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Correlation of Chlorophyll-A with Secchi Disk Depth and Water Turbidity in the International Alma Gol Wetland, Iran

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Abstract: This study was conducted to find out the correlation of chlorophyll-a with Secchi disk depth and water turbidity in the International Alma Gol Wetland. Chlorophyll-a (the main photosynthetic pigment) is an indicator to estimate phytoplankton biomass in aquatic ecosystems. Similarly, measuring chlorophyll-a concentration allows classifying the aquatic ecosystem based on trophy. Water samples were collected fortnightly from five stations in the wetland. They were collected during summer and autumn (5 months). Results illustrated that there was a significant correlation between chlorophyll-a and Secchi disk (R^2=0.650; y=-2.852x +192.8) as well as between Secchi disk and water turbidity (R^2 =0.486; y = -1.865x+82.12) but there was not significant correlation between chlorophyll-a and water turbidity (R^2=0.046; y=0.738x +33.10).

Key words: Chlorophyll-a % Phytoplankton % Secchi Disk Depth % Turbidity % Wetland

INTRODUCTION

Wetlands are now recognized as important features in the landscape that supply frequent useful services for people and fish and wildlife. Some of these services, or functions, include protecting and improving water quality, providing fish and wildlife habitats, storing floodwaters and maintaining surface water flow during dry periods. These beneficial services, considered valuable to societies worldwide, are the result of the inherent and unique natural characteristics of wetlands [1].

Studying the temporal and spatial variability of primary production and the factors that control them is necessary in understanding the biogeochemical cycle of carbon in the aquatic ecosystem [2,3]. The assimilation number (i.e. P_{max}; mg C mgChl^{-1} h^{-1}) at optimum light intensity has been a widely accepted index for the study of phytoplankton physiology and ecology [4]. Light intensity has been recognized as the most basic factor in controlling P_{max} .

Water column obtainable light measurement is a key factor in algae studies. Available light amount affects type, chlorophyll content and 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 [5]. It has been previously reported that chlorophyll-a, as an algae biomass indicator, can be estimated by water turbidity data [6-8].

Chlorophyll-a is the main photosynthetic pigment in many phytoplankton and a trophy index in aquatic ecosystems [9, 10]. Secchi disk depth is a rapid, easy and cheap method to obtain valuable information in limnologic studies [11]. The studies on different lakes showed that there is a significant hyperbolic correlation between Secchi disk depth and algae biomass estimated from chlorophyll-a concentration [12, 13].

Turbidity, a measurement of the clarity of water, is an important factor of water quality. The suspended solids in water are measured as turbidity in Nephelometric Turbidity Units (NTU). Reduced light penetration through the water is caused by high turbidity levels limiting the growth of aquatic plants [14]. Turbidity levels can be affected by both natural and anthropogenic activities and land features.

Sugimoto and Tadokoro [15] and Nagata [16] suggested that there are seasonal and geographical variations in correlation between water turbidity and chlorophyll-a concentration.

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Fig. 1: Location of the Alma-Gol wetland in the South Caspian Sea, Iran

When planktonic organisms are the source of water turbidity, water transparency is a suitable index for planktonic population estimation [17].

This study was conducted to find a suitable model for correlation between chlorophyll-a concentration with Secchi disk depth and water turbidity in the Alma Gol wetland.

Alma Gol Lake, also called Lake Ulmagol, is a freshwater lake. In 1975, the Alma Gol Lake and nearby Ala Gol and Aji Gol Lakes were designated as a wetland of international importance under the Ramsar Convention [18].

MATERIALS AND METHODS

The study was performed in Alma Gol international wetland, which is situated on the Turkmen steppes near the border with Turkmenistan in the Golestan Province, in north of Iran (Figure1). This work was conducted during summer to autumn in 2011. Area of the wetland was 207 ha. Five sampling stations were determined in the wetland. 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 wetland but because of low depth of water in summer in this wetland we recorded Secchi disk depth just in autumn. 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 GF/F filter. Thereafter, filter was pulverized with 90 and 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' content of chlorophyll-a were calculated according to Jeffrey and Humphrey [19]:

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

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.

