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Original Article

Assessment of the primary production statues of the international Gavkhooni Wetland, Iran

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Abstract: Wetlands are of the unique and productive ecosystems in the world. The present study was conducted to determine primary production statues of the international Gavkhooni Wetland, based on chlorophyll-a. Sampling was performed seasonally from March 2017 to February 2018. Four sampling stations were assigned based on latitude and longitude. Water salinity, temperature, pH, nitrate, phosphate, BOD5, TDS, EC, TSS and dissolved oxygen were determined in triplicate in each station. Trophy level was determined using index TSI. The results showed that there was no significant difference in mean chlorophyll-a content between the seasons. The highest and lowest chlorophyll-a contents were observed in spring and winter, respectively; and the significantly highest content was measured in the station A (Shakh Kenar). There was no significant difference in the water physicochemical parameters between the seasons (P>0.05). The mean water nitrate level of the sampling stations was 4.255 mg/l; the highest (5.07 mg/l) and lowest (3.35 mg/l) levels were recorded in the summer and autumn, respectively. The mean water phosphate level of the sampling stations was 1.082 mg/l; the highest (1.75 mg/l) and lowest (0.57 mg/l) levels were recorded to the winter and summer, respectively. The mean dissolved oxygen level during the study was 5.64 mg/l. According to the results, nitrate is the limiting factor for production in the Gavkhooni Wetland. Based on index TSI, the wetland is oligotrophic in the spring, autumn and winter, but mesotrophic in the summer.

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Introduction

Wetlands are of the unique and productive ecosystems in the world; as the annual ecological value of wetlands have been estimated 10 and 200 folds higher than those of the forests and agricultural fields, respectively (Kamandari, 2014). Wetland are marshes, pools and natural and artificial ponds, which have static or running water permanently or temporary, both saltwater and freshwater, and marine waters that have a depth of lower that 6 m in the lowest tide (Majnoonian, 2015). Gavkhooni Wetland is located in 140 km southeast of Isfahan and 30 km of the Varzaneh city (Najjari, 2003). The area climate is categorized as hyper-arid zone with annual average rainfall of 50-100 mm and average temperature of 15°C and average evaporation of more than 2800 mm (Najjari, 2003).

Phytoplanktons include many cyanobacteria and single-cell algae that have chlorophyll-a (Polladi et al., 2013). Diatoms and dinoflagellates are well-known marine phytoplanktons; whereas, diatoms, dinoflagellates, desmidials and blue-green algae are dominated in freshwaters. Despite that brown, green and blue-green single-cell flagellates are the main producers in a water body, it is hard to identify them, particularly when are presented in low number (Zaki et al., 2004). Phytoplanktons' density is season-depended. Silica phytoplanktons (diatoms) are dominated often in the spring and autumn; however, green algae are dominated in the late spring and early summer. Phytoplanktons can be used as water quality indicators, especially estimation of nutrient load in water or eutrophication. In addition, they are biological indicators of water quality change due to

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regional or global impacts such as invasion or toxic pollutants, temperature and increase in ultraviolet radiation (Rolland et al., 2009). Phytoplanktons are important for ecosystems in the case of organic materials production and placing at the base of the energy pyramid (Davis, 1955; Newell and Newell, 1977). Primary production is the biological base of an aquatic ecosystem; thus, determination of regional and global distribution of primary production is important (Martin, 2004; Leymarie et al., 2010). Chlorophyll-a is the major photosynthetic pigment in plants and its value can be used for determination of the plants biomass and an ecosystem trophic state (Brown et al., 1998; Kalytyte, 2007). Hence, this study was conducted to determine primary production statues of the international Gavkhooni Wetland based on chlorophyll-a content.

Materials and Methods

The Gavkhooni Wetland is a shallow and saline lake located in dry and arid climate of the central plateau of Iran. The wetland area and depth at the time of birds' migration is 63000 ha and 5 m, respectively (Abadi et al., 2008) and is considered as the only permanent saline lake in the central plateau of Iran. Water basin of the wetland is located at 33 and 11 to 42 and 33 northern latitudes and 50 and 2 to 53 and 24 eastern longitudes (Montazeri and Karimpoor, 2011).

Sampling was performed seasonally from March 2017 to February 2018. Four sampling stations were assigned based on the distance (12 km): station A (Shakh Kenar; 48 and 52 E to 20 and 32 N), station B (49 and 52 E to 19 and 32 N), station C (50 and 52 E to 19 and 32 N) and station D (the wetland estuary; 54 and 52 E to 16 and 32 N). Triplicate samples were taken from each station, from 10 am to 2 pm. For measurement of some water physicochemical parameters, 1 L water was taken from each station and transferred to laboratory, avoiding light and heat. Water salinity, temperature and pH were measured at the stations using a digital water checker apparatus (Hach, WTW 2000). Water nitrate and phosphate were measures according to standard methods using spectrophotometer (Clesceri et al., 1989). BOD5, TDS, EC and TSS were measures based on standard methods (Standard Method, 2012).

