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Nighttime pH Dynamics and Oxygen-pH Relationships under Different Fertilizer Loads in Green Water Tank Culture

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ABSTRACT

This study was conducted to investigate the effect of medium and high doses of either chemical or organic fertilizers along with supplementary feeding on pH dynamics and pH budgets in outdoor concrete tanks of Nile tilapia. The experiment lasted 90 days during summer season, 2010. The pH loss during nighttime ranged from – 0.54 unit to – 0.94 unit among treatments ($P < 0.05$), while pH gains during daytime ranged from + 0.56 unit to + 0.92 unit. The medium chemical fertilizer and control treatments had dawn pH surpluses (+ 0.054 to + 0.104) with higher daytime pH gains (+ 0.64 to + 0.84) than nighttime pH losses (- 0.54 to - 0.78), which indicated that more carbon dioxide was fixed by photosynthesis during daytime than was released during nighttime respiration. Evaluation of the daily trends in pH values indicated that the high chemical fertilizer and the high organic fertilizer treatments were characterized by net heterotrophy (negative pH budgets). This was indicated by the higher values of optimal nighttime pH loss (- 0.92 to -0.94 unit) compared to those of the actual daytime pH gains (+ 0.56 to + 0.90), within each treatment. Higher daytime oxygen gain per one unit of daytime pH gain was observed in the medium chemical fertilizer, medium organic fertilizer and control treatments (dNPP = 13.59 – 17.68 g O_2/ m^2 per one unit of daytime pH gain) compared to those of the high fertilizer treatments (9.87 – 10.61 g O_2/ m^2 per one unit of daytime pH gain), with significant differences among treatments. Better oxygen production per one unit of pH gain during daytime was observed in the medium chemical, medium organic fertilizer and control treatments (13.5-17.6:1) compared to those of the high fertilizer load treatments (9.8-10.6:1), which reflects a better environment in these treatments.

Keywords: chemical fertilizer-organic fertilizer- pH budget- algae-Nile tilapia.

INTRODUCTION

Fish consume oxygen and excrete ammonia and carbon dioxide. Metabolic carbon dioxide reduces the ambient pH of the water (Colt *et al*., 2009). During the day, photosynthesis has a significant impact on pH. This is due to the consumption of carbon dioxide needed to produce oxygen (Colt *et al*., 2009).In systems exposed to sunlight, the development of phytoplankton blooms leads to diel fluctuations of pH and concentrations of dissolved oxygen, carbon dioxide, and unionized ammonia. As a result, the performance of green water systems varies over diel scale (Hargreaves, 2006). Over the long run, the amount of carbon fixed in photosynthesis is approximately offset by the carbon released in water column respiration (Steeby *et al*., 2004).

Quantification of metabolic end products such as carbon dioxide and ammonium provides information on total mineralization (Blackbum, 1987). Oxidation of metals or inorganic compounds, *e.g*. reduced iron and manganese or the oxidation of ammonia to nitrate (nitrification), will cause oxygen consumption without direct stoichiometric coupling to organic carbon oxidation (Jones, 1982). Anaerobic processes are often quantitatively more important than aerobic processes and total carbon dioxide release must be regarded as a better measurement of benthic metabolism than oxygen uptake (Jones, 1982).

Carbon dioxide reacts with water to form a weak acid known as carbonic acid. The amount of CO_2 present as simple solution plus that in the form of carbonic acid is termed as free CO_2, while the amount present in the forms of carbonates and bicarbonates is termed as bound carbon dioxide. Processes which utilize carbon dioxide (such as photosynthesis) increase the pH. In contrast, processes releasing carbon dioxide (such as respiration) decrease the pH. The processes (photosynthesis, respiration, addition, and deposition) change the carbon budget (Mukherjee *et al*., 2002).

As carbon dioxide is utilized in photosynthesis there is a decrease in the total inorganic carbon, and a consequent increase in pH. The rate of utilization of total inorganic carbon can be assessed by measuring the total alkalinity of the water body, and the changes in pH with time. Similarly, the changes in the above parameters with community respiration during the night can be measured by the same method. Analysis of the changes in inorganic carbon budget is based on photosynthesis and respiration (Mukherjee *et al*., 2002).

