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Temperature Rising (Two Celsius) Effect on Planktonic Biomass in Subtropical Marshes, Iraq

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Abstract: Planktonic species may respond to climate change through their niche across three axes which include self, space and time. This study was designed to investigate the effect of increasing winter temperature on the plankton biomass, the mesocosm was constructed as a collection of 16 enclosures with a water-outlet system and natural sediment, two aquatic plant species and heating system. This research was conducted over 12 weeks (beginning on Dec. 2018) when the temperature of eight enclosures was 2±0.2 °C higher than the ambient temperature. Weekly abiotic parameters (salinity, pH, PO_4, NO_3, DIC) and biotic (chlorophyll-a, zooplankton and phytoplankton biomass) were reported. The obtained results showed that there were no major improvements in salinity, pH, PO_4, NO_3 and dissolved inorganic carbon (DIC). Whereas, chlorophyll-a, zooplankton and phytoplankton biomass have dramatically improved. Therefore, this research has indicated that water temperature change during the winter season due to climate change could affect planktonic biomass and early spring in subtropical marshes, but this study was performed in the mesocosm experiment and it needs to be studied in large-scale natural lake ecosystems.

Keywords: Plankton biomass, Subtropics, Climate changes, Ecosystem, Temperature, Marshes

Introduction

Recent predictions suggest that earth's surface can warm on the average by a 1.5 to 4 °C, over following century (Stocker et al., 2013; O'Gorman et al., 2016). In the subtropical areas, rainfall predicted to increased and get more intense and frequent through the end of the current (Feng et al., 2018). The heavy precipitation will also drive the higher input of nutrients describe the abbreviation dissolved inorganic carbon (DOC), and describe the abbreviation DIC from terrestrial runoff (Nicolle et al., 2012). The species could respond to climate change according to their niche through three axes includes self, space and time (Bellard et al., 2014). Variations in temperature can even have impacts on key biological processes, for example primary productivity is changing in response to warming due to climate change, so climate variability powerfully influences productivity (Hoegh-Guldberg & Bruno, 2010).

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The factors that almost limit the increasing of phytoplankton biomass include the light availability, nutrients (Marzolf, 1990; Begon et al., 2006), salinity (Al-Khalidy & Al-Haidarey, 2019), CO_2 concentration (Hamdan et al., 2018), herbivores (Kankaala et al., 2010) and temperature (Criado et al., 2018). Global warming could hold up the annual variation of phytoplankton community structure (Schwartz, 2003). At higher temperature, the planktonic species which grow superior and have a specially adapted to the different light environment could obtain a competitive utility from that change in aquatic ecosystems (Paerl & Huisman, 2008).

The warmer autumn and winter periods could promote the prolonged, early, and higher biomass of phytoplankton (De Senerpont Domis et al., 2013), also expanding the energetic period of zooplankton (grazers) which keeps feeding on phytoplankton partly as nutrients are not as limiting factors (Adrian & Deneke, 1996; Chen & Folt, 1996; Adrian et al., 2006; Sommer & Lewandowska, 2011). Generally, the zooplankton size is affected by global warming, as the larger size species be dominant with a colder climate, while the smaller size species are more adapted to the warmer environment (Atkinson et al., 2003; Peter & Sommer, 2012).

Theoretically, some studies (Parmesan, 2006; Daufresne et al., 2009) mentioned that warming causes dominants to smaller body size species which tend to faster-growing (Kiørboe, 2009) and an increase in the percentage at the community scale leading to increasing of planktonic biomass. The induction of plankton community dynamic from late winter-early spring has not been tested yet. Mesocosm experiments have been widely used to grasp the mechanisms which leading processes at the plankton food-web level. Also, mesocosm used to exam how interaction plankton to physicochemical variables (Stewart et al., 2013). Promote by these recent advances, the current study was designed multi-weeks (12 weeks) mesocosm to investigate how elevated temperature affects plankton biomass.

In marshes of the subtropics, the highest productivity and biomass of planktons are over late winter and spring, but with increasing of temperature, due to climate changes, thus it was hypothesized that increasing temperature during winter will firstly cause plankton to change toward production of highest biomass and secondly prolong the early growing season entailing the higher plankton production later in the season.

