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Water quality and algae succession in integrated fish ponds

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This study was assessed the water quality in integrated fish culture areas of Bang-Pa-In district, Ayutthaya province, Thailand, by monitoring physico-chemical parameters and their correlation with the prevalence of algal species in the ponds to give an account of the health state of aquacultures under these settings over an 8-month period. The results showed a fluctuating in the physico-chemical water quality parameters over the culture period, influenced by the frequency of water exchange and the application of lime. The predominance of *Cyclotella* (division Bacillariophyta) over other algae communities and over the entire culture period indicated conditions requiring the urgent implementation of management programs to prevent hazards due to algal proliferation.

Key words: Water quality; Algae; Integrated fish pond

Introduction

Thailand's freshwater animal production from 1985 to 2005 was yielded from aquaculture (64.50%) and capture fisheries (35.50%). Fish accounted for 93.87% of the yield, trailed by shrimps (5.18%) and other aquatic animals

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(0.95%). Fish species raised for aquaculture purposes include walking catfish, Nile tilapia, common silver barb, snake skin gourami, striped catfish, common carp, and striped snake-head fish (Department of Fisheries, 2005).

One place for commercial integrated fish culture is located in Bang-Pain district, Phranakorn-Sri Ayutthaya province. 2,412.80 hectares of the province are covered by fish culture areas run by 3,623 farmers, yielding a total of 2,176 tons of aquatic animals per year. (Inland Aquaculture Research Institute Report, 2007). Among the four types of fish culture systems found in Thailand (extensive, semi-intensive, intensive and integrated systems) (Suraneeranart, 1988; Chuchote, 1993; Landau,1992), this district has adopted the integrated system. In this aquaculture pattern, fish are raised with other aquatic animals and plants to create an environment which is beneficial for both aquatic animals and plants. Furthermore, both livestock and fish are kept in this system where the manure is used as a fertilizer to provide additional nutrients for the growth of algae which serve as food for aquatic animals in the ponds.

Physico-chemical factors are predictors of possible changes in the aquatic ecosystem and thus serve as important indicators for proper management of pond water resources. Changes in physico-chemical parameters may be caused by the crops (Kobbia, 1982) and the production, composition and dynamics of phytoplankton (Reynolds, 1984; and Descy, 1987). The pond fertilization system also has an effect on the physico-chemical properties of phytoplankton and zooplankton communities (Ibrahim *et al.,*2003). Several factors limiting the growth of epiphytic forms (Zimba, 1998) and certain compounds produced by some species of blue-green algae (Zimba *et al.,*2002) which also impair the flavor of fish flesh, thus making it unsuitable for consumption for a few days to weeks, contribute to variations in physico-chemical profiles of ponds (Killian, 1977).

Extensive information on limnological changes was provided in the work of Hutchinson (1957) which was related to the diversity of phytoplankton by succeeding investigators. Rast *et al.,*1989, reported a reduction of dissolved oxygen due to eutrophication resulting in the accumulation of minerals and organic nutrients, and the effectiveness of limiting nitrogen and silica inputs on phytoplankton in temperate and tropical water systems was demonstrated (Zimba,1998). Wide swings in phytoplankton population densities were viewed by another researcher (Killian, 1977) as a result of fluctuations in temperature, pH, carbon dioxide, light intensity, nutrient concentration, disease and the release of toxins by other organisms that compete with plankton.

As the province spearheads aquaculture development, an effort was taken to investigate the underlying reasons that influence the change of water quality in integrated aquaculture ponds and the relationship of these factors to the

succession of algal populations. Information derived from this study will be an important input for strengthening programs for proper management and utilization of water resources to impede algal blooms in integrated aquaculture farms.

Materials and methods

Study Area: A field survey was conducted in integrated fish farming areas. The sites included raising layers for egg production and culture of Nile tilapia juveniles (43 individuals/kg), small scale mud carp, Chinese carp, common carp and silver barb with a stocking rate of 7 individuals/m^2 in an area of 0.96 hectares. The water was exchanged and lime applied occasionally to manage water quality. Fish were cultured for about eight months. At the start of the experiment, three sampling areas were selected randomly from each integrated aquaculture unit.