The change in the total inorganic carbon due to photosynthesis, respiration and decomposition can be quantified by measuring the pH, since, the pH is dependent on the relative abundance of the three forms of inorganic carbon (free carbon dioxide, carbonates and bicarbonate) at a set point in time (Mukherjee *et al*., 2008). Leiher *et al*. (1988) stated that the minimum concentration that can be reached in such systems is the one that results when the rate of carbon dioxide utilization is exactly balanced by its rate of production due to respiration. With the dissociation of bicarbonates, the pH increased rapidly (Mukherjee *et al*., 2008).

At night, the biota releases carbon dioxide through community respiration. If the nighttime respiratory release of carbon dioxide is equal to the daytime photosynthetic uptake, then the bicarbonate – carbonate buffer system is reestablished for functioning in the next daytime period (Mukherjee *et al*., 2008).

The objective of the current study was to evaluate the nighttime pH dynamics and pH-oxygen relationships under different fertilizer loads in semi-intensive systems.

MATERIALS AND METHODS

The current experiment was conducted at the Fish Research Unit, Faculty of Agriculture, Cairo University in a series of rectangular concrete tanks (2.2 × 1.2 × 1.0 m each). The experiment consisted of two organic fertilizer treatments (medium and high doses), two chemical fertilizer treatments (medium and high doses) and control treatment. The control treatment received no fertilizer during the experiment. Monosex Nile Tilapia (average weight 131.3-137.7 grams / fish) were obtained from Kafr Elsheikh farm and stocked randomly at 7.0 units per concrete tank in all treatments. The experiment lasted 90 days during summer season, 2010.

All fertilizer treatments received supplementary diet (18 % crude protein) at a fixed rate (6.5 g /m^2 /day) for six days a week during the whole experiment. The control treatment included the application of a complete diet (30 % crude protein) at a fixed rate of (6.5 g /m^2 /day), six days a week during the whole experiment. All diets were formulated and processed in the Fish Research Unit. The chemical fertilizer treatments received a weekly application of chemical fertilizer (ammonium nitrate, 33%N and super-phosphate, 8% P) at medium and high doses (1.0 and 1.5 grams N / m^2 for nitrogen and 0.25 and 0.38 grams P / m^2 for phosphorus, respectively). The organic fertilizer treatments received a weekly application of chicken manure at medium and high doses (14.0 and 28.0 grams dry matter /m^2, respectively) along with the fixed feeding rate. The organic fertilizer (Poultry manure) obtained from the Poultry Production Unit, was sun dried and contained 3.87 % N and 4.18 % P_2O_5. The experiment included five treatments, with duplicate tanks per treatment.

1. *Water quality parameters*

All determinations of water quality parameters were carried out in the Fish Research Unit (Faculty of Agriculture, Cairo University). Water temperature and dissolved oxygen were measured using HANNA Instrument (model 55) dissolved oxygen meter. Readings of dissolved oxygen were taken by integrating the probe of oxygen meter over the whole depth of water up to the bottom of the tank (Szyper, 1996). Estimates of visibility were taken using secchi disk at the same day along with oxygen and pH readings. The pH was measured by a pH digital meter at the laboratory after sample collection. Water in rearing tanks were not renewed during the whole experiment, but were compensated for evaporation loss. Moreover, water were not aerated during the experimental period and depended only on oxygen production through algal photosynthesis. Natural sunlight was the only source for light radiation in the outdoor concrete tanks.

Oxygen and pH dynamics

Calculations that predict nighttime decline in DO were based on Boyd *et al*. (1978) and Romaire and Boyd (1979). The projection method was based on assuming that the DO decline during nighttime is essentially linear with respect to time. When DO concentrations at dusk and nighttime are plotted versus time, a straight line through the two points was projected to estimate DO at dawn or at other times during night. Boyd (1998) confirmed the high accuracy of the projection method in predicting DO concentrations at dawn compared with measured values. Romaire and Boyd (1979) indicated that the nighttime dissolved oxygen model gave highly reliable prediction of early morning DO concentration. An additional simplifying assumption was made not to correct daytime net primary production (dNPP) or nighttime community respiration (nCR) for diffusion according to Hargreaves and Steeby (1999).

