistical Analyses :

The data obtained were subjected to statistical analysis using One Way ANOVA test and bivariate correlations in SPSS V.17 for Windows Sp3 software in order to determine the significance of the results.

RESULTS & DISCUSSION

The average values of physico-chemical parameters and bacterial findings of water inlet as shown in Table (1); revealed that physicochemical values were within the acceptable ranges for fish culturing except for water turbidity and ammonia content (NH_3-N) showed a significant increase ($P< 0.05$) 9.8±0.4 cm and 0.158±0.06 mg/l, respectively. On the other hand, water supply showed the least contents of TC, FC and FS counts (MPN/100 mL) were 9.6±1.0, 4.1±0.6 and 4.0±0.7 respectively with no detection for Salmonella spp.. This finding was further supported by **Okonji and Akolisa (2005), Frei et al. (2006) and Bhatnagar and Singh (2010).**

Concerning to the mean values of physicochemical parameters of water collected from examined ponds Table (2), it noticed that no significant differences in the mean values of water temperature and pH meanwhile, dissolved oxygen (DO) contents showed a significant decrease ($P< 0.05$) in P2 was 5.8±0.02 mg/l followed by P1 and fingerlings pond were 6.2±0.14 and 6.3±0.12 mg/l respectively. On the other hand, water turbidity showed a significant increase ($P< 0.05$) in raising ponds; P2 and P1 were 9.1±0.6 and 9.6±0.6 cm, respectively compared with hatchery 19.3±1.3 cm. Corrpondingly, P2 had the highest content of NH_3-N and NO_2-N were 0.277±0.024 and 0.99±0.12 mg/l followed by P1 were 0.173±0.012 and 0.084±0.008 mg/l, respectively. Whereas, the highest NO_3-N content and total alkalinity were recorded in fingerlings pond were 1.88±0.2 mg/l and 275.8±8.5mg/l respectively, followed by raising ponds compared with hatchery. This finding was further supported by **Okonji and Akolisa (2005), Frei et al. (2006), Hossain et al. (2008) and Bhatnagar and Singh (2010).**

Regarding to microbiological findings of water samples as shown in Table (3), the mean values of total coliform, faecal coliform, faecal streptococci and Salmonella spp. presence in examined ponds indicated that, the hatchery showed the lowest values of estimated parameters compared with those in P2 which showed the highest values ($P< 0.05$) of TC, FC and FS were 27.7±1.9, 14.0±1.8 and 31.0±2.4 MPN/100ml respectively, followed by P1 were 20.6±1.6, 10.8±1.5 and 24.0±2.8 MPN/100ml respectively, then fingerlings pond were 13.8±2.6, 9.0±1.2 and 13.0±1.5 MPN/100ml, respectively. Salmonella spp. were detected in P2, P1 and fingerlings pond while, not detected in water from hatchery. It revealed impairment of water quality in fish ponds which exaggerated by excessive organic matter (high ammonia, nitrite and nitrate) as supported by **Markosova and Jezek (1994)** who observed that presence of organic matter (ammonia, nitrite and nitrate) in pond's water always increase the risk of bacterial growth. This results are in accordance with that obtained by **Al-Harbi and uddin (2003), Newaj-Fyzul et al. (2006) and Harnisza and Tucholskib (2010).**

The results of the quantitative estimation of bacterial level of fish samples Table (4) showed that the highest averages of bacterial counts, total coliforms and Salmonella spp. (cfu/ml) of examined fishes were in raising ponds; P2 were 37.6±4.2, 15.6±2.0 and

3.62±0.28 respectively, followed by P1were 26.2±1.7, 10.6±0.9 and 2.02±0.4, respectively meanwhile, the lowest content detected in fingerlings pond were 3.8±0.3, 2.8±0.2 and 1.07±0.2 respectively, then the hatchery were 2.4±0.4, 1.6±0.2 and ND respectively. On the other hand, faecal coliforms was significantly increase ($P< 0.05$) in P1 followed by P2 and fingerlings pond were 6.8±1.1, 5.7±0.5 and 1.1±0.17 respectively, while not detected in hatchery. It's obviously means positive correlation between microbial parameters of pond water and fish samples. Besides, poor water quality in raising ponds which act as stress factor lead to increase susceptibility of fish to infections as well as stimulate the multiplication and survival of bacteria, as supported by **Uddin et al. (1990), Guzman et al. (2004) and Onyango et al. (2009)**.