Water quality analysis: Water samples were collected on a monthly basis from the pond surfaces (at an estimated depth of 0.3 to 0.4m) from May to December 2007. Dissolved oxygen (DO), pH and water temperature were measured in situ by using a portable electronic measuring device (Multi parameter, Model 350i). Light penetration was determined by a Secchi disc, water depth by a measuring line. The water samples were held in ice boxes and immediately transported to the laboratory for analysis of water quality following common protocols. The analysis of biochemical oxygen demand (BOD) was carried out by the Azide modification method. Briefly, MnSO4 was added to the sample test tubes. An alkali iodide azide reagent was added and the precipitate formed was dissolved with concentrated H_2SO_4. The solution was titrated with $Na_2S_2O_3$ before the addition of a starch solution that changed the solution's color to blue. The blue color disappeared on subsequent mixing of the solution. BOD was calculated in ppm as described by Traichaiyaporn (2000a). NH_3-N levels were evaluated by the Nesslerisation method cited by APHA, AWWA and WPCF, 1998. Water samples were made react with $AgSO_4$ and the solution formed was mixed gently before the addition of 6N NaOH. The precipitate formed was set aside while the supernatant was collected in a separate beaker where EDTA was added. After gentle mixing, the Nessler reagent was added. The solution was read in a spectrophotometer at 430 nm with NH_4Cl as standard. NO_3-N profiles were determined by the phenoldisulphonic acid method described by Traichaiyaporn (2000a) using dried, hot-plate heated water sample residues moistened with phenoldisulphonic acid. DW (4ml) was added followed by 6 ml 12N NaOH before the solution was filtered. The level of NO_3-N was calculated after spectrophotometric reading at 425 nm with KNO_3 as standard. Total nitrogen

(TN) levels were detected by the Macro-Kjeldahl method cited by APHA, AWWA and WPCF, 1998. Water samples were briefly dispensed in Kjeldahl flasks before the addition of a digestion mixture of 200 ml distilled water and boiling beads. Flasks were placed in the Kjeldahl apparatus and catalyst added. The solution was allowed to cool before subsequent addition of 300 ml distilled water and 100 ml NaOH. Then, phenolphthalein was added to the solution which was then distilled. 200 ml of the distillate were collected in a separate beaker and 0.02% H_2SO_4 added. Nitrogen was indicated by a lavender solution. Total Kjeldahl nitrogen (TKN) was determined from the distillate collected after the Kjeldahl digestion of the samples. TKN levels were derived from the calibration graph of the ammonia nitrogen level where both ammonia and organic nitrogen components of the distillate were computed as TKN. Total phosphorus (TP) was evaluated by persulfate digestion/stannous chloride method (APHA, AWWA and WPCF, 1998) in which phenolphthalein was added to the water samples until the solution turned red. H_2SO_4 or ammonium persulfate was added and the solution was heated for 30 to 40 minutes. The solution was allowed to cool before adding 1 drop of phenolphthalein and NaOH. The solution was mixed gently and molybdate (4 ml) added, followed by 0.5 ml stannous chloride. The resulting solution was read in a spectrophotometer at 690 nm with a standard reagent. Orthophosphate phosphorus (PO_4-P) was determined by the stannous chloride method described by Traichaiyaporn (2000a) requiring the reaction of water samples with molybdate. The solution was read in a spectrophotometer at 690 nm with KH_2PO_4 as standard. Chlorophyll- a was detected by the cold acetone method described in APHA, AWWA and WPCF, 1998. Materials collected after the filtration of water samples were crushed with mortar and pestle and washed with 90% acetone. Samples were pooled and centrifuged for 5 minutes at 2000 rpm. Samples were refrigerated for 18 hours and subsequently centrifuged as before. The Chlorophyll-a level was calculated after spectrophotometric reading at 664, 647 and 630 nm with the recommended standard.

Algal analysis

Water samples from fish ponds were transferred to a 500 ml cylinder and fixed with Lugol's iodine solution (5 mL). The preserved samples were put in the dark for 10 days to allow concentration through decantation. The lower layer (20 to 25 mL) containing the algal sediment was transferred to a 50 ml cylinder. The second decantation was conducted after further 7 days and the lower layer (10 mL) containing the algal sediment was put in a glass vial and stored in a dark cupboard. The concentrated sample containing the algal sediment was counted using a drop microtransect method under a compound

light microscope (Traichaiyaporn, 2000b). The algal species were identified by using algae identification guides (Wongrat, 1999; Prescott, 1978; Akihiko, 1966).