The index TSI was used to determine the wetland trophic state (Kerbs, 1989) as following formula: $TSI(CHL_a) = 9.81 \ln(CHL_a) + 30.6$, where CHL_a is chlorophyll-a concentration(mg/m^3). This index categorize a water body into 3 classes (oligotrophic, mesotrophic and eutrophic) using digit scale (0-100). TSI near zero is ultra-oligotrophic water and the value near 100 is hyper-eutrophic water. The most common method to determine primary production in aquatic ecosystems is measurement of chlorophyll-a based on the following formula (Kerbs, 1989):

$$P = \frac{R}{K} \times C \times 3.7$$

Where P = phytoplanktons' photosynthesis (g carbon/m^2/day), R = relative amount of light radiate to the water, K = reflection coefficient (m) and C = chlorophyll-a concentration (mg/m^3). The value 3.7 is based on gram on fixed carbon per gram of chlorophyll during 1 hour photosynthesis. The coefficient K is 0.3 for shallow wetlands (Kerbs, 1989).

Statistical analysis: Comparison of the primary production among the seasons and stations was conducted using completely randomized block (sampling stations). Data were analyzed by two way ANOVA followed by Duncan test at significance levels of 0.05. Principal components analysis (PCA) was used to analyze the main factors of the physicochemical factors. Multivariate stepwise regression was used to find relationship between chlorophyll-a content and environmental factors. All analyses were performed in software SAS.

Results

Table 1 shows water physicochemical parameters, trophic index and Carlson index (TSI) in different seasons in the Gavkhooni Wetland. There was no significant difference in the water physicochemical parameters between the seasons (P>0.05). The mean water nitrate level of the sampling stations was 4.255 mg/l; the highest (5.07 mg/l) and lowest (3.35 mg/l) levels were recorded in the summer and autumn,

Table 1. Water physicochemical parameters, trophic index and Carlson index (TSI) in different seasons in the Gavkhooni Wetland (2017-2018).

Parameter	Winter	Fall	Summer	Spring
Dissolved oxygen (mg/L)	0.81±4.87	1.1±5.32	1.14±5.45	0.67±6.95
BOD(mg/L)	0.3±2.62	0.61±2.32	0.8±1.92	0.73±2.82
Primary production (g/m^{2}day C)	1.34±11.75	1.43±13.25	1.7±12.5	1.25±14.5
pH	1.2±7.87	1.2±7.79	1.23±7.92	1.54±7.22
Temperature (˚C)	0.89±9	1.78±12.46	2.45±21.75	2.45±17.25
Salinity (ppt)	0.76±8.5	2.1±19.78	1.1±10.07	1.6±10.37
Nitrate (mg/L)	0.65±3.6	0.56±3.35	1.1±5.07	1.13±5
Phosphate (mg/L)	0.23±1.75	0.1±0.64	0.1±0.57	0.46±1.37
EC (ms/cm)	4.3±62	4.76±51.18	4.32±49	3.98±48
TDS (mg/L)	2.45±24.5	2.2±16.42	2.3±30.25	2.45±21.57
Depth (m)	0.23±1.72	0.43±1.72	0.63±2.27	0.53±2.2
Trophy Index (TSI)	38 (Oligotrophic)	39.2 (Oligotrophic)	43.2 (Mesotrophic)	35.3 (Oligotrophic)

Table 2. Results of PCA analysis in decrease in water physicochemical characteristics in the Gavkhooni Wetland (2017-2018).

Cumulative variance	Percentage of variance	Total	Component
21.3	21.76	2.97	1
43.31	20.1	1.76	2
60.43	15.97	1.32	3

Table 3. Output of cumulative percentage of water physicochemical characteristics in the Gavkhooni Wetland.