Dissolved oxygen data were analyzed to calculate the duration (hours) that DO concentrations were less than 1.0 mg /l or near zero oxygen in the per-dawn hours. Determination of daytime net primary production and nighttime community respiration required the measurements of dissolved oxygen. Water temperature was measured at dusk while DO and pH were measured three times daily (early morning at 07: 00 a.m., dusk at 08:00 p.m. and nighttime at 00: 00 h). The duration of nighttime hours (from dusk to dawn) during the last month of the experiment was approximately 10 hours while the daytime period lasted 14 hours. All the following formulas are models developed by the authors and were derived from Boyd *et al.* (1978), Romaire and Boyd (1979), Szyper (1996), Boyd (1998) and Hargreaves and Steeby (1999).

Oxygen dynamics parameters

Nighttime community respiration per hour ($nCRh^{-1}$) = (dusk oxygen concentration –midnight time oxygen concentration) /4.

Optimal nighttime community respiration (nCR) = hourly measured nighttime community respiration × nighttime duration (10 hours).

Daytime net primary production (dNPP) = dusk oxygen concentration – dawn oxygen concentration.

Duration (in hours: minutes) before daybreak where oxygen concentration was below 1.0 g O_2/m^2 = [(dusk DO concentration - 1) / $nCRh^{-1}$]-10.

The pH gains and losses during daytime and nighttime hours were considered as indices for algal photosynthesis in terms of the amount of CO_2 consumed during daytime by algae or the amount of respiratory CO_2 released during nighttime through community respiration, respectively. Consequently, the pH decline during nighttime was employed to reflect the rate of community respiration during nighttime hours while the pH increase during daytime was used to reflect the daytime net rate of primary production (dNPP) in terms of oxygen production.

pH dynamics parameters

Daytime pH gain (dpH gain, units /daytime) = dusk pH - early morning pH.

Nighttime pH loss per nighttime hour (npH loss h^{-1}) = (dusk pH value –midnight time pH value) /4.

Optimal nighttime pH loss (npH loss, units / nighttime) = hourly optimal nighttime pH loss × nighttime duration (10 hours).

Dawn pH surplus or deficit = actual pH gain - optimal pH loss.

dNPP: dpH gain ratio = dNPP / dpH gain.

nCR: npH loss ratio = nCR / npH loss.

2. *Statistical analysis*

Water quality parameters in culture tanks were subjected to one – way analysis of variance to determine significant statistical differences among treatments. Differences among means were assessed by Duncan multiple range test (Duncan, 1955). Statistically significant differences were determined by setting the aggregate type I error at 5% for each comparison. These statistical analyses were performed using the software package SPSS for windows, Release 8.0 (SPSS, 1997).

RESULTS AND DISCUSSION

A. The pH dynamics

1. Morning , dusk and midnight pH

Data of average morning, midnight and dusk pH values are shown in Table 1. Lower averages of morning and dusk pH ($P < 0.05$) were observed in the high fertilizer treatments compared with the low fertilizer treatments, which probably were induced by the decomposition of dead algae(bacterial respiration) in the bottom sediment as well as the excessive algal respiration in the water column, induced by algal blooms. This could be explained by the higher respiratory CO_2 production (i.e. acid substance), as a result of the higher fertilizer inputs which induced algal blooms leading to the active production of respiratory CO_2 by aquatic organisms. Phytoplankton as a major oxygen consumer during nighttime produced high amount of CO2 during dark period, thus lowering pH value during nighttime. Moreover, Hargreaves (2006) indicated that photosynthesis and respiration of phytoplankton dominate oxygen and pH dynamics in pond water.

Most of the water column (dark zone) was a net consumer of oxygen and produced a high amount of respiratory carbon dioxide which decreased water pH. Mukherjee *et al*. (2002) indicated that processes which utilize carbon dioxide (*i.e.* photosynthesis) increase the pH while processes that release carbon dioxide (*i.e.* respiration) decrease the pH. These two processes (photosynthesis and respiration) change the carbon budget.

