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ORIGINAL PAPER

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Assessment of the Water Quality of Four Fish Farms in Al-Qassim Region of Saudi Arabia

Abstract: Ground water quality of four fish farms (A, B, C and D) at different locations in Al-Qassim region was studied seasonally. The use of ground water in these fish farms was found to be suitable for fish culture except at farm D where the water temperature was very high (50.8°-57.1°C). The water is being stored initially in a fully aerated pond overnight and was observed to be suitable for tilapia culture. There was no significant seasonal difference in pH, hardness and salinity whereas NO_3-N, NO_2-N, NH_3-N and PO_4 showed higher values in winter. Water quality parameters such as pH, alkalinity, NO_3-N, NO_2-N, NH_3-N and PO_4 were recorded to be always higher in fish farm A than the other three farms. The growth rate of the fish in fish farm D decreased apparently because 50-60% of the fish were deformed.

Key words: Fish farm; water quality; ground water.

تقييم نوعية المياه في أربع مزارع سمكية في منطقة القصيم بالمملكة العربية السعودية

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المستخلص: تمت وعلى مدى عام كامل دراسة نوعية المياه الجوفية في أربع مزارع سمكية عُبّر عنها بالأحرف (A B C D) تقع في منطقة القصيم بالمملكة العربية السعودية بهدف تحديد صلاحيتها لتربية الأسماك . أثبتت النتائج أن نوعية هذه المياه مناسبة للاستزراع السمكي ماعدا مياه المزرعة (D) حيث وجد أن درجة حرارة هذه المياه تتراوح ما بين 50.8° - 57.1° مئوية، ولكن تبين انه بتخزين هذه المياه في أحواض مهواة لمدة (24ساعة) تصبح مناسبة لزراعة أسماك البلطي .أظهرت النتائج انه لا توجد فروق معنوية للأس الهيدروجيني والعسرة والملوحة خلال فترة الدراسة بينما كان هناك ارتفاع في (NO_3-N, NO_2-N, NH_3-N, PO_4) خلال فصل الشتاء .كما دلت النتائج ارتفاع تراكيز بعض عناصر نوعيه المياه مثل الأس الهيدروجيني و (NO_3-N, NO_2-N, NH_3-N, PO_4) في المزرعة (A) عن المزارع الأخرى . وقد بينت الدراسة أن معدل نمو الأسماك في المزرعة (D) منخفض مقارنه بنظيره في المزارع الأخرى وذلك نتيجة للتشوه الخلقي الذي تجلى في 50 – 60 % من أسماك المزرعة المذكورة .

كلمات مدخلية: مزارع سمكية، نوعية المياة، المياة الجوفية

Introduction

Land-based fish culture using tilapia in Saudi Arabia has received a considerable attention during recent years. The main reason for the success of tilapia farming is their ability to adapt easily even in lacustrine or in low quality of water (Payne, 1971). They can tolerate a very low dissolved oxygen (<1 mg/L) by gulping air from the surface (Stickney *et al.* 1977) and grow optimally at 30°C (Chimits, 1955). The fish is known to grow fast and the production is quite high with relatively low inputs.

Tilapia has also been reported to be able to adjust and grow vigorously on a wide variety of readily available food (Tudorancea *et al.* 1988). Because of the above features it can be cultured extensively and intensively for commercial purpose. Al-Qassim is an agricultural region, situated in the central province of Saudi Arabia and has many fish farms employing simple technology to sophisticated aquaculture practices. Concrete and fiberglass tanks of different size are generally used for tilapia culture but some farms also use earthen ponds, especially for fingerling production. Ground water is the main source for aquaculture in Saudi Arabia, the quality of which is quite different from one place to another (Al-Hinty and Siddiqui 1993). The basic goal of fish farming is growth and production (yield) and many factors are responsible to interact synergistically to stress fish or cause mortality affecting fish yield. Water quality parameters are one of the basic factors in fish culture which exert a major influence on growth and production.

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The people of Al-Qassim region in Saudi Arabia are mainly dependent on agriculture. Many new farmers initially embraced fish culture with high expectations, but on later abandoned them, due to lack of experience, training, proper planning and management.. They spent huge amounts of money in construction of tanks or ponds without monitoring the ground water that has to be used for fish culture. No reliable information is available on the effects of water quality and environmental conditions on growth and production of tilapia in this region. Realizing the paucity of such information, this project was undertaken to investigate the basic conditions necessary for the proper management of fish farms and to initiate and encourage the fish farmers. The main objective of this study is to ascertain the seasonal profile of water quality and its influence on growth and production of hybrid tilapia (*Oreochromis niloticus x O. aureus*) at different localities in Al-Qassim region.