Factor	Cumulative percentage
Dissolved oxygen	0.7
BOD	0.65
pH	0.69
Temperature	0.41
Salinity	0.52
NO_3	0.72
PO_4	0.43
EC	0.96
TDS	0.93
Depth	0.62
TSS	0.49

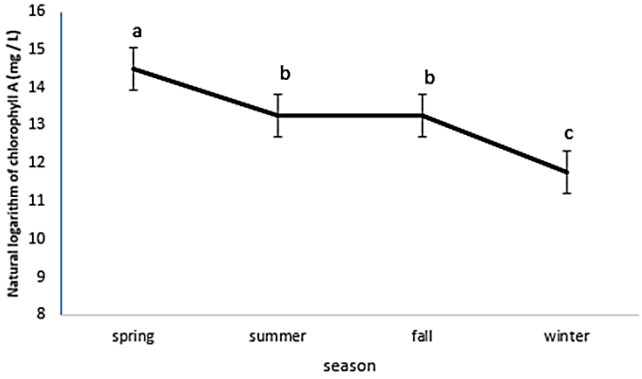

Figure 1. Mean natural log of chlorophyll-a (mg/m3) in different seasons in the Gavkhooni Wetland (2017-2018)

respectively. The mean water phosphate level of the sampling stations was 1.082 mg/l; the highest (1.75 mg/l) and lowest (0.57 mg/l) levels were measured in the winter and summer, respectively. The mean dissolved oxygen level during the study was 5.64 mg/l with the highest value in the spring (6.95 mg/l) and the lowest level in the winter (4.87 mg/l). The mean of water salinity was 12.18 ppt and the maximum and minimum levels were observed in the autumn (19.78 ppt) and winter (8.5 ppt), respectively. The highest and lowest temperatures were recorded in the summer (21.75) and winter (9), respectively; the mean value was 15.11. Based on index TSI, the wetland is oligotrophic in the spring, autumn and winter, but mesotrophic in the summer.

PCA analysis was used to determine the significant water physicochemical parameters in chlorophyll-a content. Three factors presented in Table 2 encompass 60.43 percent of total variance; thus were considered as the main factors. These factors were used in stepwise regression to find a reliable equation among the main factors. Dissolved oxygen, nitrate, EC and TDS had higher cumulative variance compared to the other factors (Table 3). The stepwise test revealed that among these parameters, nitrate was the only significant factor in chlorophyll-a content: Chlorophyll-a = 26.24 – 3.45 NO_3 (R^2=0.77)

Based on the results, water nitrate is the limiting

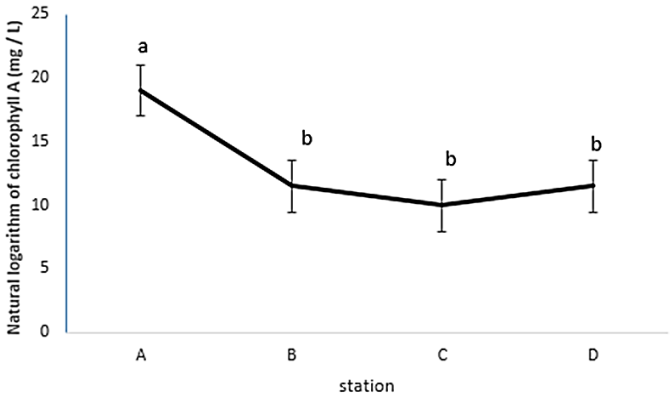

Figure 2. Mean content of chlorophyll-a (mg/m3) in different stations in the Gavkhooni Wetland (2017-2018).

factors for production in the Gavkhooni Wetland. There was no significant difference in chlorophyll-a concentrations between the stations (P>0.05) (Fig. 1). The highest and lowest chlorophyll-a contents were observed in spring and winter, respectively. The significantly highest content was related to the station A, but the lowest one in the station C.

Discussion

Wetlands are of the most important ecosystems in the world, which have unique biodiversity and high biomass, and controlling role in hydraulic systems, temperature balance, flood and storm, and role in biocontrol diseases, relation, transportation, tourism, creation, science and biosphere stock (Bennett, 2002).

Lack of a significant difference in water physiochemical parameters between the seasons could be due to the similarity of the environmental conditions. Nitrate is the limiting factors for plankton growth in the oceans; whereas, phosphate is the limiting factors in freshwaters (Camacho, 2003). According to the results, nitrate was the only limiting factor in the Gavkhooni Wetland, which is in accordance with findings of Abolhasani et al. (2013) in the Shadegan Wetland. Varela and Penas (1985) also found a strong relationship between nutrient content and phytoplankton growth. Khalife Nilsaz (2009) found no relationship between nutrient content and chlorophyll-a content in the wetland Shadegan.

The highest chlorophyll-a and dissolved oxygen concentrations were observed in the spring; the lowest found in winter. Studying the vertical distribution of dissolved oxygen in the Strait of Hormoz, Bahrami and Ebrahimi (2008) found that the highest oxygen content was at the depth 10-15 m, where the highest chlorophyll-a content was observed.

