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Relationships between secchi disk visibility, water temperature and dissolved oxygen in freshwater fishpond

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Abstract
A study was conducted to determine the relationships between secchi disk variability, water temperature and dissolved oxygen in fish ponds. Multiple regression correlation analysis was done to evaluate the relationships between the variables. Results indicated that the ranges of secchi disk visibility, water temperature and dissolved oxygen in the study ponds were just within the ranges of the variables for tilapia culture. Multiple regression correlation showed no (or insignificant) relationships with dissolved oxygen and water temperature, dissolved oxygen with secchi disk visibility and water temperature with secchi disk visibility.

Key words: Secchi disk, Water temperature, Dissolved oxygen

Introduction

Fish production is usually closely related to phytoplankton abundance (Boyd 1982) and phytoplankton is in turn the main nutritional component for tilapia (Harbott 1982). Fish perform best and healthiest when dissolve oxygen (DO) concentrations are near saturation. However, DO is directly controlled by the amount of phytoplankton in the ponds (Boyd 1982) but oxygen depletions resulting from massive plankton blooms can results in fish kills.

In fish ponds, plankton is usually the primary source of turbidity which is generally desirable for fish culture but the turbidity resulting from high concentrations of humic substances is not desirable because of acidity, low nutrient levels and limited light penetration for photosynthesis. Secchi disk visibility (SDV) however, provides an estimate of water transparency (turbidity) that is generally related to plankton abundance (Barica 1975). At lower SDV plankton blooms are so dense that there is high probability of problems with DO. Higher SDV indicates insufficient phytoplankton productivity to support enough fish food organisms for fish production.

Temperature is among the most important environmental variable that influence behavior of aquatic poikilotherms (Gunter 1957, Kinne 1963). The rates of biochemical

processes of organisms are temperature dependent (Boyd 1990) and increasing water temperature enhancing fish metabolism and synthesis of body tissues (Perin 1993).

As of Moncrief and Jones (1977) a 10°C increase of temperature roughly doubles biochemical rate. They also suggested that oxygen consumption increase with temperature increase until a maximum value is achieved and then oxygen consumption decreased relatively rapidly as temperature continuous to increase. However, to obtain optimum fish growth, temperature, SDV and DO are important. Therefore, this study aimed to evaluate the relationship between secchi disk visibility, water temperature and dissolved oxygen using multiple regression and correlation.

Materials and methods

A case study was conducted in fishponds at the University Agribusiness Program Fish Farm of Central Luzon State University, Science City of Munoz, Nueva Ecija, Philippines. Eight ponds were selected where tilapia (*Oreochromis niloticus)* was cultured. Each of the ponds consisted 3000 m^2 area. Average water depth ranged from 0.90-1.0 m. Fingerlings of tilapia were released with stocking density of 4/m^2. Chicken manure at the rate of 2000 kg/ha/week was applied twice a day at 9 am and 1 pm. Each of the selected pond was divided into three locations from where SDV, water temperature and DO were determined three times in a week at 9-10 am and which was continued for a month. Measurements of these variables were taken 1 m away from the dike.

Measurement of SDV

A Secchi disk, made of wood consisted of a weighted circular plate, 20-cm in diameter with the surface, pointed with opposing black and white was used to determine the SDV depth. The secchi disk was attached to a calibrated line a ring at the center so that when hold by line, it hanged horizontally. To determine the SDV, the secchi disk was lowered into the water until it was disappeared and noted the depth. Lowered the disk a few more cms and then slowly raised until it was appeared and also recorded the depth. The average of the two reading considered for the final secchi disk variability depth. Clearness of the day, lee side of the sun and without sunglass of the observer was taken into consideration during the period of observation.

Measurements of DO and water temperature

Dissolved oxygen and water temperature were measured by using Polarograhhic digital oxygen meter. The electrode of the digital DO meter was submerged under water at about 10-15 cm. The meter automatically gave the reading of DO and temperature. The reading of DO and temperature are usually blinking. However, DO and temperature were recorded when the reading of the variables were stable.