Table (1). ***The pH dynamics in fertilized concrete tanks under different fertilizer loads.***

Treatment / Parameter	Chemical Fertilizer		Organic Fertilizer		Control 30% C.P.
	Medium	High	Medium	High	
Early morning pH (units)	**8.35 c**	**8.04 d**	**8.57 cd**	**8.18 b**	**8.92 a**
Dusk pH (units)	**9.19 b**	**8.95 c**	**9.24 b**	**8.74 d**	**9.56 a**
Daytime PH gain (units/ daytime)	**+ 0.84 ab**	**+ 0.90 a**	**+ 0.66 b**	**+ 0.56 c**	**+ 0.64 bc**
Midnight pH (units)	**8.88 b**	**8.57 c**	**8.96 b**	**8.37 d**	**9.35 a**
PH loss/nighttime hour (unit/night hour)	**0.078 bc**	**0.094 a**	**0.069c**	**0.092a**	**0.054 c**
Optimal nighttime pH loss (unit/ nighttime period)	**- 0.78 bc**	**- 0.94 a**	**- 0.69 c**	**- 0.92 ab**	**- 0.54 c**
Dawn pH surplus/ deficit parameter (± unit)	**+ 0.054 a**	**- 0.042 a**	**- 0.028 a**	**- 0.362 b**	**+ 0.104 a**
Duration of oxygen concentration below 1.0 gram oxygen/ m^2	**00:35**	**00:58**	**03:06**	**04:32**	**00:12**

Means in the same row with different letters are significantly different ($P < 0.05$)

2. The pH losses and gains

In the photosynthetic green water systems, carbon dioxide is added through community respiration and is removed through photosynthesis (Hargreaves, 2006). During the day, photosynthesis has a significant positive impact on pH. This is due to the consumption of carbon dioxide needed to produce oxygen (Colt *et al.*, 2009). The addition or removal of carbon dioxide changes the pH value through community respiration and photosynthesis, respectively.

The pH was depressed during nighttime hours due to the excretion and gradual accumulation of respiratory CO_2. The pH loss during nighttime ranged from – 0.54 units to – 0.94 units among treatments ($P < 0.05$), while pH gains ranged + 0.56 to + 0.9 during daytime. When the algal CO2 demand exceeds available carbon dioxide levels, the pH will increase for several days or weeks and the alkalinity will decline. However, when algal CO2 consumption during daytime equals CO2 production through community respiration during nighttime, early morning pH value tends to stabilize over several days or weeks.

Mukherjee *et al*. (2008) reported that the carbonate – bicarbonate alkalinity system is similar to a battery that is discharged during the day and recharged during the nighttime. The medium chemical fertilizer and control treatments had dawn pH surpluses (+ 0.054 to +0.10) with higher daytime pH gains (+0.64 to +0.84) than nighttime pH losses (- 0.54 to -0.78), which indicated that more carbon dioxide was fixed by photosynthesis during daytime than was released during nighttime respiration. Therefore, more oxygen was produced by photosynthesis during daytime than was consumed by nighttime respiration in these treatments, indicating oxygen surpluses at dawn.

The carbon cycle in experimental tanks was reflected in the magnitude of gross pH change per day in water expressed as the sum of daytime pH gain and the optimal nighttime pH loss during a single day. The gross pH change during a single day reflected the biological activities of aquatic organisms in terms of respiration and photosynthesis.

Higher values of pH change observed in the current experiment, reflected higher biological activities in water. The decomposition of the dense sedimented dead algae and faeces in the aerobic bottom sediments, adds respiratory CO_2 through the aerobic bacterial respiration, which lowered the pH values at both dawn and dusk in the high fertilizer treatments. Dense growth of algae in the photic zone always increases community respiration and CO_2 production by algae itself and aerobic bacteria working on decomposition of organic matter (*i.e*. sedimented algae , faeces and metabolites).