Materials and Methods

Four fish farms, hereinafter called fish farms (A, B, C and D), in Al-Qassim region were selected. The study was carried out for one complete year between April 1996 and March 1997. Al-Qassim region is an agricultural area where farmers use ground water for the fish farming while the discharged water from the fish farms is used for irrigation of the crops. The names of the fish farms, location, facilities available, cultured species and the annual production values are given in Table 1(a). Information regarding the stocking rate of the fish, feeding rate and source, and water exchange are given in Table 1(b).

Water and fish samples from the culture tanks were collected biweekly between 0700 h to 0800 h from the fish farms without disturbing their culture systems. Whereas ground water samples were taken from the running water pump at monthly intervals.

Dissolved oxygen (DO) was measured by Winkler's modified method (APHA, 1992). Temperature and pH were recorded by a pH meter (HACH) and salinity with the help of a refractometer (A 366, ATC). NO_3-N, NO_2-N, NH_3-N and PO_4 were analyzed with the help of a spectrophotometer (HACH DR/2000), while alkalinity and hardness were measured by HACH titration cartridge and transparency was recorded by using a Secchi disc of 30 cm diameter.

Twenty-thirty fish were caught by cast net every month and the fish were measured to the nearest 0.1 cm, weighed up to 0.1 gm. Growth rate was calculated from the weight increment divided by the number of days.

Results

The results of ground water analysis of four fish farms are given in Table 2. Ground water was used directly to the fish culture ponds in all the farms except in fish farm D where ground water temperature was very high (50.8-57.1°C), here, the water was stored initially in a fully aerated cooling pond overnight to use it in the morning of the next day. Results of water analysis of the cooling pond of fish farm D are given in Table 3.

The results of the water quality, recorded in four fish farms in Al-Qassim region, are summarized in Table 4.

Dissolved oxygen content was higher in the fish farms C and D while it was relativily lower in the farms A and B. Values of pH, alkalinity, NO_3-N, NO_2-N, NH_3-N and PO_4 were higher in the water of the farm A as compared to the other farms. There were no significant seasonal differences in pH, hardness and total dissolved solids. However, small fluctuations were observed in the values of dissolved oxygen, alkalinity, nitrate and nitrite contents. Seasonal fluctuations in phosphate contents were observed only in fish farm A in the months of July and October of 1996. Total dissolved solids were higher in fish farm D from September onwards due to the use of new well water.

Significant differences were also observed in NO_2-N and NH_3-N contents during winter in the water of all the fish farms. The highest values of NH_3-N were recorded in fish farms A and D, while NO_2-N was observed to be higher in fish farms A and B.

Monthly mean length and mean weight of the fish samples from the four fish farms are recorded in Table 5 (a and b). The actual growth rates of the fish were difficult to calculate due to the continuous catching of large size fish to supply to the market, therefore, the values of the growth rate are not accurate. Based on 112 days study in fish farm B, 168 days in fish farm C and 140 days in fish farm D, the growth rates of fish were 0.95, 0.53 and 0.33 gm/day respectively (Table 6). The growth rate of fish farm A could not be deterrmined owing to some technical difficulties. The lowest growth rate was observed in fish farm D as 50-60% of fish were deformed.

The annual production of fish farms A, D and B were calculated to be 200, 45.66 and 14.4 tones/ha respectively (Table 6.) The production data of fish farm C was not available as the owner sold the farm.

Table 1 (a). Details of four selected fish farms in Al-Qassim region

Fish Farm	Location	Facilities	Culture species
A	20 kms. west from Buraydah city	Culture tanks = 32 units hexagonal (area= 120 m^2 each). 1 unit rectangular shape divided into different compartments using plastic netting attached to a steel frame (area = 6,160 m^2) Total watered area = 10,000 m^2 Water depth = 2 m Aeration = Paddle wheels Number of turbine pumps utilized = 2 units	Hybrid Tilapia (*Oreochromis niloticus* x *O. aureus*)
B	25 kms west from Buraydah city	Culture tanks = 6 units rectangular tanks (area 800 m^2 each) 12 units earthen rectangular tanks (total area = 13,945 m^2) Total watered area = 18, 745 m^2 Water depth = 1.5 m Aeration = Paddle wheels Number of turbine pumps utilized = 1 unit	Hybrid Tilapia (*Oreochromis niloticus* x *O. aureus*)
C	45 kms south from Buraydah city	Culture tanks = 7 units rectangular concrete tanks (area 150 m^2 each) Total watered area = 1050 m^2 Water depth = 1 m Aeration = air blower which operates at night only Number of turbine pumps utilized = 1 unit	Hybrid Tilapia (*Oreochromis niloticus* x *O. aureus*)
D	100 kms east from Buraydah city	Culture tanks = 10 units rectangular concrete tanks (total area 438 m^2) Total watered area = 438 m^2 Water depth = 1.5 m Aeration = Air blower Number of turbine pumps utilized = 3 units	Hybrid Tilapia (*Oreochromis niloticus* x *O. aureus)*