The average of body weight gain and survival rates of fishes in raising ponds throughout the production period Table (5) obvious that a significant increase ($P< 0.05$) in all examined parameters; final body weight, body weight gain, daily weight gain and survival rate in P1 were 244.5±3.5 g, 32.88±4.2%, 0.87±0.02 g and 96.0±1.7% respectively, compared with P2 were 218.0±8.0 g, 27.60±3.0%, 0.77±0.05 g and 93.0±1.2%, respectively. These variations clarified the impact of physical, chemical and bacterial quality of water in both examined ponds on fish performance. These results are in parallel to that obtained by **Mohamoud et al. (2002), Newaj-Fyzul et al. (2006), Jha el al. (2008) and Bhatnagar and Singh (2010)** who reported that higher weight gain and survival rate of fish could be attributed to better water quality.

Table (6) discussed the correlations between water quality and bacterial content of water in P2 showed that, water temperature significantly correlated with NO_2-N and NO_3-N contents while, negatively with turbidity and DO content. On the other hand, DO level was negatively correlated with NH_3-N, NO_2-N and NO_3-N, as increase of these parameters depend mainly on biological oxygen demand. Similar results obtained by **Tomasso (1994), Takeuchi et al. (1998), Chaurasia and Pandey (2007) and Mahmoud et al. (2009).** Moreover, water turbidity, NH_3-N and alkalinity were significantly positive correlated with TC, FC and FS. Meanwhile, DO was negatively correlated with them. These results are supported by **El-Shafai et al. (2004), Abo-Elela et al. (2005) and Hossain et al. (2008)** who indicated that distribution of the different bacterial population was affected with one or more chemical parameters of pond's water such as alkalinity, ammonia, nitrates.

Table (1): Mean ±SE of physico-chemical parameters and bacterial findings of samples from the water inlet.

Examined parameters / Water inlet	Mean
Physico-chemical parameters (mg/l): Temp. (C^0)	25.06 ±0.5
Turbidity (cm)	9.8±0.4 **
pH	8.25±0.1
Dissolved oxygen (DO)	7.03±0.18
Ammonia (NH_3- N)	0.158±0.06**
Nitrite (NO_2- N)	0.061±0.007
Nitrate (NO_3- N)	0.069±0.008
Total alkalinity	236.0±7.2
Bacterial findings (MPN/100ml): Total Coliform (TC)	9.6±1.0
Faecal coliform (FC)	4.1±0.6
Faecal Streptococci (FS)	4.0±0.7
Salmonella Spp	N D

** Superscript indicate a significant difference at P < 0.05 ND: Not Detected

Table (2): Mean ±SE of physico-chemical parameters of pond's water samples throughout the study period.

parameters (mg/L) / Water	Hatchery	Fingerlings Pond	P1	P2
Temp. (C^0)	25.6±0.5	26.2±0.5	26.3±0.6	25.9±0.5
Turbidity (cm)	19.3±1.3 ^{c}	9.9±0.6 ^{b}	9.6±0.6 ^{b}	9.1±0.6 ^{a}
pH	8.3±0.1	8.4±0.06	8.4±0.1	8.5±0.07
Dissolved oxygen (DO)	6.8±0.16 ^{a}	6.3±0.12 ^{b}	6.2±0.14 ^{b}	5.8±0.02 ^{c}
Ammonia (NH_3- N)	0.084±0.007 ^{c}	0.145±0.014 ^{b}	0.173±0.012 ^{ab}	0.277±0.024 ^{a}
Nitrite (NO_2- N)	0.068±0.007 ^{c}	0.081±0.009 ^{b}	0.084±0.008 ^{b}	0.99±0.12 ^{a}
Nitrate (NO_3- N)	0.081±0.009 ^{b}	1.88±0.2 ^{a}	1.19±0.6 ^{ab}	1.2±0.06 ^{ab}
Total alkalinity	244.7±7.0 ^{c}	275.8±8.5 ^{a}	268.5±8.4 ^{b}	252.3±6.5 ^{bc}

Means having the different letter are indicate a significant difference at P < 0.05

Table (3): Mean ±SE of bacterial findings of pond's water samples throughout the study period.