Statistical analysis

Data collected were statistically analysed using SPSS version 14 (SPSS, 1989). Differences in mean values of water quality and algal populations were established using Analysis of Variance (ANOVA). The comparison of mean monthly values was done using Duncan Multiple Range Test (DMRT).

Results

Water quality: Air temperature rose from May to August, and then levelled off until December. It fluctuated significantly ($p < 0.01$) between months. Water temperature was high in May and June but significantly declined ($p < 0.01$) from July to December. Water transparency values were highest from May to August but were significantly ($p < 0.01$) lower from September to November. pH reached its low in May, significantly increased ($p < 0.01$) in June and continually declined from July to December. $CaCO_3$, alkalinity remained uniform in the months of May, August, September and October. Alkalinity, however, remained low in June and July. DO levels were significantly higher in the months of May to July, started to decline in August, then followed a uniform decline from September to December ($p < 0.01$). NH_3N was high from May to July, then significantly declined ($p < 0.01$) in August but gradually increased from September to November and finally decreased in December. NO_3N levels were low from May to August but significantly rose from September to November ($p < 0.01$), then declined in December. Levels of total potassium nitrogen (TKN) were comparably low in May to June, elevated in July to August ($p < 0.01$) then gradually decreased from September until December. There was a gradual increment of Total Phosphorus levels from May to November that significantly ($p < 0.01$) reversed in December. Similarly, increments of PO_4 levels were significant ($p < 0.01$) from May to November but reversed abruptly in December. Chlorophyll-a was initially low in May, increased from June to August ($p < 0.01$) before decreasing from September onward (Table 1).

Table 1. Monthly data on water quality parameters of integrated fish ponds

Parameters	Time Interval (months)							
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Air temperature (°C)	30.20^{b} ±0.00	31.10^{b} ±0.00	31.40^{a} ±0.00	31.30^{a} ±0.00	29.90^{c} ±0.00	29.60^{d} ±0.00	29.30^{e} ±0.00	28.60^{e} ±0.00
Water temperature (°C)	33.11^{a} ±0.10	32.93^{a} ±0.39	31.71^{b} ±0.13	31.69^{b} ±0.20	30.82^{c} ±0.05	29.88^{d} ±0.20	29.39^{e} ±0.27	29.29^{e} ±0.17
Water transparency (cm)	21.20^{a} ±0.36	20.45^{a} ±1.80	15.78^{c} ±1.11	19.78^{ab} ±0.51	17.56^{bc} ±2.52	11.56^{d} ±1.40	11.17^{d} ±0.60	16.06^{c} ±0.79
Water depth (m)	1.02^{a} ±0.11	0.99^{a} ±0.09	0.99^{a} ±0.09	0.99^{a} ±0.09	1.07^{a} ±0.04	1.07^{a} ±0.04	1.07^{a} ±0.04	1.07^{a} ±0.04
pH	6.99^{e} ±0.156	8.18^{a} ±0.23	7.87^{b} ±0.16	7.46^{cd} ±0.24	7.39^{d} ±0.168	7.52^{cd} ±0.11	7.71^{bcd} ±0.16	7.70^{cd} ±0.04
Alkalinity as $CaCO_3$ (mg/l)	115.56^{b} ±8.39	104.45^{c} ±3.03	104.56^{c} ±1.39	112.22^{bc} ±1.92	113.33^{b} ±3.33	120.00^{b} ±3.33	156.67^{a} ±7.27	158.66^{a} ±2.08
DO (mg/l)	11.87^{a} ±1.04	11.87^{a} ±1.04	10.76^{ab} ±0.18	10.14^{b} ±0.35	7.94^{c} ±0.33	8.70^{c} ±0.82	8.65^{c} ±0.91	8.21^{c} ±0.74
BOD (mg/l)	19.90^{e} ±0.17	24.72^{de} ±1.72	48.33^{c} ±5.47	30.96^{d} ±4.08	25.83^{d} ±1.50	58.33^{b} ±5.20	70.00^{a} ±5.07	59.17^{b} ±5.46
NH_3-N (mg/l)	0.270^{ab} ±0.156	0.298^{ab} ±0.191	0.356^{a} ±0.207	0.028^{c} ±0.013	0.073^{bc} ±0.027	0.088^{bc} ±0.071	0.151^{abc} ±0.073	0.016^{c} ±0.004
NO_3-N (mg/l)	0.018^{c} ±0.011	0.010^{c} ±0.003	0.020^{c} ±0.006	0.014^{c} ±0.006	0.045^{b} ±0.017	0.047^{b} ±0.011	0.095^{a} ±0.017	0.010^{c} ±0.004
TKN (mg/l)	1.194^{bc} ±0.226	1.325^{b} ±0.267	1.759^{a} ±0.200	1.551^{ab} ±0.291	1.124^{bc} ±0.242	1.274^{bc} ±0.262	0.841^{cd} ±0.149	0.607^{d} ±0.170
Total P (µg/l)	22.239^{c} ±4.916	29.736^{b} ±3.65	24.520^{bc} ±1.95	26.499^{bc} ±1.93	29.125^{b} ±0.14	29.987^{b} ±0.12	35.863^{a} ±5.87	21.510^{c} ±1.48
PO_4-P (µg/l)	11.385^{d} ±1.345	17.173^{c} ±0.95	17.570^{c} ±0.96	21.506^{b} ±3.33	25.917^{a} ±1.87	22.969^{ab} ±0.61	22.818^{ab} ±2.92	11.907^{d} ±2.39
Chlorophyll-a (µg/l)	1.731^{d} ±0.238	2.918^{bc} ±0.611	5.038^{a} ±0.711	3.245^{ab} ±0.754	2.156^{cd} ±0.572	3.096^{bc} ±0.240	2.629^{bcd} ±0.602	1.854^{d} ±0.384