Table 1(b). Stocking rate, feeding rate and ground water exchange of four selected fish farms

Fish farm	Stocking rate	Feeding rate	Feeding source (s)	Water exchange
A	80 / m^2	2.5 - 3.0%	Silos	20% - 30% daily
B	30 / m^2	2%	Silos and Arasco	Twice a week (50% of the water volume)
C	20 / m^2	1.5%	Silos	20% daily
D	60 / m^2	3%	Prepared by own Co.	50% daily

Table 2. Water quality parameters of ground water of four selected fish farms in Al-Qassim region

	Fish farm A			Fish farm B			Fish farm C			Fish farm D		
Parameters	Mean	S. D.	Range	Mean	S. D.	Range	Mean	S. D.	Range	Mean	S. D.	Range
Water Temp. (^{o}C)	31.00	0.73	30.20–-32.00	28.30	0.10	28.20-28.40	27.80	0.83	27.00-28.50	53.95	3.58	50.80–57.10
Dissolved Oxygen (ppm)	2.25	0.64	1.50– 3.00	3.50	0.50	3.00-4.00	3.60	0.46	3.20-4.20	0.22	0.05	0.20– 0.30
pH	7.09	0.18	6.90– 7.32	6.90	0.15	6.80– 7.10	7.35	0.45	6.75– 7.86	6.90	0.05	6.90– 7.00
Alkalinity (ppm)	153.00	12.00	141.00-170.00	149.00	11.00	141.00-162.00	127.00	5.00	120.00-135.00	115.00	4.00	111.00-120.00
NO_3-N (ppm)	0.82	0.98	0.00-2.10	0.33	0.32	0.10- 0.70	00.00	00.00	00.00	1.60	0.52	1.20–2.40
NO_2-N (ppm)	0.001	00.00	0.001-0.003	0.001	00.00	0.001-0.002	00.00	00.00	00.00	0 003	00.00	0.003-0.005
NH_3-N (ppm)	0.08	0.08	0.01-0.16	0.05	0.06	0.01-0.13	0.03	0.03	0.00-0.08	0.09	0.03	0.04-0.12
PO_4 (ppm)	0.03	00.00	0.02–0.06	0.01	00.00	0.01–0.02	0.004	00.00	0.00-0.02	0.11	0.02	0.09-0.15
T D S (ppm)	537.00	73.00	480.00–640.00	726.00	64.00	680.00-800.00	1222.00	172.00	1080.00-1520.00	1120.00	215.00	900.00–1310.00
Hardness as Ca CO_3(ppm)	565.00	12.00	550.00– 580.00	666.00	57.00	600.00-700.00	750.00	70.00	700.00– 850.00	690.00	134.00	560.00–850.00
Salinity (ppt)	0.47	0.09	0.40– 0.60	0.50	0.10	0.40– 0.60	0.80	0.08	0.80– 1.00	0.82	0.09	0.70–0.90

Table 3. Water quality parameters of cooling pond of fish farm D

Parameters	Mean	S. D.	Range
Water Temp.(^{o}C)	30.00	0.35	29.70 - 30.40
Dissolved Oxygen (ppm)	3.00	0.34	2.80 - 3.40
pH	7.70	0.51	7.31 - 8.29
Alkalinity (ppm)	115.00	4.00	112.00 - 120.00
NO_3-N (ppm)	2.60	0.20	2.50 - 2.90
NO_2-N (ppm)	0.003	0.00	0.002 - 0.004
NH_3-N (ppm)	0.06	0.03	0.04 - 0.10
PO_4 (ppm)	0.11	0.00	0.11 - 0.12
TDS (ppm)	956.00	37.00	930.00 - 1000.00
Hardness as $CaCO_3$ (ppm)	733.00	57.00	700.00 - 800.00
Salinity (ppt)	1.80	0.76	1.00 - 2.50

Table 4. Water quality parameters of the fish culture tanks at four selected fish farms in Al-Qassim region