Data were analyzed using statistical software SPSS v. 18. Data were subjected to correlate and Bivariate test to find significant correlation between chlorophyll-a and Secchi disk depth, as well as between Secchi disk depth and water turbidity. $P < 0.01$ considered to be significantly different.

RESULTS

Results showed that there was a negative significant correlation between chlorophyll-a and Secchi disk depth, as well as between Secchi disk depth and water turbidity ($P<0.01$) but there was no significant correlation between chlorophyll-a and water turbidity ($P>0.05$). Chlorophyll-a ranged between 4.38 to 156.55 mg/m^3, Secchi disk depth ranged between 25 to 75 cm and water turbidity ranged between 6.73 to 60.50 NTU (Tables 1, 2 and 3).

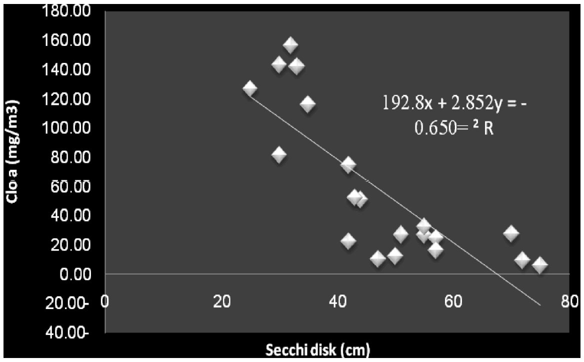

Fig. 2: Correlation between chlorophyll-a concentration and Secchi disk depth in autumn

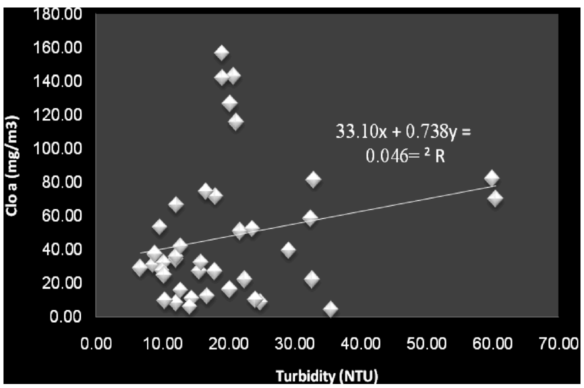

Fig. 3: Correlation between chlorophyll-a concentration and turbidity in the whole period

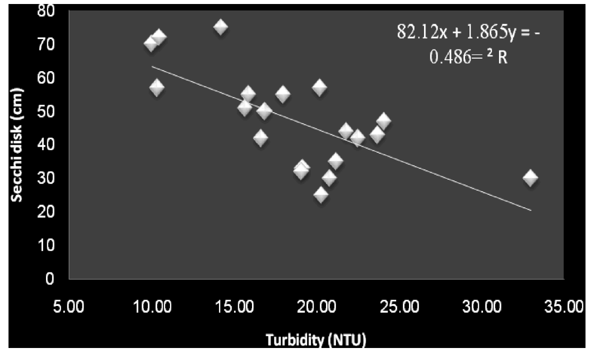

Fig. 4: Correlation between Secchi disk depth and turbidity in autumn

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

Results show that there was a significant correlation between chlorophyll-a and Secchi disk (R^2=0.650; y=-2.852x+192.8) as well as between Secchi disk and water turbidity (R^2=0.486; y=-1.865x+82.12) but was not significant correlation between chlorophyll-a and water turbidity (R^2=0.046; y=0.738x+33.10) (Figures 2, 3 and 4).