Values represent means (±standard deviation, below each mean value) of the physico-chemical and biological parameters describing the water quality in pond. Values with the same letter superscripts are not significantly different ($P < 0.01$).

Algal succession: Microscopic examination of the morphology of algae samples from three fish ponds revealed the identities of 95 species belonging to 7 divisions. Of the total 95 algal species identified, 35 species belonged to Chlorophyta; 25 to Cyanophyta; 10 to Bacillariophyta; 18 to Euglenophyta; 2 to Chrysophyta and Pyrrhophyta each; and 3 species to Cryptophyta. Current data further indicated that thirteen algal genera were common in all ponds and were observed each month. These were *Cyclotella* and *Nitszchia* (division Bacillariophyta); genera *Monoraphidium, Tetrastrum, Scenedesmus* and *Crucigeniella* (division Chlorophyta); genera *Merismopedia, Plaktolyngbya, Cyclindrospermopsis, Anabaena* and *Spirulina* (division Cyanophyta); and

genera *Euglena and Phacus* (division Euglenophyta). Out of the 13 genera, the most common species of algae which inhabited the ponds throughout the entire duration of the study was *Cyclotella* sp (Table 2).

Table 2. Diversity and classification of algae in integrated fish ponds

Species	Time interval (Months)							
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
DIVISION CHLOROPHYTA								
Actinastrum hantzschii	+++	-	-	-	-	-	-	-
Actinastrum sp.	+++	-	-	-	-	-	-	-
Ankistrodesmus sp.	+++	-	-	-	-	-	-	-
Closterium sp. 1	+++	-	-	-	-	-	-	-
Coelastrum pseudomicroporum	+++	-	-	-	-	-	-	-
Cosmarium sp.1	+++	-	-	+	-	-	-	+
Crucigenia sp.	-	-	-	-	-	-	++	-
Crucigeniella crucifera	+++	+++	+	+	+	-	-	-
Crucigeniella rectangularis	+++	-	+	+	-	+	++	++
Dictyosphaerium granulatum	-	-	+	++	+	-	-	+
Dictyosphaerium sp.	-	-	-	-	-	-	+	
Didymocystis sp.	+++	-	+	-	-	-	-	-
Elakatothrix sp.	+++	+++	-	-	+	+	-	-
Euastrum sp.	+++	-	-	-	-	-	-	-
Monoraphidium arcuatum	+++	-	+	+	+	+	++	+
Monoraphidium caribeum	+++	+++	+	+	+	+	+	+
Monoraphidium contortum	+++	+++	+	++	-	+	+	+
Monoraphidium griffithii	+++	-	+	+	+	++	+	+
Monoraphidium minutum	+++	+++	+	+	+	++	+	+
Oocystis sp.	+++	+++	+	-	-	-	-	-
Pandorina sp.	+++	+++	-	+	-	-	+	-
Pediastrum duplex	+++	-	-	+	+	+	+	-
Pediastrum tetras	+++	+++	+	+	+	+	+	-
Scenedesmus bernardii	+++	+++	-	-	+	+	-	-
Scenedesmus disciformis	+++	+++	-	+	-	+	+	-
Scenedesmus microspina	+++	+++	+	-	+	+	+	+
Scenedesmus opoliensis	+++	+++	+	-	+	+	-	-
Scenedesmus pannonicus	+++	+++	+	+	-	+	+	-
Scenedesmus perforatus	+++	+++	+	+	+	+	+	-
Scenedesmus velitaris	+++	+++	-	+	+	-	+	+