Water / Bacterial Findings (MPN /100ml)	Hatchery	Fingerlings Pond	P1	P2
Total Coliform (TC)	9.6±1.0 c	13.8±2.6 b	20.6±1.6 ab	27.7±1.9 a
Faecal coliform (FC)	4.1±0.6 c	9.0±1.2 bc	10.8±1.5 b	14.0±1.8 a
Faecal Streptococci (FS)	4.0±0.7 c	13.0±1.5 b	24.0±2.8 a	31.0±2.4 a
Salmonella Spp.	ND	+ve	+ve	+ve

Means having the different letter are indicate a significant difference at $P < 0.05$ ND: Not Detected

Table (4): Mean±SE of bacterial findings of fish samples throughout the study period.

Fish collected from / Bacterial findings	Hatchery	Fingerlings Pond	P1	P2
Total Bacterial Count (TBCx10^3)	2.4±0.4 c	3.8±0.3 c	26.2±1.7 b	37.6±4.2 a
Total Coliform (TC) (MPN/100ml)	1.6±0.2 c	2.8±0.2 c	10.6±0.9 b	15.6±2.0 a
Faecal coliform (FC) (MPN/100ml)	ND	1.1±0.17c	6.8±1.1 a	5.7±0.5 b
SalmonellaSpp.(cfu/ml)	ND	1.07±0.2 c	2.02±0.4 b	3.62±0.28 a

Means having the different letter are indicate a significant difference at $P < 0.05$
ND: Not Detected

Table (5): Mean±SE of growth rate and survival rate (%) of fish in raising ponds (P1 and P2)

Raising ponds / Fish performancs	P1	P2
Initial body weight(g)	7.6±1.3	7.6±2.0
Final body weight(g)	244.5±3.5 a	218.0±8.0 b
Daily weight gain(g)	0.87±0.02 a	0.77±0.05 b
Body weight gain (%)	32.88±4.2 a	27.60±3.0 b
Survival rate (%)	96.0±1.7 a	93.0±1.2 b

Means having the different letter are indicate a significant difference at $P < 0.05$

Table (6): Correlations between physico-chemical and bacterial parameters of water in pond (2).

Water parameters	Temp.	Turbidity	pH	DO	NH_3-N	NO_2-N	NO_3-N	Alkalinity
Temp.	1							
Turbidity	0.688**	1						
pH	0.362	-0.139	1					
DO	-0.250	-0.228	-0.171	1				
NH_3-N	0.315	0.296	0.327	-0.821**	1			
NO_2-N	0.647**	-0.141	0.554*	-0.519*	0.674**	1		
NO_3-N	0.529*	0.022	0.735**	-0.502*	0.727**	0.844**	1	
Alkalinity	-0.041	0.204	0.048	-0.569*	0.372	0.134	0.147	1
TC	-0.414	0.700**	-0.126	-0.508*	0.522*	-0.018	0.028	0.534*
FC	-0.207	0.636**	-0.010	-0.518*	0.659**	0.203	0.239	0.494*
FS	-0.358	0.676**	-0.049	-0.610**	0.620**	0.101	0.161	0.680**