All the collected data were computed as multiple regression and correlation analysis using Microsoft Excel program by computer.

Results and discussion

Secchi disk visibility provides an estimate of phonic zone where most of the natural food (plankton) for fish being grown. Results of SDV monitoring exhibits the overall ranged from 9.90-36.38 cm. Highest SDV observed in pond number 1 & 6 ranged from 20.72 – 32.66 and 19.95 – 36.38 cm, respectively (Table 1). These results just within the range (15-40 cm) for tilapia culture as suggested by Boyd (1982). Rest of the ponds showed lower SDV than the recommended for tilapia culture.

Table 1. Ranges of secchi disk visibility, temperature and dissolved oxygen of the study ponds

Pond No.	Ranges		
	Secchi disk visibility (cm)	Temperature (O^C)	Dissolved oxygen (mg/l)
1	20.72 - 32.66	24.53 – 28.63	5.45 –19.15
2	13.21 - 26.87	24.87 – 28.90	3.47 – 9.04
3	12.32 - 32.54	24.93 – 28.50	3.89 – 8.97
4	16.27 - 27.85	25.23 – 28.97	3.70 – 6.54
5	9.90 - 20.25	24.52 – 29.40	3.12 – 5.41
6	19.95 - 36.38	24.73 – 29.50	4.07 - -8.46
7	13.88 - 23.40	24.50 – 29.53	4.42 – 8.34
8	15.52 - 26.43	25.00 – 29.20	3.97 – 7.97

As the SDV provides the estimate of water transparency (turbidity) which is generally related to plankton abundance (Barica 1975, Almazan and Boyd 1978), planktons provides oxygen ranges from 20-25 mg/l, about 80% of the total source through photosynthesis in a sunny day (Zhu and Tang 1996) and DO is directly controlled by the amount of phytoplanktons in the pond, besides other factors (Boyd 1982), hence DO might have some influence in relationship with SDV. However, multiple regression ($r = 0.102^{ns}$, $Y = 5.466 + 0.0287 X$) of SDV and DO showed no (or insignificant) relationship in the study (Fig. 1). Perhaps, turbidity produced by dirt and other suspended particles prevented sunlight from reaching the plankton which contributed not to produce enough oxygen, resulted in insignificant relationship between SDV and DO.

Temperature is among the most important environmental variable that influence biological process, survivability, growth and reproduction and susceptibility to diseases of organisms (Boyd 1990). However, temperature ranged from 24.50 to 29.53 ^{o}C (Table 1) which found ideal for tilapia culture. Generally, tilapia able to live over a wide ranges of water temperatures from 8-42^{o}C (Balarin and Haller 1982 as cited by Mair and Abella 1997). It has also been observed that when rain occurred at night followed by wind at the time of monitoring, comparatively lower temperature was measured at the following day. Prein (1993) suggested that water temperature increased with solar radiation but

decreased by wind-driven evaporation cooling. He also reported that variation of water temperature is responsible for 38% by solar radiation and wind of which wind responsible for 36% alone. The results of the study, to some extent again confirmed the findings of Prein (1993).