Scenedesmus sp. 1	+++	+++	+	+	+	+	+	+
Tetraedon caudatum	+++	+++	-	+	-	-	-	-
Tetraedon minimum	+++	-	-	-	+	-	+	+
Tetraedon elegan	-	-	-	-	+	+	+	-
Tetrastrum heteracanthum	+++	+++	+	+	+	+	+	+
DIVISION CYANOPHYTA								
Anabaena catenula	+++	+++	+	+	+	++	+	+
Anabaena spiroides	+++	+++	-	-	-	+	-	-
Aphanocapsa sp.	-	-	-	++	-	-	-	-
Arthospira fusiformis	++	-	-	-	-	-	-	-
Chloroflexus sp.	-	+++	-	-	-	-	-	-
Chroococcus minutes	+++	-	-	+	-	+	+	+
Chroococcus sp.	-	-	-	+	-	-	-	-
Cylindrospermopsis curvispora	+++	-	+	+	++	++	++	+
Cylindrospermopsis helicoidea	+++	+++	-	-	-	+	+	+
Cylindrospermopsis raciborskii	+++	-	-	-	-	+	+	-
Gomphonema sp.	-	+++	-	-	-	-	-	-
Gomophosphaeria sp.	-	-	-	+	-	+	-	-
Komvophoron sp.	+++	+++	-	-	-	-	-	-
Lyngbya sp.	-	+++	-	-	-	-	-	-
Merismopedia convulata	+++	-	++	++	+	++	++	++
Merismopedia punctata	+++	-	+	+	+	++	+	+
Microcystis aeruginosa	-	-	-	-	-	+	-	-
Oscillatoria agardhii	+++	-	+	+	-	-	-	-

Oscillatoria limosa	+++	-	-	-	-	-	-	+
Oscillatoria redekei	+++	-	-	+	-	+	+	-
Planktolyngbya limnetica	+++	+++	+	+	++	++	++	++
Pseudanabaena catenata	+++	+++	-	-	-	-	+	+
Pseudanabaena sp. 1	+++	-	-	-	-	-	-	-
Pseudanabaena sp. 2	-	-	-	-	++	-	-	-
Spirulina sp.	-	+++	+	-	-	++	+	+
DIVISION BACILLARIOPHYTA								
Aulocoseira granulata.	+	-	-	-	-	-	-	-
Cyclotella sp.1	+++	+++	+	+	+	++	+	+
Cyclotella sp.2	+++	+++	+	++	+++	++	++	+
Cymbella sp.	++	-	-	-	-	-	-	-
Fragilaria sp.	+++	-	+	-	-	-	-	-
Gomphonema sp.	-	-	+	-	-	-	-	-
Meloseira sp.	+++	+++	-	-	-	-	-	-
Nitszchia sp.1	+++	+++	+	+	+	-	-	+
Nitszchia sp.2	+++	-	-	-	-	-	-	-
Nitszchia sp.3	+++	-	-	-	-	-	-	-
DIVISION EUGLENOPHYTA								
Euglena acus	+++	+++	+	+	++	++	+	+
Euglena texta	-	-	-	-	+	-	-	-
Euglena viridis	-	-	++	+	++	++	++	+++
Euglena sp. 1	+++	-	-	-	-	-	-	+
Euglena sp. 2	+++	-	-	-	+	-	-	+
Lepocinclis sp.	+++	-	+	+	++	+	+	+
Phacus acuminatus	-	-	+	-	+	-	-	-
Phacus longicauda	+++	+++	+	-	-	+	+	+
Phacus orgicularis	-	-	-	-	+	+	+	-
Phacus triqueter	+++	-	+	+	+	+	+	+
Phacus sp. 1	+++	-	+	+	+	+	+	+
Phacus sp. 2	+++	-	-	-	-	-	-	+
Phacus sp. 3	+++	-	+	-	-	-	+	++
Strombomonas sp.	-	+++	+	-	+	+	-	-
Trachelomonas acanthostoma	-	-	-	-	+	-	-	-
Trachelomonas caudata	+++	-	-	-	+	-	-	-
Trachelomonas cylindrica	+++	-	-	-	+	-	-	-
Trachelomonas volvocina	+++	-	+	-	+	-	-	-
DIVISION CHRYSOPHYTA								
Isthmochloron gracile	+++	-	-	-	-	-	-	-
Isthmochloron sp.	+++	-	-	-	-	-	-	-
DIVISION PYRRHOPHYTA								
Perdinium sp. 1	-	-	+	+	+	-	-	+
Peridinium sp. 2	-	-	+	+	+	-	+	+
DIVISION CRYPTOPHYTA								
Cryptomonas sp. 1	-	+	-	-	-	-	+	-
Cryptomonas sp. 2	-	-	-	-	-	-	+	-
Cryptomonas sp. 3	-	-	-	-	-	-	+	-