**. Correlation is significant at the 0.01 level

*. Correlation is significant at the 0.05 level

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الملخص العربى

النوعية الصحية للمياه وتأثيرها على إنتاجية أسماك البلطي المستزرعة

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أجريت هذه الدراسة الحقلية فى الفترة مابين أبريل ٢٠٠٨ حتى نهاية ديسمبر ٢٠٠٩ بمركز بحوث الثروة السمكية بالعباسية التابعة لمحافظة الشرقية بهدف التعرف على بعض أنواع المياه المستخدمة فى المزارع السمكية وتأثيرها على معدلات النمو والإنتاج عن طريق تقدير بعض الخواص الفيزيائية والكيميائية والبكتيرية للمياه المستخدمة من جهة وتقدير معدلات النمو والبقاء فى الأسماك المستزرعة من جهة وتقدير معدلات النمو والبقاء فى الأسماك المستزرعة من جهة أخرى ولتحقيق الهدف من الدراسة تم تجميع عدد ٣٠٠ عينة مياه (مصدر المياه بالإضافة إلى المفرخ وأحواض الزريعة وأحواض التربية) لإجراء التحليل الفيزيائى الكيميائى والبكتيرى للمياه كما تم أخذ عدد ٣٦٠ عينة أسماك من مراحل الإنتاج المختلفة بالمزرعة طوال فترة الإنتاج حيث تم تقدير العدد الكلى لبكتريا وبكتريا الكوليفورم وكوليفورم البراز وميكروب السالمونيلا، وقد أوضحت النتائج أن حوض التربية ٢ سجل أعلى نتائج لكلا من الأمونيا والنيتريت وبكتريا الكوليفورم وكوليفورم البراز والميكروب السبحى البرازى وميكروب السالمونيلا وكانت ٠ر٢٧ ± ٠ر٠٢٤ و ٠ر٩٩ ± ٠ر١٢ و ٢٧ر٧ ± ١ر٩ و ١٤ر٠ ± ١ر٨ و ٣١ر٠ ± ٢ر٤ ونتيجة إيجابية لسالمونيلا على التوالى يليه حوض التربية ١ وكانت ٠ر٣٧١ ± ٠ر٢١٠ و ٠ر٨٤٠ ± ٠ر٠٠٨ و ٢٠ر٦ ± ١ر٦ و ١٠ر٨ ± ١ر٥ و ٢٤ر٠ ± ٢ر٨ ونتيجة إيجابية لسالمونيلا على التوالى مقارنة بالمفرخ الذى سجل أقل النتائج وكانت ٠ر٠٨٤ ± ٠ر٠٠٧ و ٠ر٠٦٨ ± ٠ر٠٠٧ و ١٠ر٧ ± ٠ر٩ و ٨ر٠ ± ٠ر٧ و ٧ر٠٥ ± ٠ر٨ ونتيجة سلبية لسالمونيلا على التوالى، وبالمثل عينات الأسماك المجمعة من حوض التربية ٢ سجلت أعلى القيم لكل من العد الكلى لبكتريا وبكتريا الكوليفورم وكوليفورم البراز وميكروب السالمونيلا وكانت ٣٧ر٦ ± ٤ر٢ و ١٥ر٦ ± ٢ر٠ و ٥ر٧ ± ٠ر٥ و ٣ر٦٢ ± ٠ر٢٨ على التوالى يليه حوض التربية ١ وكانت ٢٦ر٢ ± ١ر٧ و ١٠ر٦ ± ٠ر٩ و ٦ر٨ ± ١ر١ و ٢ر٢٠ ± ٠ر٤ على التوالى، هذه النتائج تفسر سوء الصفات الفيزيائية والكيميائية للمياه فى حوض التربية ٢ يليه حوض التربية ١ مما يساعد على نمو وتكاثر الميكروبات فى كلاً من المياه والأسماك المستزرعة ومن ثم انعكس ذلك على الكفاءة الإنتاجية للأسماك حيث سجلت أعلى القيم لمعدلات النمو والبقاء فى حوض التربية ١ و كانت ٢٣ر٨٨ ± ٤ر٢جم و ٦٩ر٠ ± ١ر٧٪ على التوالى مقارنة بحوض التربية ٢ وكانت ٢٧ر٦٠ ± ٣ر٠جم و ٩٣ر٠ ± ١ر٢٪ على التوالى، لذا أوضحت النتائج أنه يمكن تحسين إنتاجية الأسماك عن طريق المحافظة على النوعية الصحية للمياه وفقاً للمعدلات المثلى.