The obtained correlation in the present work:

Chl-a = -2.852 S.D+192. 8   r = 0.81

Log Chl-a = -0.267 Log S.D+2.075 r = 0.855

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

Chlorophyll-a (mg/m^3)	Maximum	Minimum	Mean	Standard deviation
Summer	82.29	4.38	37.75	23.10
Autumn	156.55	6.14	58.01	51.26
Total	156.55	4.38	47.88	40.56

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

Secchi disk depth (cm)	Maximum	Minimum	Mean	Standard deviation
Autumn	75	25	47.25	14.49

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

water turbidity (NTU)	Maximum	Minimum	Mean	Standard deviation
Summer	60.50	6.73	21.31	16.05
Autumn	33.00	10.01	18.69	5.42
Total	60.50	6.73	20.00	11.90

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

	Chlorophyll-a	Log Chlorophyll-a	Turbidity	Log Turbidity
Chlorophyll-a	1			
Log Chlorophyll-a	0.930**	1		
Turbidity	0.405	0.184	1	
Log Turbidity	0.302	0.075	0.960**	1

** Correlation is significant at the 0.01 level.

DISCUSSION

Phytoplankton dynamic, including their production and biomass spatiotemporal variations, is dependant to light availability [20]. It is recognized that physiological acclimation to alter in light intensity is a main factor determining variation in photosynthetic responses and growth rates of phytoplankton in nature [21].

The depth in the water column to which light pierces is determined by the amount to which it is absorbed and scattered by dissolved compounds and suspended

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

	Secchi depth	Log Secchi depth	Chlorophyll-a	Log Chlorophyll-a	Turbidity	Log Turbidity
Secchi depth	1					
Log Secchi depth	0.99**	1				
Chlorophyll-a	-0.807**	-0.846**	1			
Log Chlorophyll-a	-0.842**	-0.855**	0.934**	1		
Turbidity	-0.697**	-0.676**	0.332	0.391	1	
Log Turbidity	-0.737**	-0.707**	0.374	0.418	0.978**	1

** Correlation is significant at the 0.01 level.

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

	Chlorophyll-a	Log Chlorophyll-a	Turbidity	Log Turbidity
Chlorophyll-a	1			
Log Chlorophyll-a	0.898**	1		Turbidity
	0.217	0.188	1	
Log Turbidity	0.260	0.185	0.944**	1

** Correlation is significant at the 0.01 level.

particles contained within the water. These calculations indicate that phytoplankton are likely to be light limited when turbidities are greater than ca. 100 NTU.

Measuring chlorophyll-a concentration allows estimating the phytoplankton biomass with their spatiotemporal differences [22]. Since chlorophyll-a extent is not always possible, aquatic sciences' scientists acknowledge to use Secchi disk as an inexpensive and easy technique, because there is a strong correlation between water transparency and chlorophyll-a concentration [23].

For the relationship between the observed chlorophyll-a concentration and Secchi depth, negative non-linear correlations were revealed [12, 13, 24-26] but, ponds with high turbidity resulting from clay particles present wrong estimation about phytoplankton [27].

Line dispersal increases parallel with chlorophyll-a concentration increment and minimize this effect, data are transformed to logarithmic scale [28]. In this study, the estimated chlorophyll *a* concentrations were positively correlated with the observed chlorophyll *a*. These results supported with many researchers [12, 24, 26, 29-32].

The present results illustrated the stronger correlation between chlorophyll-a and Secchi disk compared to the previous studies, however, was very lock to these results of Hosseini and Ordog [12], Berzonic [26], Canfield and Bachmann [24] and Canfield and Hodgson [31]. Hosseini and Ordog [12] proposed that the higher correlation coefficient is related to higher reproductively in artificial lakes.

According to the obtained results, at least 86 and of total chlorophyll-a can be estimated from Secchi disk depth in the Alma Gol wetland. Results showed that Secchi depth had significant correlation to chlorophyll-a but there was not significant correlation between chlorophyll-a and Turbidity.

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