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Correlation of Chlorophyll-A with Secchi Disk Depth and Water Turbidity in Aquaculture Reservoirs A Case Study on Mohammadabad Reservoirs, Gorgan, Iran

Hamideh Kordi, Seyed Abbas Hoseini, Mohammad Sudagar and Ali Akbar Alimohammadi

Department of Fisheries, Gorgan University of Agricultural Sciences and Natural Resources, Iran

Abstract: As the main photosynthetic pigment, chlorophyll-a is an indicator to evaluate phytoplankton biomass in aquatic ecosystems. Likewise, measuring chlorophyll-a concentration allows classifying the aquatic ecosystem based on trophy. The present work aimed to seek for any potential correlation between chlorophyll-a concentration with Secchi disk depth as well as water turbidity to facilitate chlorophyll-a determination. Water samples were collected from two adjacent reservoirs. A total of five stations were assumed and the samples were collected during summer and autumn (5 months). Results showed that there was a significant correlation between log chlorophyll-a and log Secchi disk ($R^2 = 0.72$; $y = -1.445x + 3.978$) as well as between log chlorophyll-a and water turbidity ($R^2 = 0.60$; $y = 0.027x + 1.074$).

Key words: Chlorophyll-A % Phytoplankton % Secchi Disk Depth % Turbidity % Reservoir

INTRODUCTION

Water column available light measurement is an important factor in algae study. Available light amount affects type, chlorophyll content, biomass of periphyton and algae. Generally, 80 percent of algae biomass is present in the surface layer which receives more light. Water transparency can be measured by Secchi disk, turbidometer, lightmeter and sensors [1]. It has been previously reported that chlorophyll-a, as an algae biomass indicator, can be estimated by water turbidity data [2-4].

Chlorophyll-a is the main photosynthetic pigment in many phytoplanktons and a trophy index in aquatic ecosystems [5, 6]. Since, Secchi disk depth has been measured from 1900 in oceanographic studies, estimation of chlorophyll-a amount from the data related to water turbidity can be an applicable method for concomitant studies on algae biomass [2]. Secchi disk depth is a rapid, easy and cheap method to obtain valuable information in limnological studies [7]. Sugimoto and Tadokoro [8] and Nagata [9] suggested that there are seasonal and geographical variations in correlation between water turbidity and chlorophyll-a concentration.

When planktonic organisms are the source of water turbidity, water transparency is a suitable index for estimating the planktonic population [10]. Several studies on different lakes showed that there is a significant hyperbolic correlation between Secchi disk depth and algae biomass estimated from chlorophyll-a concentration [11, 12].

The present work was conducted to present a suitable model for correlation between chlorophyll-a concentration with Secchi disk depth and water turbidity in reservoirs.

MATERIALS AND METHODS

The work was conducted during summer to autumn 2011 on Mohammadabad reservoirs, Gorgan, Iran. Two reservoirs were studied. Area of the reservoirs was 25 and 10 ha. Three sampling stations were determined in the large reservoir and 2 in the small one. Water samples were collected fortnightly to determine water turbidity (expressed as nephelometer turbidity unit (NTU); turbidometer, Wagtech, Berkshire, UK) and chlorophyll-a concentration. At each sampling, water transparency (cm) was recorded using a Secchi disk in the field. To determine chlorophyll-a concentration, water samples were light-protected and transferred to laboratory at 4°C. Samples were shaken and certain volume of water (based on water color) was filtered using a vacuum pomp and

Corresponding Author: M. Hamideh Kord, Department of Fisheries, Gorgan University of Agricultural Sciences Natural Resources, Iran. Tel: 09117700882.

Table 1: Maximum, minimum, mean and standard deviations for chlorophyll-a values

Chlorophyll-a (mg/m^3)	Maximum	Minimum	Mean	Standard deviation
Summer	153.32	16.56	70.42	38.83
Autumn	127.31	12.21	43.69	31.07
Total	153.32	12.21	57.05	37.26

Table 2: Maximum, minimum, mean and standard deviations for Secchi disk depth values

Secchi disk depth (cm)	Maximum	Minimum	Mean	Standard deviation
Summer	65	20	39.25	17.02
Autumn	85	27	47.65	17.50
Total	85	20	43.45	17.56

Table 3: Maximum, minimum, mean and standard deviations for water turbidity values

Secchi disk depth (cm)	Maximum	Minimum	Mean	Standard deviation
Summer	35.1	8.28	21.91	8.88
Autumn	36.1	8.95	20.63	8.23
Total	36.1	8.28	21.27	8.48

GF/F filter. Thereafter, filter was pulverized with 90% acetone in a mortar. The resulting mixture was centrifuged for 10 min (3000 rpm) and supernatant was poured into a glass cuvette. The optical density was read at 630, 647, 664 and 75 nm. Samples' chlorophyll-a content was calculated according to Jeffrey and Humphrey [13]:

$$\text{Chlorophyll-a} = (11.85*(E664-E750)-1.54*(E647-E750)-0.08(E630-750))*Ve/L*Vf$$

Where L was cuvette thickness in centimeter, Vf was filtered water volume in liter and Ve was supernatant volume in milliliter. Chlorophyll-a content was expressed as mg/m^3.