The carbon cycle in shrimp polyculture ecosystems was studied. The results showed that the plankton community respiration rate was 49 percent of the rate of phytoplankton gross oxygen production (Guo-cai *et al*., 2000).

The decomposition of dense dead algae and faeces in the anaerobic bottom sediments, also adds respiratory CO_2 through the anaerobic bacterial respiration using sulfate (SO_4) and nitrate (NO_3) for respiration or through methane production at the water-sediment interface (Hargreaves, 2006), which lowered the pH value in the pre-dawn hours. The dense growth of algae found in the high chemical fertilizer treatment is considered as a major input of decomposable organic matter when settled at the bottom sediment. Algal blooms induced by high fertilizer inputs always increased bacterial oxygen demand, community respiration and CO_2 production.

Bacterial activities in the bottom sediment, which include faeces, feed wastes and dead algae, produce large amounts of respiratory CO2 which reduce the pH. Most of the dietary carbon content (*i.e*. 75% of total dietary carbon) is excreted as respiratory CO2 by fish and aerobic bacteria during active metabolism, lowering the pH value of water (Boyd, 1990).

The development of phytoplankton blooms leads to diel fluctuation of pH, dissolved oxygen and carbon dioxide through aerobic decomposition (Hargreaves, 2006). Oxygen consumption by bacteria during the process of decomposition of waste organic matter and dead phytoplankton often exceeds gross photosynthesis (net heterotrophy) in aquatic systems with high rates of allochtonous organic matter such as feed and organic fertilizers (Hargreaves, 2006) . This leads to near zero oxygen concentrations for several hours before dawn in ponds with high algal density where a large proportion of the water column (dark zone) is considered a net consumer of oxygen (Hargreaves, 2006). Mukherjee *et al.* (2008) indicated that the change in the total inorganic carbon due to photosynthesis, respiration and decomposition could be quantified by measuring the pH.

2. Dawn pH surplus /deficit parameter

The medium chemical fertilizer and control treatments had dawn pH surpluses (+0.054 to + 0.104) with higher daytime pH gains than optimal nighttime pH losses, indicating positive pH budgets. Data of dawn pH surpluses and deficits are shown in Table 1. Evaluation of the daily trends in pH values indicated that the high chemical fertilizer and the high organic fertilizer treatments were characterized by net heterotrophy (negative pH budgets).

The dawn pH surplus / deficit parameter had negative values (- 0.042 to - 0. 362) in those treatments, indicating that more carbon dioxide was released during nighttime respiration than was fixed by photosynthesis during daytime. This was indicated by the higher values of optimal nighttime pH loss (- 0.92 to - 0.94 unit) compared to those of the daytime pH gains (+ 0.56 to + 0.90) within each treatment. Algal blooms and organic matter at the bottom sediment increased the community respiration rate and produced large amounts of respiratory CO2 which depressed the pH value in the high fertilizer treatments. Tucker (2003) reported that dawn pH surplus indicates net autotrophy while dawn pH deficit indicates net heterotrophy (oxygen shortage at dawn).

The production of respiratory CO_2 by the anaerobic bacteria at the bottom sediment rich in senescent algae may have accounted for the higher optimal nighttime pH loss in the high fertilizer treatments. It is known that the aerobic bacteria slow their decomposition activities when dissolved oxygen decrease below 2.0 mg /l. The production of the respiratory CO_2 by the anaerobic bacteria at the bottom sediment may also lead to a higher pH deficit under slightly positive oxygen budget.

Mukherjee *et al.* (2002) indicated that community respiration can be measured from the rate of pH loss during nighttime when there is no photosynthetic demand for carbon dioxide and the biota release carbon dioxide through community respiration. King (1970) and King and Novak (1974) reported that when the nighttime respiratory release of carbon dioxide by community respiration is equal to the daytime photosynthetic uptake of CO_2, then the dawn surplus /deficit parameter equal zero and the dawn pH value stay the same over time during the growing season (cited in Mukherjee *et al*., 2008).