	Fish farm A			Fish farm B			Fish farm C			Fish farm D		
Parameters	Mean	S. D.	Range	Mean	S. D.	Range	Mean	S. D.	Range	Mean	S. D.	Range
Water Temp. (^{o}C)	23.10	3.40	17.00-27.80	22.60	3.90	14.00-28.00	21.80	4.17	13.60-26.80	27.24	2.43	23.60-31.00
Dissolved Oxygen (ppm)	3.70	1.10	2.00-6.30	3.50	1.20	1.80-7.00	5.84	2.20	1.20-11.40	4.20	1.30	2.30-7.00
pH	7.72	0.53	7.08-8.72	7.25	0.29	6.70-7.81	7.57	0.38	6.81-8.40	7.48	0.25	7.00-7.95
Alkalinity (ppm)	163.00	12.00	140.00-191.00	147.00	10.00	129.00-169.00	114.00	13.00	70.00-135.00	123.00	25.00	47.00-155.00
NO_3-N (ppm)	2.80	1.50	0.40-5.90	1.30	1.40	0.10-4.60	0.91	0.92	0.10-3.50	1.08	0.73	0.20-3.00
NO_2-N (ppm)	0.100	0.155	0.002-0.410	0.050	0.110	0.001-0.446	0.008	0.015	0.001-0.068	0.017	0.026	0.001-0.075
NH_3-N (ppm)	1.07	1.36	0.06-3.64	0.17	0.037	0.01-1.82	0.13	0.19	0.01-0.81	0.78	1.08	0.01-3.64
PO_4 (ppm)	1.58	0.63	0.38-3.00	0.09	0.08	0.01-3.69	0.14	0.19	0.01-0.24	0.14	0.03	0.11-0.25
T D S (ppm)	540.00	40.00	470.00-630.00	665.00	125.00	530.00-1150.00	1347.00	119.00	1100.00-1520.00	1728.00	649.00	850.00-2700.00
Hardness as $CaCO_3$(ppm)	616.00	14.00	610.00-640.00	690.00	19.00	660.00-725.00	810.00	28.00	770.00-850.00	910.00	63.00	820.00-1000.00
Salinity (ppt)	0.50	0.08	0.40-0.60	0.95	0.09	0.90-1.00	0.93	0.08	0.80-1.00	2.00	0.84	0.85-3.50
Secchi Disk depth (cm)	41.00	24.00	15.00-100.00	72.00	20.00	35.00-95.00	85.00	19.05	50.00-100.00	88.00	19.61	25.00-100.00

Table 5 (a). Monthly records of mean length and weight of the fish samples from four selected fish farms in Al-Qassim region

Months	Fish farm A				Fish farm B			
	Mean Length (cm)	S. D.	Mean Weight (gm)	S. D.	Mean Length (cm)	S. D.	Mean Weight (gm)	S. D.
1996								
April	23.27	4.13	286.0	109.5	17.03	3.55	94.7	54.2
May	21.30	2.31	213.6	27.3	-	-	-	-
June	21.75	2.95	238.2	79.2	17.53	2.49	105.1	48.3
July	18.10	3.18	112.0	57.0	19.57	2.35	151.9	42.2
August	17.55	1.88	106.3	28.8	18.95	1.80	201.7	36.7
September	-	-	-	-	19.45	2.04	165.2	38.4
October	22.99	2.70	228.4	78.0	18.81	1.64	139.5	29.5
November	23.10	3.65	248.0	91.4	19.00	1.80	149.8	38.6
December	20.87	4.25	231.5	121.2	19.86	2.29	183.8	54.4
1997								
January	20.18	4.79	190.0	116.6	20.03	1.76	167.9	35.2
February	24.03	1.51	269.1	55.4	20.34	1.48	159.2	27.7
March	25.45	1.86	344.7	66.9	21.07	1.24	191.2	34.2

Table 5 (b). Monthly records of mean length and weight of the fish samples from four selected fish farms in Al-Qassim region

Months	Fish farm C				Fish farm D			
	Mean Length (cm)	S. D.	Mean Weight (gm)	S. D.	Mean Length (cm)	S. D.	Mean Weight (gm)	S. D.
1996								
April	16.80	2.10	87.6	23.7	20.77	2.25	198.6	60.1
May	-		-	-	-	-	-	-
June	16.30	1.16	114.6	27.1	19.52	2.50	183.0	61.8
July	17.81	1.63	120.1	22.8	23.75	1.13	244.0	26.5
August	18.72	2.12	141.9	51.1	23.79	1.25	248.0	36.4
September	17.61	1.49	147.3	32.5	21.30	2.63	189.1	63.9
October	18.99	2.51	177.0	51.8	20.60	2.17	212.4	
November	18.72	2.21	141.9	46.2	-	-	-	-
December	17.59	2.74	124.7	50.6	21.01	2.06	202.9	53.7
1997								
January	18.27	1.85	111.8	34.4	19.36	2.03	177.4	39.2
February	18.09	2.26	103.2	41.9	20.55	2.91	171.8	61.5
March	19.86	2.53	169.0	53.2	20.54	1.70	165.6	52.3