Materials and Methods

Mesocosm designed as set of sixteen enclosures (one m^3 volume) contain a natural sediments and two types of aquatic plants: floating (*Lemna minor*) and submerged (*Hydrilla* sp.) which had been collected from the standing pool marsh that joins the Euphrates river, Iraq (Figure 1), filled with water (input and outlet flow system) and supplied with heating system. During subtropics winter (the first week of Dec. 2018 until the last week of Feb. 2019, at University of Kufa, Iraq), the temperature of eight enclosures was 2±0.2 ºC elevated compared with ambient. In each enclosure, salinity (Sal), water temperature (WT) and pH ware measured by a sensors of Multi 340i meter (WTW-Germany). Also, 40 ml of water samples was filtered through 0.45 Millipore filter papers and stored in 50 ml Falcon tubes in the freezer to measure dissolved inorganic carbon (APHA, 2012), PO_4 (ISO, 2008) and NO_3 (ISO, 1996). Chlorophyll-a samples were taken by filtering 100 ml of water through 0.45 µm Millipore filter. Filters were directly covered in aluminium foil and stored at -20 °C (Parsons et al., 1984). Phytoplankton and zooplankton biomass samples were collected from planktonic net (20 µm mesh size) and preserved with Lugol's solution. Phytoplankton was identified according to Thomsen (1992) and Tikkanen & Willen (1992). Geometric formulas were then used for dominant species for determining bio volumes, which were converted to biomass (µg/l wet weight) using a density of 1g cm-3 (Wetzel & Likens, 2000; Lau et al., 2007). Zooplankton were classified and measured using inverted microscopy. The volume of individuals was measured and converted to dry weight using length-weight regressions (Bottrell et al., 1976). The carbon content was estimated as 50% of dry biomass (Salonen et al., 1976).

IBM-SPSS statistics 24 was used to test treatment responses versus ambient. Two-tailed t-test and repeated measures two way ANOVA were applied to test the variability and the statistical significance of this experiment. In addition, Pearson’s correlation coefficient is considered to test the correlation among the different variables. Treatment effect are considered statistically significant as P-value <0.05.

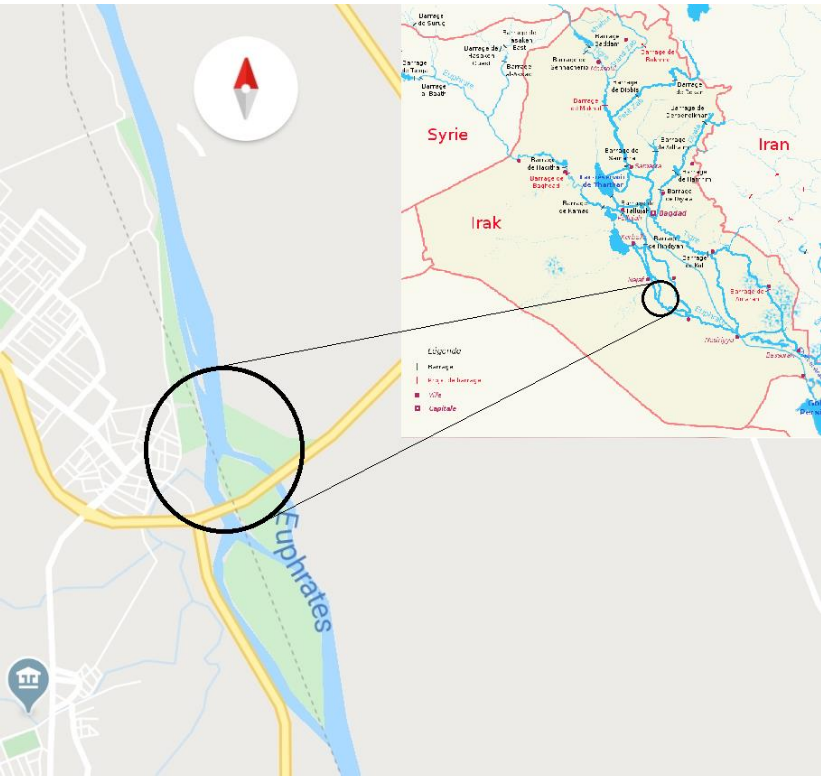

Figure 1: The site of the river from which researchers took sediment and aquatic plants (31°56'20.2"N 44°28'44.7"E).