Legend: (-, Not found; +,1 to100 units ml^{-1}; ++, 101 to 1000 units ml^{1}; and +++, greater than 1000 units ml^{-1})

Discussion

The result of the study gave an insight in the physico-chemical and biological profiles of ponds in the selected study site. Water temperatures ranged from 29.29 to 33.11 ºC with a low in December. For comparison, the temperatures reported from the Mae Ngat Somboonchol Reservoir, Chiang Mai, during 1998 to 2001, varied between 23.83 and 32.50 ºC (Proongkiat, 1999; Kimpakorn and Traichaiyaporn, 2000). Optimum temperature conditions depend on the fish species to be cultured and range from 25 to 33 ºC in Thailand. Water transparency ranged from 11.17 to 21.20 cm. The transparency in freshwater ponds is reduced by phytoplankton, zooplankton

(microscopic plants and animals) and suspended solids such as clay and silt particles in the water column. The optimal value for transparency in aquaculture is 30 cm (Musit, 1992). The mean pH ranged from 6.99 to 8.18. in comparison with a report of Junshum (2007) who stated that a pH range of 7.09 to 9.01 at the Mea Moh power plant. The optimal pH range lies between 6.5 and 9.0, this depended on the species to be cultured. (Boyd, 1990). Alkalinity ranged from 104.45 to 158 mg/l, revealed significant differences. It is recommended to maintain alkalinity between 50 to 300 mg/l to ensure a proper buffering (stabilizing) effect to pH swings that occur in ponds due to the respiration of the aquatic flora (Buttner *et al*., 1993; Boyd, 1990). The correct pH and alkalinity are essential for a successful pond fertility programme, where fertilizers containing nitrogen, phosphorous and potassium are added to encourage the growth of phytoplankton. Phytoplankton also produces the dissolved oxygen through photosynthesis during the day. Thus, it is the most important source of dissolved oxygen in pond systems (Buttner *et al*., 1993). DO values ranged from 7.0 to 11.87 mg/l, showed significant differences between months. Dissolved oxygen is probably the most critical water quality variable in freshwater aquaculture ponds. To achieve good growth levels, a good rule of thumb is to maintain DO levels at saturation, or at least 5 ppm (Buttner *et al*., 1993; Boyd, 1990). BOD levels were between 19.9 and 70 mg/l and also differed significantly between months, with a high in November. Ammonia-nitrogen concentration ranged from 0.028 to 2.98 mg/l. There were significant differences between months, with a peak in November. The nitrate-nitrogen concentration varied between 0.010 and 0.095 mg/l with significant differences between months and a high in November. For comparison, Boyd (1990) reported a total ammonia nitrogen (ammonium plus ammonia expressed in terms of nitrogen) average of 0.052 mg/l and a nitrate-nitrogen average of 0.075 mg/l in unfertilized woodland ponds in Alabama. In ponds used for intensive fish culture, much higher concentrations of inorganic nitrogen are common. Fed channel catfish ponds contain up to 0.5 mg/l total ammonia nitrogen and 0.25 mg/l nitrate-nitrogen. This study found values within the range described by Ingthamjit *et al*. (1992) and Stephens and Farris (2004) in their studies on water quality under the conditions of hybrid catfish intensive culture. TKN concentrations ranged from 0.607 to 1.759 mg/l and thus differed significantly between months. Nitrogen is also present in soluble organic compounds and as a constituent of living and dead particulate organic matter. Concentrations of organic nitrogen are usually well below 1 mg/l in unpolluted natural water. In fish ponds, phytoplankton blooms normally are heavy and concentrations of organic nitrogen may exceed 2 or 3 mg/l (Boyd, 1990). Total P had values from 21.5 to 35.86 µg/l. Significant differences in Total P