RESULTS

Results showed that there was a negative and significant correlation between chlorophyll-a and Secchi disk depth, as well as a positive and significant correlation

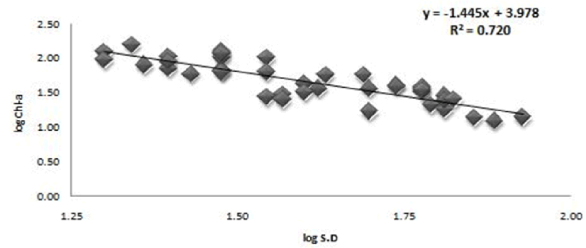

Fig. 1: Correlation between log chlorophyll-a concentration and log Secchi disk depth in whole studied period

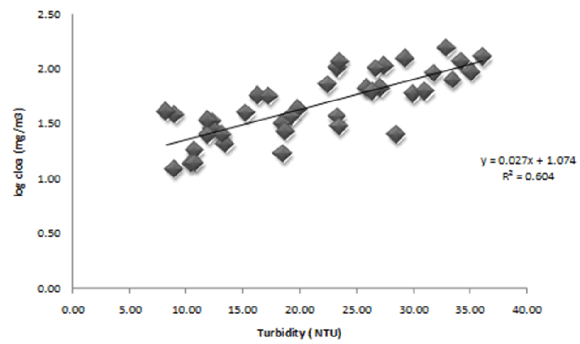

Fig. 2: Correlation between log chlorophyll-a concentration and water turbidity in whole studied period

between chlorophyll-a and water turbidity ($P < 0.01$). Chlorophyll-a ranged between 12.21 to 153.32 mg/m^3, Secchi disk depth ranged between 20 to 85 cm and water turbidity ranged between 8.28 to 36.1 NTU (Table 1, 2 and 3).

Correlation between the variables in the model for summer, autumn and whole studied showed in Table 4, 5 and 6 respectively.

Results show that there was a significant correlation between log chlorophyll-a and log Secchi disk ($r^2 = 0.72$; $y = -1.445x + 3.978$) as well as between log chlorophyll-a and water turbidity ($r^2 = 0.604$; $y = 0.027x + 1.074$) (Figure 1 and 2).

Table 4: Correlation between the variables in the model for summer

	Secchi depth	Log Secchi depth	Chlorophyll-a	Log Chlorophyll-a	Turbidity
Secchi depth	1				
Log Secchi depth	0.992**	1			
Chlorophyll-a	-0.850**	-0.854**	1		
Log Chlorophyll-a	-0.878**	-0.872**	0.961**	1	
Turbidity	-0.946**	-0.951**	0.795**	0.798**	1

** Correlation is significant at the 0.01 level.

Table 5: Correlation between the variables in the model for autumn

	Secchi depth	Log Secchi depth	Chlorophyll-a	Log Chlorophyll-a	Turbidity
Secchi depth	1				
Log Secchi depth	0.99**	1			
Chlorophyll-a	-0.649**	-0.679**	1		
Log Chlorophyll-a	-0.801**	-0.804**	0.936**	1	
Turbidity	-0.875**	-0.906**	0.798**	0.824**	1

** Correlation is significant at the 0.01 level.

Table 6: Correlation between the variables in the model for whole studied period

	Secchi depth	Log Secchi depth	Chlorophyll-a	Log Chlorophyll-a	Turbidity
Secchi depth	1				
Log Secchi depth	0.984**	1			
Chlorophyll-a	-0.769**	-0.804**	1		
Log Chlorophyll-a	-0.846**	-0.850**	0.952**	1	
Turbidity	-0.899**	-0.912**	0.766**	0.778**	1

** Correlation is significant at the 0.01 level.

DISCUSSION

Phytoplankton dynamic, including their production and biomass spatiotemporal variations, is dependant to light availability [14]. Measuring chlorophyll-a concentration allows estimating the phytoplankton biomass as well as their spatiotemporal variations [15]. Since chlorophyll-a measurement is not always possible, aquatic sciences scientists accept to use Secchi disk as a cheap and easy method, because there is a strong correlation between water transparency and chlorophyll-a concentration [16].

Generally, there is a direct correlation between Secchi disk transparency and phytoplankton abundance. If be used in a regular and right manner, Secchi disk transparency can be an important managerial tool in aquaculture [17]. However, ponds with high turbidity derived from clay particles present an incorrect estimation about phytoplankton biomass based on Secchi disk depth [18].

Since it has been believed that there is a hyperbolic and significant correlation between Secchi disk transparency and chlorophyll-a concentration [19 and 11], many researchers have attempted to obtain a negative linear correlation based on data collected from different aquatic ecosystem and their logarithmic transformation [20, 21]. Line dispersal increases parallel with chlorophyll-a concentration increment and to minimize this effect, data are transformed to logarithmic scale. Log Secchi disk depth is often used against log chlorophyll-a concentration [22]. The followings are the examples in this case:

Ln S.D = 1.601 - 0.766 Ln Chl-a	r = 0.65	[23]
Log Chl-a = 1.1666 Log S.D + 3.6858	r = 0.7	[24]
Ln S.D = 1.25 - 0.489 Ln Chl-a	r = 0.79	[25]
Ln S.D = 2.04 - 0.68 Ln Chl-a	r = 0.82	[19]
Log S.D = 1.25 - 0.55 Log Chl-a	r = 0.82	[21]
Log S.D = 2.376 - 0.452 Log Chl-a	r = 0.84	[11]
Ln S.D = 10.66 - 0.29 Ln Chl-a	r = 0.41	[26]

The obtained correlation in the present work:

Log Chl-a = 1.445 Log S.D + 3.978   r = 0.85

The present results showed the stronger correlation between chlorophyll-a and Secchi disk compared to the previous studies, however, was very close to the results of Hosseini and Ordog [11], Berzonic [21], Canfield and Bachmann [19] and Canfield and Hodgson [25]. Hosseini and Ordog [11] suggested that the higher correlation coefficient is related to higher reproductivity in culturing pond and artificial lakes.

According to the obtained results, at least 85 % of total chlorophyll-a can be estimated from Secchi disk depth in the reservoir. Results showed that Secchi depth had better correlation to chlorophyll-a than turbidity.

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