Results and Discussion

Normally, the water temperature of subtropical lakes decreased in winter then it will be slightly increased during end of winter and early spring (Al-Haidary & Al-Zurfi, 2014; Al-Zurfi & Al-Haidarey, 2015). So, according to that, this experiment was designed. Based on rising temperature of treatment enclosures 2±0.2 ºC (Figure 2), there were no significant changes in salinity, pH, PO_4, NO_3 and DIC (Table 1),

Al-Khalidy & Al-Haidarey (2019) mentioned that the salinity plays as a key driver of phytoplankton biomass and chlorophyll-a. In the current study, the salinity concentration ranged between 0.637±0.217 ppt to 0.75±0.083 ppt in control and treatment enclosures, respectively (Table 1), but there was no significant changed variation/ differentiation due to changed temperature (P-value of T-test >0.05). Therefore, in the current study, the salinity was not related with plankton biomass and primary production (P-value of correlation >0.05).

Usually pH plays an important role in redox-potential reactions in aquatic ecosystems. In this work, pH ranged between 7.875±0.435 to 7.738±0.070 in control and treatment enclosures, respectively (Table 1), but it was not responded significantly due to elevated temperature (P-value of T-test >0.05). Thus, pH did not play an important role to driving the biomass of plankton or chlorophyll-a (P-value of correlation >0.05).

Nutrients, as part of top-down factors, could play a significant role in driving the plankton biomass and primary production (Shi et al., 2017). In the present study, when comparing nutrients (PO_4 and NO_3) of control and treatment enclosures, no changing in nutrients concentration due to changes of temperature (Table 1) was noted. Also, their concentrations were not significantly correlated with the primary productivity (chlorophyll-a) and planktonic biomass (P >0.05).

Dissolved inorganic carbon (DIC) could be affected by various environmental factors. The value of DIC is also affected by both pH and WT (Le et al., 2016). In spite of the importance of DIC in photosynthesis and increasing of biomass (Hamdan et al., 2018), the present study concluded that DIC was not affecting plankton biomass and chlorophyll-a (P-value of regression >0.05) and this agrees with Al-Khalidy & Al-Haidarey (2019). Also, DIC was not affected by elevated temperature (P-value of T-test >0.05).

On the other hand, as shown in Figure 3 and Table 1, there were significant changes in chlorophyll-a, and zooplankton and phytoplankton biomass (P-value of T-test ≤0.01). Also, there were a significant correlation of WT with chlorophyll-a and planktonic biomass (P-value of regression ≤0.01). Previous work (Weyhenmeyer et al., 2012) has found that the environmental factors which affected by seasons, like water temperature, play as a key driver of plankton biomass and primary production. Therefore, in response to the elevated temperature of mesocosm, the potential shift of the ecosystem was dramatically changed toward early spring conditions in treatment enclosures causes significant shifting in the plankton biomass and slightly depletion in nutrients.

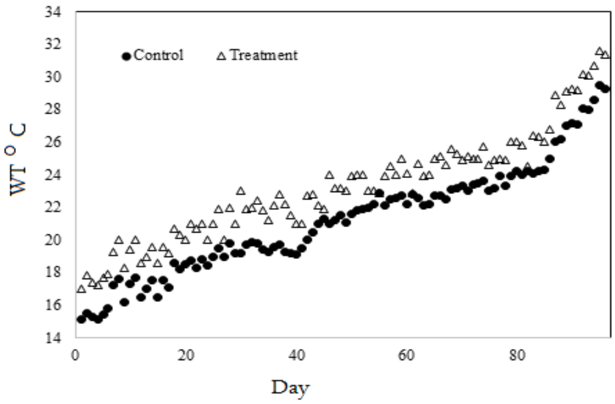

Figure 2: Means of water temperatures (°C) in control and treatment enclosures during the study period.

