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Phytoplankton Composition, Water Quality and Primary Productivity of Tilapia Ponds Located inside the Pampanga State Agricultural University, Magalang, Pampanga during Dry and Wet Seasons

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Abstract - This study was carried out in the dry (February-April) and wet (July-September) seasons of 2019 at the Pampanga State Agricultural University, Magalang, Pampanga. It aimed to identify phytoplankton composition, water quality and primary productivity of tilapia ponds within the jurisdiction of the institution. Results revealed that phytoplankton community is composed of 7 divisions, 30 families and 39 genera of which Chrysophyta is the dominant division with 14 representative genera. However, community structure differs between seasons due to the absence of some genera. Moreover, significant variation was observed in terms of overall abundance of which dry season showed denser phytoplankton individuals ($P<0.05$). Water quality variables also showed significant variation ($P <0.05$) except for transparency and TDS. Water quality during dry season showed more suitability for plankton growth compared to wet season. Lastly, GPP is higher during dry season ($P<0.05$) but comparable with wet season as to NPP and R ($P >0.05$).

Keywords: Phytoplankton, water quality, primary productivity, pond, season

INTRODUCTION

Aquatic environments harbor various forms of microscopic growths that played essential role in nutrient cycling and energy conversion [1]. Also, these organisms are regarded as important components in the diet of cultured stocks especially in extensive and semi-intensive farming [2]. Furthermore, they are good indicators of phytoplankton abundance in relation to bottom soil types [3]. The organisms suspended in the water column are collectively known as plankton. The plankton community is commonly categorized into two major divisions, the autotrophs or phytoplankton and the heterotrophs or zooplankton. The phytoplankton group is considered the base of the food chain in different aquatic environments. Moreover, this group has wider spectrum compared to the animal counterpart due to the huge number of representative taxa and broader categories.

In tilapia ponds, phytoplankton are grown through fertilization for the purpose of reducing the amount of feed to be given throughout the culture period [4]. However, fertilization is not the only factor responsible for the growth of phytoplankton in ponds. Studies revealed that the presence of grazer organisms [5] and water quality parameters directly affect phytoplankton production in ponds [6]. There have been substantial studies on the effect of these factors on the community structure and abundance of planktonic organisms in different bodies of water [7].

The study was conducted at the Pampanga State Agricultural University, one of the academic institutions in Central Luzon offering quality agricultural education. The institution occupies an approximately 500 hectares of government agricultural lands located at the northwestern side of Mount Arayat in Magalang, Pampanga. Because of its geographic character, it is endowed with natural resources. The abundant supply of water in the area offered opportunity for freshwater aquaculture. Among the aquatic resources, Nile tilapia became the leading aquaculture commodity of the institution. There have been three distinct aquaculture areas within its property; however, one of these areas is operated by a private company. At present, there is still no initiative undertaken to provide baseline information on the composition of phytoplankton and primary productivity of tilapia ponds managed by the institution. Hence, an investigation was made.

MATERIALS AND METHODS

Collection and Preservation of Water samples

The assessment was carried out in the selected ponds inside the Pampanga State Agricultural University that are devoted for semi-intensive farming of Nile tilapia (*Oreochromis niloticus*). These ponds are usually fertilized with organic and inorganic fertilizer during the preparation period to trigger the growth of phytoplankton. Water samples were collected on a monthly-basis during dry season (February to April, 2019) and wet season (July to September, 2019) in selected tilapia ponds using modified plankton net with 5 microns mesh size. The plankton net was towed in the selected ponds at a distance of 10 m and samples were preserved in sterile plastic bottles by adding 10% formalin.

Water Quality Assessment

The physico-chemical properties of water were assessed prior to the collection of water samples. Among the parameters assessed are water transparency, temperature, dissolved oxygen, pH and total dissolved solids. Water transparency was determined using a Secchi disk. Temperature and dissolved oxygen were assessed using AZ 8403 model dissolved oxygen meter. The level of pH was measured using Milwaukee pH600 pocket-sized pH meter while total dissolved solids were measured using Water Quality TDS meter. Lastly, ammonia was estimated using colorimetric method.

Identification, Counting and Density Estimation

A drop of water (1 ml) was taken from the concentrated volume of samples and placed in a glass slide for identification of planktonic organisms. This was observed under 1,000 magnification level of a compound microscope (XSZ-107BN model). Photographs were taken and identified by comparing with the published work of Reynolds (1984) [8] and the electronic publication of the University of California (undated). Identification was only made up to the genus level.