The results of the present study showed that station A had higher chlorophyll-a content than the others due to the presence of floating plants. The plants absorb water nitrate and phosphate (Li et al., 2009) and these parameters were low in the growth season in the station A. On the other hand, phosphate absorption by plant biomass and formation of insoluble and precipitated phosphorous decrease water phosphate content (Southwood and Henderson, 2000). The lowest chlorophyll-a content was observed in the station C, which may be because trees shading the water surface.

Primary production is not often variable during a year, especially in the regions with narrow climate fluctuations. In the wetlands with narrow climate change, there is often a minimum production level in the middle of winter to the early spring and a maximum level in the late spring or the autumn (Naz and Turkman, 2005). The highest chlorophyll-a content in the Wetland Gavkhooni was observed in the spring, which might be due to the deposition of nutrient in the winter, increasing water temperature and photoperiod. It is suggested that water nutrient levels increases in the winter because phytoplanktons' populations decrease markedly. This nutrient load promotes significantly the planktonic bloom in the spring (King et al., 2002). Study in the southern part of the Caspian Sea showed that the highest phytoplankton density and peak is observed in the spring (Ganjian and Makglogh, 2004). In addition, the lowest production was observed in the winter that might be due to decline in phytoplankton population. In the Baikal Lake, it was found that temperature and thermocline are effective factors on regional distribution patterns and seasonal succession (Fietz and Welch, 2005).

In the summer, rotifer of the genus *Brachionus* were dominated because of water salinity elevation and other zooplanktons are low in number (Kotani et

al., 2005). As a result, high production was observed in the summer and autumn.

According to the wetlands trophic classification based on chlorophyll-a (Camacho, 2003), the Gavkhooni Wetland, with chlorophyll content of 13.18 mg/m^3, is categorized as mesotrophic. As the wetland receives agricultural wastewaters, this may increase the water nutrients; this might be positive now, but in the future, this may lead to ecological revolution in the wetland (Galbraith, 2005) and it is potentiated to reach eutrophic state.

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چکیده فارسی

ارزیابی وضعیت تولید اولیه تالاب بین المللی گاوخونی ایران

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چکیده:

تالاب ها از جمله اکوسیستم‌های منحصر به‌فرد و از پر تولیدترین محیط‌های جهان می‌باشند. این تحقیق با هدف تعیین وضعیت تولید اولیه بر مبنای کلروفیل a در تالاب بین المللی گاوخونی انجام گرفت. نمونه‌گیری به‌طور فصلی ازفروردین ۹۶ الی اسفند ۹۶ انجام گرفت. در مجموع ۴ ایستگاه با توجه به طول و عرض جغرافیایی در نظر گرفته شد. در هر ایستگاه پارامترهای شوری، دمای آب، pH، نیترات، فسفات، BOD_5، TDS، EC، TSS و اکسیژن محلول با سه تکرار اندازه‌گیری شد. برای تعیین سطح تروفی از شاخص TSI استفاده شد. نتایج نشان داد تفاوت معنی‌داری در میانگین کلروفیل a بین فصل‌ها وجود نداشت. تغییرات فصلی کلروفیل نشان داد که بیشترین میزان کلروفیل a در فصل بهار وکمترین آن در فصل زمستان می‌باشد، همچنین میانگین کلروفیل a در ایستگاه A (شاخ کنار) بیشتر از دیگر ایستگاه‌ها بود. تفاوت معنی‌داری در پارامترهای فیزیکوشیمیایی آب در فصول مختلف مشاهده نشد ($P<۰/۰۵$). میانگین نیترات در ایستگاه‌های مختلف ۴/۲۵۵ میلی‌گرم در لیتر بود و به ترتیب در فصل تابستان و پاییز بیشترین و کمترین (به میزان ۵/۰۷ میلی‌گرم در لیتر و ۳/۲۵ میلی گرم در لیتر) مقادیر آن مشاهده گردید. بیشترین و کمترین مقادیر فسفات در فصل زمستان و تابستان مشاهده شد (به میزان ۱/۷۵ میلی گرم در لیتر و۰/۵۷ میلی گرم در لیتر) و میانگین آن ۱/۰۸۲ میلی گرم در لیتر بدست آمد. میانگین اکسیژن محلول در کل دوره نمونه برداری ۵/۶۴ میلی گرم در لیتر بود. نتایج نشان داد که تالاب گاوخونی از دسته تالاب‌هایی است که در آن، نیترات عامل محدودکننده تولید به‌شمار می‌رود. در بررسی سطح تروفی تالاب به‌وسیله شاخص TSI، تالاب در فصل بهار، پاییز و زمستان در وضعیت الیگوتروف و در فصل تابستان در وضعیت مزوتروف بود.

کلمات کلیدی: کلروفیل آ، ارزیابی، وضعیت تولید اولیه، فاکتورهای فیزیکوشیمیایی.