Phytoplankton stock and activity in aquaculture ponds are recognized as critical system components to be managed for successful crop production (Colman and Edwards, 1987; Smith and Piedrahita, 1988; Boyd, 1990 and Szyper, 1996). These components, standing central to the oxygen and carbon cycles, are intimately connected with the wellbeing of crop animals, through respiratory dynamics in all systems, and through food chains in extensive systems receiving no feed inputs (Szyper, 1996). Management of pond ecosystems should be directed toward maintenance of stability in the standing stock of phytoplankton and other microbes, and in the diel extremes of dissolved oxygen concentrations, particularly the early-morning minimum (Szyper,1996) .

B. Relationships between dissolved oxygen and pH change

Averages of daytime oxygen gain to daytime pH gain ratio ranged 9.87 to 17.68: 1 among treatments, with significant differences among means (Table 2). Higher daytime oxygen gain per one unit of pH gain was observed in the medium fertilizer and control treatments (dNPP = 13.59 – 17.68 g O_2/ m^2 per one unit of pH gain) compared to those of the high fertilizer treatments (9.87 – 10.61 g O_2/ m^2 per one unit of pH gain), with significant differences among treatments. This was due to the high dense algal blooms in water (*i.e*. shallow Secchi disk reading) present in the high fertilizer treatments accompanied by anaerobic nighttime activities.

Averages of nighttime oxygen loss to nighttime pH loss ratio ranged 9.59 to 16.46: 1 among treatments, with significant differences among means. Higher nighttime oxygen loss per one unit of pH loss was observed in the medium fertilizer and control treatments (13.87 – 16.46 g O_2/ m^2 per one unit of pH loss) compared to those of the high fertilizer treatments (9.59 – 12.08 g O_2 / m^2 per one unit pH loss). This may be due to the presence of anaerobic respiration (anaerobic carbon dioxide production) in the high fertilizer treatments during nighttime hours, increasing the rate of pH loss during nighttime without the need for dissolved oxygen consumption.

Better oxygen production per one unit of pH gain during daytime, was observed in the medium chemical, medium organic fertilizer and control treatments (13.59-17.68:1) compared to those of the high fertilizer load treatments (9.87-10.61:1), which reflected their better environment in those treatments.

The medium chemical fertilizer and the control treatments had higher dissolved oxygen content through the nighttime period, higher daytime net primary productivity, moderate algal blooms and better environmental conditions for fish production. Feed conversion ratios (2.26-2.46:1) and daily weight gains (0.82-0.83 gram/fish/day) were significantly improved in those treatments compared to the treatments with high fertilizer loads (3.26-4.3:1 and 0.46-0.58 g/fish/day, respectively) as reported by Elnady *et al*. (2010). The better environment improved treatment performance in terms of daily weight gain and feed conversion ratio. Considering a nighttime period of 10.0 hours during this study, it is not recommended to use a high fertilizer

Table (2). ***The pH dynamics and oxygen-pH relationships in fertilized concrete tanks under different fertilizer loads.***

Parameter \ Treatment	Chemical Fertilizer		Organic Fertilizer		Control
	Medium	**High**	**Medium**	**High**	**30% C.P.**
Daytime net primary production dNNP (g O_2 /m^2/daytime)	**10.62 a**	**7.99 ab**	**8.23 ab**	**6.87 b**	**10.25 a**
Optimal nighttime community respiration nCR(g O_2 /m^2/nighttime)	**10.62a**	**8.73 a**	**10.62 a**	**10.68 a**	**10.25 a**
Daytime oxygen gain: pH gain (g O_2 /m^2/daytime per one unit of pH gain)	**13.59 bc**	**9.87 d**	**14.19 b**	**10.61 cd**	**17.68 a**
Optimal nighttime oxygen loss : pH loss (g O_2 /m^2/nighttime per one unit of pH loss)	**13.87 ab**	**9.59 b**	**15.57 a**	**12.08 ab**	**16.46 a**
Secchi disk readings (cm)	**15.5 a**	**9.6 b**	**15.1 a**	**11.6 b**	**15.3 a**
Water temperature (^oC)	**30.8 b**	**30.0 c**	**30.8 b**	**30.8 b**	**31.6 a**

Means in the same row with different letters are significantly different ($P < 0.05$)

dose along with supplementary feeding due to its negative effect on both oxygen budget and fish growth

Depending on how low the dissolved oxygen concentration is and how long it remains low, fish may consume less feed, grow slowly, convert feed less efficiently, and be more susceptible to infectious diseases (Tucker, 2005).