Counting of phytoplankton was done by transferring another 1 ml of sample directly to an improved Neubauer haemocytometer using a pipette and focused under 16 x 10 magnifications. Density of each phytoplankton genus was estimated using the formula: density (no. of cells/ml) = average no. of cells per square/volume of the square.

Assessment of Primary Productivity

Primary productivity of the selected ponds was determined using light and dark bottle technique [9]. Assessment was also made during dry and wet seasons. The values for gross primary productivity (GPP), net primary productivity (NPP) and respiration (R) were calculated using modified formula [10].

GPP (mg C m^{-3} hr^{-1}) = (12/32)*((LB-DB)/T*PQ)*1,000

NPP (mg C m^{-3} hr^{-1}) = (12/32)*((LB-IB)/T*PQ)*1,000

R (mg C m^{-3} hr^{-1}) = (12/32)*((IB-DB)/T)*RQ)*1,000

where: LB, IB, DB refers to the concentrations of dissolved oxygen in the "Light" Bottle, "Initial" Bottle and "Dark" Bottle respectively, while T, PQ and TQ refers to the time of incubation, photosynthetic quotient and respiratory quotient, respectively. Strickland and Parsons (1960) suggested a PQ value of 1.25 and RQ value of 1.0 [10].

Treatment and Analysis of Data

The data collected from each period of assessment were consolidated and subjected to some descriptive statistics. Mean readings of water quality variables, density and primary productivity were compared between seasons using one -tailed Student's t Test.

RESULTS AND DISCUSSION

Qualitative assessment revealed 7 major divisions, 30 families and 39 genera of phytoplankton during the period of the study. Among the divisions of phytoplankton, Chrysophyta was found dominant comprising 14 representative genera. This is comprised of 13 families with a single representative genus except for Fragilariaceae with 2 identified genera. The division Cyanophyta ranked second when it comes to the number of identified families and genera. The family Euglenaceae of the division Euglenophyta is comprised of the genera *Euglena*, *Astasia*, *Galothrix*, *Phacus*, *Colacium*, and *Leponcinclis*. Meanwhile, the division of Chlorophyta has 4 identified families of which each has a single representative genus. The divisions of Charophyta and Pyrrophyta both have 2 representative families with single genus identified except for the family Gymnodiaceae. Lastly, the division Cryptophyta has a single representative family and genus.

There have been many undertakings that show the diversity of phytoplankton in ponds. However, their structure may differ in relation to location and season. The result on species composition is in similarity with previous studies [11, 12]. The former found the dominance of the division Chrysophyta in rivers and Euglenophyta in ponds. However, the latter study reported higher number of phytoplankton genera in the Chlorophyceae. A study relating the effect of chicken manure and organic fertilizer in the abundance and composition of plankton in tilapia ponds revealed a total of 29 genera under Chlorophyta, 10 under Cyanophyta and 12 under Chrysophyta [13]. These phytoplankton divisions were also found in the stomach of *O. niloticus* in fertilized ponds indicating their importance to the diet of the fish [14]. All life forms in the in aquatic environment depend on phytoplankton because they are at the base of the food chain [15].

As to seasonal occurrence, most are present in both seasons and among pond areas. As indicated in Table 1, the genera *Colacium*, *Cymbella*, *Pleurosigma*, *Cyclonexis Closterium* and *Karenia* were not observed in the dry season. Meanwhile, the genera *Astasia*, *Lepocinclis*, *Amphora*, *Amphipleura*, *Leptolyngbya* and *Anabaena* are not present during the assessment in the wet season. This result implies seasonal variation had great influence on the community structure of phytoplankton. In a study on the influence of physico-chemical parameters on phytoplankton communities in Parangipettai coastal waters, Bay of Bengal, India, it was found out that seasonal variations as well as nutrient availability can bring significant changes in phytoplankton community structure [16].