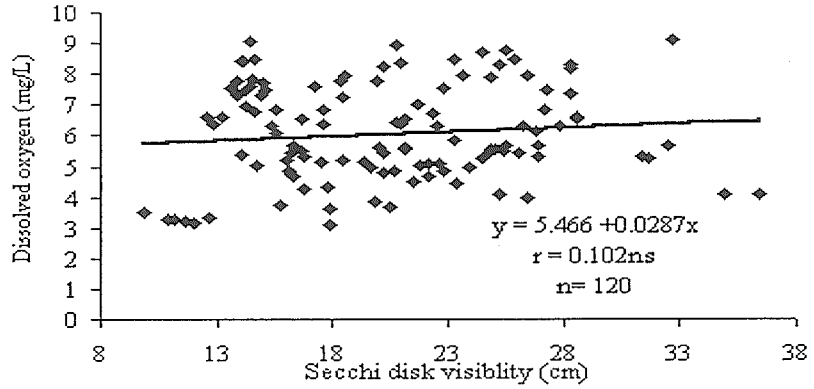

Fig. 1. Relationship between Secchi disk visibility and dissolved oxygen

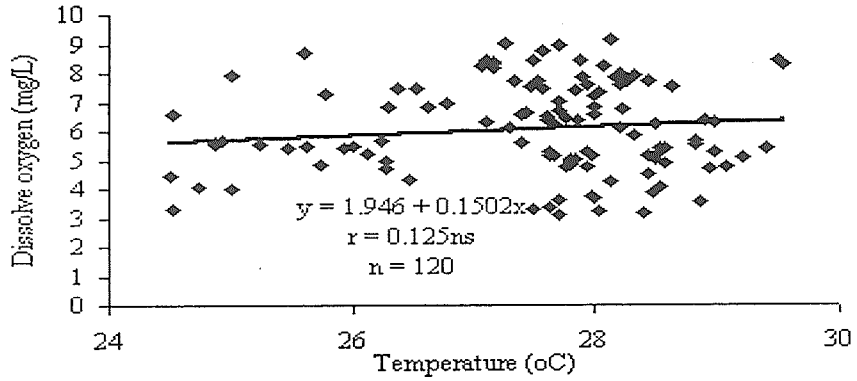

Fig. 2. Relationship between temperature and dissolved oxygen

Dissolved oxygen is the most limiting water quality parameters to fish life and commonly managed in fishponds particularly in intensive culture systems. Dissolved oxygen in the study ponds recorded ranged from 3,12 – 12.96 mg/l (Table 1). Highest DO measured from the pond number 1, ranged from 5.45 – 12.95 mg/l followed by pond number 7, ranged from 4.42 – 8.34 mg/l and pond number 6, ranged from 4.07 – 8.46 mg/l. In the other ponds DO observed just above the critical level (0.1 – 3.0 mg/l) as cited by Mair and Abella (1997). Dissolved oxygen below 5 mg/l is undesirable in ponds (Swingle 1969, Boyd 1990). Prein (1993) reported that water temperature has a relatively strong influence on DO. Multiple regression correlation of DO versus temperature showed that DO had no (or insignificant) relationship ($r = 0.125^{ns}$, Y= 1.946+ 0.150X)

with temperature (Fig. 2). Similar results have also been observed in relationship between secchi disk visibility and temperature (Fig. 3).

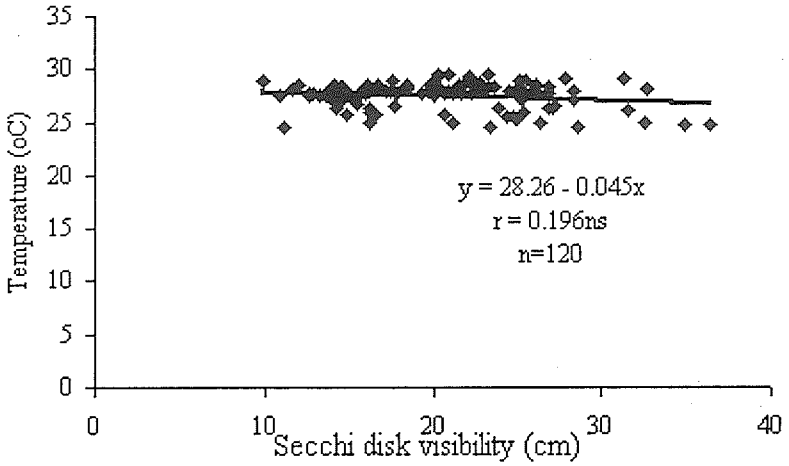

Fig. 3. Relationship between Secchi disk visbility and temperature

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