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ديناميكية الأس الحامضي أثناء الليل والعلاقات بين تركيز الأكسجين وقيم الأس الحامضي تحت جرعات مختلفة من التسميد فى نظام أحواض المياه الخضراء.

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أجريت هذه الدراسة لبحث تأثير نظام التغذية التكميلية مع استخدام التسميد العضوي أو التسميد المعدني (بمستوى جرعات متوسطة ومرتفعة) على ديناميكية وميزانية الأس الحامضي فى أحواض تسمين البلطى النيلى. استمرت الدراسة لمدة 90 يوماً خلال فصل الصيف (2010). تراوح مقدار النقص فى قيم الأس الحامضي لمياه الأحواض أثناء الليل بين – 0.54 إلى – 0.94 وحدة عبر المعاملات (مستوى معنوية أقل من 0.05). بينما تراوحت مقدار الزيادة فى قيم الأس الحامضي لمياه الأحواض أثناء النهار بين + 0.56 إلى + 0.92 وحدة. وقد كانت ميزانية الأس الحامضي موجبة عند الفجر(+ 0.054 إلى + 0.104) فى معاملة التسميد الكيميائي المتوسط ومعاملة الكنترول، حيث كانت مقدار الزيادة فى قيمة الأس الحامضي أثناء النهار (+ 0.64 إلى + 0.84) أكبر من مقدار النقص فى قيمة الأس الحامضي أثناء الليل (- 0.54 إلى – 0.78). وهذا يوضح أن الطحالب استهلكت كمية من ثاني أكسيد الكربون فى عملية التمثيل الضوئي أثناء النهار أكبر من كمية ثاني أكسيد الكربون المنطلقة من تنفس جميع الكائنات المائية أثناء الليل. وعند تقييم التغيرات اليومية فى قيمة الأس الحامضي عبر الأيام اتضح أن ميزانية التنفس التي ينتج عنها انطلاق ثاني أكسيد الكربون كانت سالبة (ميزانية الأس الحامضي سالبة). وهذا انعكس فى زيادة مقدار النقص فى قيمة الأس الحامضي أثناء الليل نتيجة تنفس الكائنات المائية (- 0.92 إلى – 0.94 وحدة) بالمقارنة بمقدار الزيادة الفعلية فى قيمة الأس الحامضي أثناء النهار (+0.56 إلى +0.9) نتيجة التمثيل الضوئي للطحالب داخل كل معاملة.وقد ارتفع تركيز الأكسجين فى مياه الأحواض نتيجة زيادة قيمة الأس الحامضي أثناء النهار بمقدار وحدة واحدة فى معاملة التسميد المتوسط ومعاملة الكنترول (الزيادة الصافية فى تركيز الأكسجين = 13.59 – 17.68 جرام اكسجين فى المتر المربع المائي فى اليوم لكل وحدة أس حامضى) بالمقارنة بمثيلاتها فى معاملات التسميد المرتفع (9.87 – 10.61 جرام أكسجين فى المتر المربع المائي فى اليوم لكل وحدة أس حامضى) مع وجود فروق معنوية بين المعاملات. وقد تميزت معاملات التسميد الكيميائي المتوسط والتسميد العضوى المتوسط والكنترول بالإنتاج الجيد للأكسجين الناتج عن زيادة قيمة الأس الحامضي بمقدار وحدة واحدة أثناء النهار (13.5 – 17.6 : 1) بالمقارنة بمثيلاتها فى معاملات التسميد المرتفع (9.8 – 10.6 :1) والتي عكست البيئة الجيدة الناتجة عن استخدام هذه المعاملات.

الكلمات الدالة : السماد الكيميائي – السماد العضوي – ميزانية الأس الحامضي – الطحالب – البلطي النيلي.