Table 1. Planktonic genera identified and their occurrence during dry and wet season

Division	Family	Genus	Dry	Wet
Euglenophyta	Euglenaceae	*Euglena*	/	/
		Astasia	/	X
		Galothrix	/	/
		Phacus	/	/
		Colacium	X	/
		Leponcinclis	/	X
Chrysophyta	Catenulaceae	*Amphora*	/	X
	Bacillariaceae	*Nitzschia*	/	/
	Fragilariaceae	*Asterionella*	/	/
		Synedra	/	/
	Stauroneidaceae	*Stauroneis*	/	X
	Pinnulariaceae	*Pinnularia*	/	/
	Surirellaceae	*Surirella*	/	X
	Rhizosoleniaceae	*Rhizosolenia*	/	/
	Naviculaceae	*Navicula*	/	/
	Amphipleuraceae	*Amphipleura*	/	X
	Cymbellaceae	*Cymbella*	X	/
	Pleurosigmataceae	*Pleurosigma*	X	/
	Chromulinaceae	*Cyclonexis*	X	/
	Gomphonemataceae	*Gomphonema*	/	/
Chlorophyta	*Hydrodictyaceae*	*Pediastrum*	/	/
	Scenedesmaceae	*Scenedesmus*	/	/
	Oocystaceae	*Oocystis*	/	/
	Cholodendraceae	*Tetraselmis*	/	/
Cyanophyta	*Leptoolyngbyaceae*	*Leptolyngbya*	/	X
	Merismopediaceae	*Merismopedia*	/	/
	Microcoleaceae	*Planktothrix*	/	/
	Nostocaceae	*Anabaena*	/	X
	Microcystaceae	*Microcystis*	/	/
	Oscillatoriaceae	*Oscillatoria*	/	/
		Lyngbya	/	/
	Spirulinaceae	*Spirulina*	/	/
Charophyta	*Desmidiaceae*	*Staurastrum*	/	/
	Peniaceae	*Closterium*	X	/
Pyrrophyta	*Ceratiaceae*	*Ceratium*	/	/
	Gymnodiniaceae	*Gyrodinium*	/	/
		Gymnodinium	/	/
	Kareniaceae	*Karenia*	X	/
Cryptophyta	*Cryptomonadaceae*	*Chroomonas*	/	/

With regards to the density of planktonic divisions (Table 2), it was observed that individuals belonging to the division Chrysophyta dominated the community in both seasons. Meanwhile, lowest density was recorded in the division Cryptophyta in both seasons. Comparing the density of phytoplankton division between seasons, significant difference was observed in the divisions of Chrysophyta, Chlorophyta, Cyanophyta and Cryptophyta (*P*<0.05). Further, these divisions are higher in the dry season except for Cryptophyta. The result may imply that phytoplankton density in selected tilapia ponds varies as season shifts. Thus, seasonal change is a major driving factor that influences the density of phytoplankton of tilapia ponds in Pampanga State Agricultural University. During dry season, the intensity of sunlight is higher and water temperature increases which could directly trigger the proliferation of phytoplankton. Minimal phytoplankton density in water corresponds with low temperature [17]. However, temperature could not be the only factor that influences phytoplankton abundance in tropical earthen ponds [18]. Low density of phytoplankton during wet or rainy season could be due to increased dilution, water outflow, silting, low transparency and flooding [19].

Table 2. Density of phytoplankton during dry and wet seasons.

	Mean Density (no./ml)				
Division	**Dry**	**Wet**	**t critical**	**t stat**	**p(T<=t)**
Euglenophyta	1522.63	576.13	2.92	25.11	0.00*
Chrysophyta	2694.72	1358.02	6.31	8.86	0.03*
Chlorophyta	2908.09	589.85	6.31	7.54	0.04*
Cyanophyta	1680.73	584.36	2.92	9.61	0.01*
Charophyta	209.19	222.22	6.31	-0.3	0.41
Pyrrophyta	98.32	45.82	6.31	2.67	0.11
Cryptophyta	20.71	16.63	6.31	1.98	0.15
Overall	9134.40	3393.04	6.31	39.43	0.01*

The level of water quality in terms of transparency, temperature, dissolved oxygen, pH, TDS and ammonia of tilapia ponds during dry and wet seasons are presented in Table 2. It was reported that abundance of phytoplankton is correlated with water quality parameters [20]. Comparison on the transparency, TDS and ammonia level of water did not show any significant difference between seasons. Meanwhile, temperature, dissolved oxygen and pH varied significantly ($p<0.05$). This result indicates that seasonal variation causes significant change in the temperature, dissolved oxygen and pH of tilapia ponds in the area but insignificantly affects transparency, TDS and ammonia level. Temperature is a parameter that is of great importance because it directly affects other parameters [21]. Unlike lakes, ponds are relatively shallow in which its temperature corresponds with changes in atmospheric temperature. Higher temperature observed in the dry season is a function of temperature increase in the atmosphere. This strong correlation was also observed in other studies [22]. Although variation was observed, the levels of temperature during dry and wet season are still within the optimum range (18.3 – 37.8 ºC) for plankton production in tropical ponds [23]. These readings were also within the range (25 – 30 ºC) given by for best phytoplankton production in tropical ponds [24].