Table 6. Annual total production of four selected fish farms in Al-Qassim region

Fish farm	Stocking rate (fish/m²)	Total water area (m²)	Water depth (m)	Growth rate (gm/day)	Annual production (ton/ha)
A	80	10000	2.0	-	200.00
B	30	18745	1.5	0.95	14.40
C	20	1050	1.0	0.53	-
D	60	438	1.5	0.33	45.66

Discussion

Quality of aquaculture water can be affected by many factors including climatic conditions, pond or tank management, water turn-over rate, quality of feed, feeding schedule, stocking density, species cultured and the development stage of the fish. In this study it was found that all the farms were using their own management strategies as dictated by their needs and limitations. However, ground water, supplied to the fish tanks, in all the fish farms was found to be suitable for tilapia culture. Significantly, low growth rate (0.33 gm/day) was recorded in fish farm D because more than 50% of the fish were deformed, and 5% out of them were completely blind.

The values of water quality parameters were not significantly different during summer time (May to October), as all the farms were well managed. During winter (November to February), NO_3-N, NO_2-N and NH_3-N were prevailingly high in farm A and farm B. Ammonia is a primary metabolic waste and is highly toxic to fish particularly in its un-ionized form (Flis, 1963; Alabaster and Lloyd, 1980) whereas nitrite ions are reported to be responsible for methaemoglobinemia (Tomasso *et al.*, 1979), therefore, their allowable levels must be lower than 1.0 ppm (Meade, 1989). The increased concentrations of total N in fish farms are generally contributed by organic N and NH_4 though the concentrations of these components vary through the daily cycle (Soberg and Bregnballe, 1977). It was observed that in the farms studied, especially farm A, a high quantity of fecal matter and uneaten feed was deposited at the bottom of the culture tanks because the drainage system was not enough to drain all the water to remove the wastes. Besides this the farmers prefer to change the water in the selling tanks where marketable size fish were stocked. Therefore, the high values of ammonia and nitrite are the results of organic decomposition of uneaten feed and fecal matter of the fish even though it did not affect the production as the large size fish had already been removed from the culture tanks and were being stocked in the selling tanks before the winter.

In the present study the NH_3-N level reached (0.78 mg/L) and (1.07 mg/L) in farms D and A respectively, which might be due to the higher stocking rate.

Tilapia has a high tolerance for NH_3-N and NO_2-N as compared to other fish species. Redner and Stickney (1979) reported that *Tilapia* sp. has LC 50 (24h) when unionized ammonia was 2.3 mg/L, whereas 16-18% mortality occurred in *Cyprinus carpio* when unionized ammonia was 0.9-1.3 mg/L even at a low temperature (11°C) (Alabaster and Lloyd, 1980).

During this study, it was observed that alkalinity, pH and phosphate were always higher in farm A than the other farms, while the Secchi disc reading was always lower, probably due to the photosynthetic activity of the algal biomass and deposition of wastes in the bottom of the culture tanks. pH of the water was affected more due to the existence of CO_2 in the water as this causes a decrease in the pH by increasing acidity. Alkalinity is also affected by the presence of bicarbonates of Mg^{++} and Ca^{++} in addition to the buffering capacity of water and its redox potential.

Our data shows that water quality was somewhat different in all the fish farms, however, the ranges of quality parameters were within normal limits. The variation in the concentrations of certain parameters may be inherent in aquaculture operation and, therefore, difficult to control.

In management practice, the growth rate is lower in high stocking densities and the yield is higher up to the carrying capacity (Hepher, 1967). Although, growth rate in farm A could not be observed due the recruitment of the large size fish, the annual production (200 tones/ha) proves that high yield could be obtained with well managed ponds in Al-Qassim region.

This study provides a preliminary kind of water quality survey with the intention to stress the need for proper monitoring and evaluation of water quality even before an aquaculture facility is set up. Proper cleaning of the tanks or ponds with a well-defined management strategy could have a significant effect over water quality and, in turn, over fish production in this region since the water quality is found to be acceptable for fish culture.

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