Table 1: Mean ± standard deviation of control and treatments, regression P-value and t-test of studied variables.

Variables	Control (±SD)	Treatment (±SD)	P-value of regression with WT	T-test (P-value)
WT (◦C)	21.220 (±3.363)	23.2 (±3.318)	-	<0.01*
DIC (µMol/l)	111 (±41.116)	109 (±10.731)	0.222	0.863
NO_3 (µg-N/l)	10.588 (±6.352)	13.9 (±8.260)	0.506	0.414
PO_4 (µg-P/l)	0.128 (±0.052)	0.1 (±0.033)	0.496	0.255
pH	7.875 (±0.435)	7.738 (±0.070)	0.658	0.423
Salinity (ppt)	0.637 (±0.217)	0.75 (±0.083)	0.098	0.221
Phytoplankton biomass (µg.C/l)	6.071 (±0.906)	8.265 (±0.303)	<0.01*	<0.01*
Zooplankton biomass (µg.C/l)	0.550 (±0.071)	0.288 (±0.036)	<0.01*	<0.01*
Chlorophyll-a (µg/l)	0.814 (±0.267)	2.725 (±0.893)	<0.01*	<0.01*

*Significant.

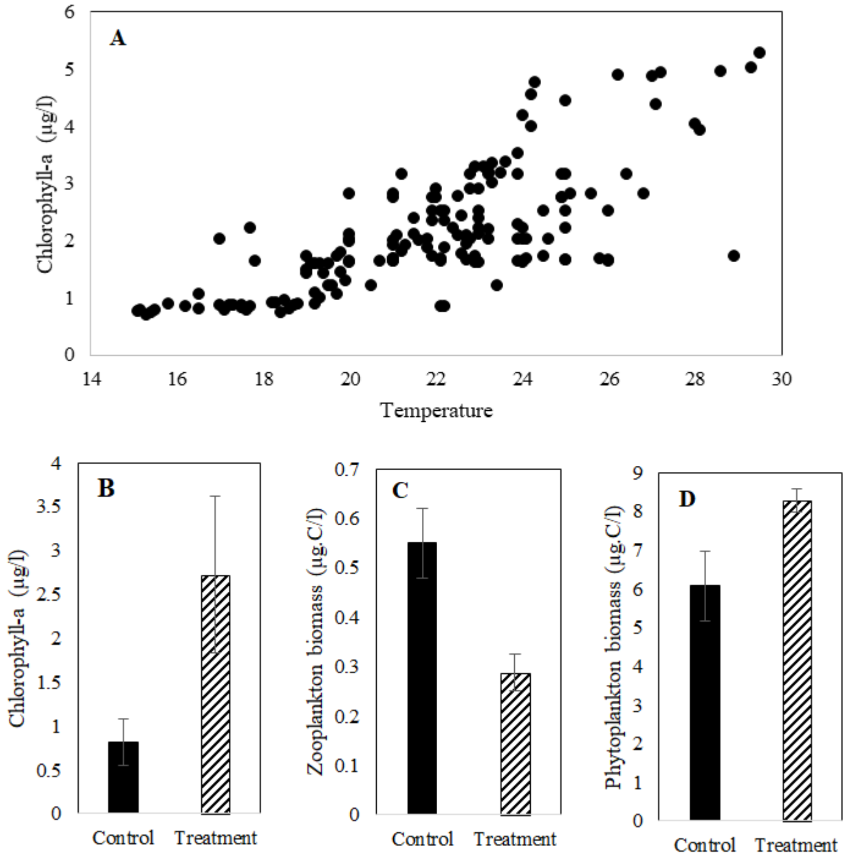

Figure 3: The significant correlation of the chlorophyll-a with water temperature (A), and the differences between control and treatment of chlorophyll-a values (B), zooplankton biomass (C) and phytoplankton biomass (D).

Conclusions

Through this study, the salinity, pH, nutrients, which include phosphate, nitrate and DIC were not affected by rising water temperature, and did not play as main role drivers to plankton biomass, while climate changes could be the main key driver to plankton biomass in the subtropics. This study also concluded that the increase of temperature might cause shifting in plankton biomass like that which happened in spring.

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