Table 3. Level of water quality parameters of tilapia ponds during dry and wet seasons.

Parameter	Mean		T critical	T stat	p(T<=t)
	Dry	Wet			
Transparency (cm)	27.06	25.13	6.31	2.48	0.12
Temperature (˚C)	30.05	25.03	6.31	9.8	0.03*
Dissolved Oxygen (mg/L)	5.023	3.76	2.92	10.24	0.00*
pH	6.90	6.15	2.92	7.28	0.01*
TDS (mg/L)	171.19	205.690	6.31	-5.74	0.05

The dissolved oxygen of water is the second most important parameter in pond fish culture. Lower mean dissolved oxygen concentration observed during wet season can be attributed to low reception of solar energy during this period. Precipitation during this period limits the amount of energy supply for phytoplankton growth. However, this was not in agreement with the findings of other authors suggesting a considerable increase of dissolved oxygen in colder months [25, 26]. Meanwhile, a lower dissolved oxygen concentration in ponds covered with macrophytes [27]. During the period of assessment, tilapia ponds subjected in this study were partly infested with some macrophytes such as *Azolla*, duckweed and duck lettuce which may be reduced the amount of dissolved oxygen loss in the atmosphere. The inflow of allochthonous materials during wet season could possibly impair photosynthetic activities of plankton [28]. In this study, the decrease in transparency may be an indication of increase in allochthonous materials. Meanwhile, it was reported that the optimum concentration of dissolved oxygen for tilapia culture must be 5 mg/l or higher [29].

As to pH, mean reading in dry season is significantly higher than wet season with a slightly acidic level. It is regarded that biological activity greatly influences water pH particularly in aquaculture ponds [30]. For plankton growth, the ideal pH must be in the range of 6.8 to 8.0 [30]. The mean pH reading in dry season falls within the optimum range while mean reading in wet season was slightly deviated from this range. The drop in pH during wet season could be attributed partially to the minimal erosion of pond dikes and transport of decomposing materials into the water. A similar finding was reported in a study on the vertical and surface water variations of pH and dissolved oxygen in Asa lake Ilorin, Nigeria [31]. Meanwhile, the decrease in water transparency during wet season has direct relationship to these materials. The inflow of water during rainy periods carries silt and other materials causing turbidity [32]. This is also evident in the rise of TDS readings in wet season.

The result on primary productivity presented in Table 4 indicates a significant variation between seasons as to GPP (P<0.05).

Table 4. Primary productivity of tilapia ponds during dry and wet seasons

Primary Productivity Measurement	Mean		t critical	t stat	p(T<=t)
	dry	wet			
GPP (mg C m^{-3} hr^{-1})	19.29	13.84	2.92	3.11	0.04*
NPP (mg C m^{-3} hr^{-1})	7.19	4.58	6.31	2.22	0.13
R (mg C m^{-3} hr^{-1})	14.53	11.11	6.31	1.82	0.16

However, NPP and Respiration showed no differences (*P*>0.05). This result implies that GPP is relatively higher in the dry season but the level of NPP and R are comparable to the level observed in the wet season. Higher GPP in dry season could be attributed to higher overall density of phytoplankton. Also, temperature may have positive influence for the gross primary production of phytoplankton. It was reported that phytoplankton primary productivity has a positive correlation with temperature [33]. Temperature of water is a function of solar energy. Thus, the higher the temperature, the higher the amount of energy received by a body of water. And, this energy is virtually important in the photosynthetic activity of phytoplankton. Meanwhile, seasonal fluctuations in gross and net primary production in surface waters in a tropical pond were observed and higher values were recorded from March to May while lowest during the monsoon months of July and August [34]. The present finding corroborates to their study.

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