concentrations occurred between months. Ortho-phosphorus ranged from 11.39 to 25.92 µg/L with significant differences between months. Concentrations of phosphorus in water are quite low; dissolved orthophosphate concentrations are usually no greater than 5 to 20 µg/l and seldom exceed 100 µg/l even in highly eutrophic waters, and the concentration of total phosphorus rarely exceeds 1,000 µg/l (Boyd, 1990). The levels of chlorophyll-a detected in this study ranged from 1.73 to 5.03 µg/l and were clearly lower than the levels reported by the above investigators. The variations of water quality found in this study do not reach the water quality standards (Class 3) for medium clean fresh surface water resources used for consumption but undergoing Journal of Agricultural Technology 2011, Vol. 7(5): 1427-1433 However, the effluents from intensive fish culture remain a major concern as a source of pollutants to natural waters (Egna and Boyd, 1997). The fluctuations of the water quality parameters during the eight months of the study period can be attributed to seasonal variations as claimed by Zen and Sonmez (2006) although other researchers (Abdel-Tawwab *et al*., 2005) related these variations to natural food and feed supplementation and the use of fertilizers in ponds. Based on the data generated in this study, the ranges of water quality parameters observed considerably correlated to the presence of algal populations.

As mentioned earlier, the data revealed the predominance of the algae *Cyclotella* sp. in ponds over all other diatoms and algae. Several accounts have disclosed its presence outnumbers all other algal populations in integrated fish pond communities. The abundance of *Cyclotella* was closely related to the trophic status of lakes as described in the studies of Stephens and Farris (2004); Littler and Graffius (1974); Lin (1983); Chowdhury and Mamun (2006). Other studies confirmed that many species of *Cyclotella* are typical in oligotrophic lakes (Reynolds, 1984; Thompson and Rhee, 1994) while it was also reported among organisms found in eutrophic lakes and reservoirs of Turkey (Akbay *et al*., 1999). In the ponds, diatoms dominated by algae had their best growth in the rainy season (May to July) while lower cell numbers coincided with the onset of winter (November to December), a finding that also shows th effect of seasons on the development of algae. Water temperatures ranging from 29˚C to 32˚C and visibility (turbidity) values between 11 and 21 cm at the peak of *Cyclotella* growth as observed in the study underscore the crucial roles of these factors in the seasonal development of algae. The relationship between water temperature and growth of algae and other diatoms observed in the present study is in agreement with the reports of other researchers (Blent and Feray, 2006). The work of Ingthamjit *et al.* (1992) compared the succession of algae in integrated fish ponds and in natural lakes as influenced by high stocking density and daily fertilization of ponds with chicken manure while nutrient

accumulation and water changes were described as factors that mediate the proliferation of algae (Ingthamjit *et al*., 1992; Brunson *et al*., 1994). The studies of Brunson *et al.* (1994) and Zimba *et al.,* (2003) documented a variety of algal successions in fish ponds than in natural lakes. However, this contrasts to a report that a limited algal density in commercial ponds of channel fish is more affected by nutrients than by light (Tucker and Van der Ploeg, 1993). Many other types of algae exhibit wide swings in population densities which are claimed to be caused by changes in temperature, pH, carbon dioxide, light intensity, nutrient concentration, disease and the release of algae toxins by other organisms that compete with planktons (Killian, 1977). In this study, the peak of algal proliferation was observed in June, coinciding with the highest values of water temperature, transparency, water depth, pH, DO and NH_3N noted which indicate the presence of conditions favourable for algal growth and proliferation.

Conclusion

The analysis of the prevalence of algal species in integrated fish culture ponds revealed the optimal physico-chemical conditions for algal growth. The existence of *Cyclotella* in ponds was found to indicate conditions demanding immediate measures such as routine change of water and lime application to prevent hazards due to accumulation of toxic products from the proliferating algae in ponds. The management program employed proved its effectiveness as optimal growth of stock was attained at the end of the rearing period, with best survival rates and no incidence of death.

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