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Effect of Temperature, Salinity, and Nutrients on Phytoplankton Diversity and Community Composition in Artificial Fish Farms in Basrah, Iraq.

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Abstract

The study is important to investigate the relationship between temperature, salinity, and nutrients and the diversity of the phytoplankton community in artificial fish farms in Basrah, Iraq. The study was carried out in four fish farms, two located in Abu Al-Khasib and two in Al-Sayba, during winter (January) and summer (July) of 2025. Water temperature, salinity, pH, and nutrients (NO_3, PO_4, and SiO_3) were measured in fish farms. Phytoplankton samples were collected by using a net with a 20 μm mesh diameter. The results showed clear seasonal variations in phytoplankton abundance and species composition. A total of 53 species of phytoplankton were observed. Bacillariophyta had 35 species (59%), followed by Chlorophyta (17%) belonging to 6 species, Cyanophyta (14%) belonging to 6 species, Euglenozoa (7%) belonging to 4 species, and Dinophyta (3%) belonging to 2 species. Water temperature ranged from 5 to 34°C, salinity from 3.7 to 13.1 ppt, and pH from 7.8 to 8.5. The statistical analysis showed significant differences in phytoplankton composition, water temperature, and salinity among stations and seasons ($p < 0.05$), and no significant differences in pH among stations and seasons ($p > 0.05$). The reactive nitrate ranged from 1.3 to 4.2 µg/l. The reactive phosphate levels ranged from 0.02 to 0.11 µg/l, whereas the reactive silicate levels ranged from 31.5 to 90.4 µg/l; NO_3, PO_4, and SiO_3 all showed significant differences across all sites and seasons ($p < 0.05$). The Shannon - Weiner index (H`) values ranged from 2.1 to 1.2 and recorded significant differences in all sites and seasons ($p < 0.05$). The higher temperatures and salinity levels during the summer were related to the increased dominance of cyanobacteria, green algae, and diatoms. Statistical analysis mentions that temperature, salinity, and nutrients were the main factors influencing phytoplankton distribution and diversity. The results highlight the importance of monitoring environmental parameters to maintain ecological balance and productivity in artificial aquaculture systems.

Keywords: Abu Al-Khasib, Artificial Fish Farm, Al-Sayba, Environmental parameters, Phytoplankton

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Introduction :

Food security is a basic pillar for achieving sustainable development worldwide (Varzakas and Smaoui, 2024). Lately, the demand for fish and seafood has increased significantly, driven by global population growth, evolving dietary habits, and an increasing need for nutritious food options (Garlock *et al*., 2022). Over the past two decades, the reduction of wild fish stocks has led to great depletion in fisheries production (Garlock *et al*., 2022). Consequently,

aquaculture has obtained prominence and experienced rapid expansion, emerging as a key solution to meet the rising demand for both freshwater and marine products, as well as animal protein for human consumption (Hua *et al.*, 2019).
One of the fundamental challenges confronting aquaculture is the rising cost of feed, specifically feeds based on fish meal. Phytoplankton, as primary producers, play an important role in sustaining higher trophic levels by providing essential nutrients through photosynthesis. However, phytoplankton are highly sensitive to environmental factors, which can affect their physiological characteristics so, the quality and quantity of food available to higher trophic organisms (Kang *et al.*, 2017; Lee *et al.*, 2020). In artificial fish farms, phytoplankton serve as an essential food source, especially for herbivorous aquatic species, and are considered a cost-effective alternative or supplement to conventional feed (Yisa, 2006; Bwala *et al.*, 2009). Water, on the other hand, forms the main environment in that aquatic organisms perform vital functions such as feeding, breeding, digestion, and excretion (Bronmark and Hansson, 2005). The quality of water in fish ponds is determined by the interplay of various physicochemical factors, which can significantly impact pond productivity as well as the overall health and well-being of the fish (Anetekhai *et al.*, 2018). The small waterbodies, such as ponds, can provide a more diverse phytoplankton community than a single large one (Bolgovics *et al.*,2019), calling for spatial variance on phytoplankton diversity in freshwater systems, and the limited connectivity among aquatic environments leads to a reduction in the regional biodiversity in the ponds (Carneiro *et al.*, 2024; Scheffer *et al.*, 2006). Increases in different environmental conditions and resource availability are expected to positively affect phytoplankton abundance, such as the temperature,which can change the solubility of gases like CO_2 and O_2 dissolved in water, which are important for photosynthesis and metabolism. It is easier to dissolve these gases at low temperatures than at high ones and speed up photosynthesis. (Neori and Holm-Hansen 1982; Takarina *et al.*, 2019). Local limnological pond characteristics, like age, area, and perimeter, along with landscape factors like land use and connectivity, influence variables and phytoplankton dynamics. Larger connectivity may lead to less nutrient amount due to the effect of high-quality streams, indirectly reducing phytoplankton abundance while facilitating species richness through colonization. Pond age is very important for both phytoplankton abundance and richness, which affect comprehensive functional diversity within ponds (Tulsankar *et al.*, 2020; Oertli and Parris, 2019; Bichsel *et al.*, 2016). The presence and growth of phytoplankton in the pond water is influenced by environmental conditions such as light, temperature, and concentration of nutrients in the water. (Yusoff *et al.* 2002). However, Basrah still lacks comprehensive studies that investigate how environmental variables such as temperature, salinity, and pH shape phytoplankton community structure in artificial fish ponds. In contrast, numerous studies from other countries have extensively examined similar ecological relationships, such as the work of (Carneiro *et al.*, 2024) on diversity of phytoplankton in artificial ponds (Tambaru *et al.*, 2024) on diversity of phytoplankton and its relationship with environmental parameters(Palupi *et al.*,2022) on diversity of phytoplankton in shrimp ponds (Takarina *et al.*,2020) on diversity of phytoplankton in shrimp farming, and (Takarina *et al.*,2019) on diversity of phytoplankton and its relationship with environmental parameters.

Despite the important role of phytoplankton in maintaining ecological stability in fish ponds, the impact of environmental factors such as salinity, temperature, and pH on the composition of the phytoplankton community in artificial ponds in Basrah remains poorly understood. This gap explains the need for a detailed analytical investigation to improve water quality management and support sustainable aquaculture in the region.

Materials and Methods

Study area:This study was conducted at four artificial fish farms—Abu Al-Khasib 1 (30° 26' 06.58" N 48° 03' 31.91" E), Abu Al-Khasib 2 (30° 25' 26.10" N 48° 05' 43.96" E), Al-Sayba 3 (30° 22' 18.25" N 48° 10' 01.97" E), and Al-Sayba 4 (30° 21' 31.49" N 48° 10' 12.40" E). These farms receive water through the irrigation canal that extends for 20 km from the Kutaiban area north of Basra to avoid the effects of the saline tongue from the Arabian Gulf. The canal runs parallel to the Shatt al-Arab for 40 km before crossing to the other side of the river. The canal is designed to discharge 30 $M^3S^{-1}$and extends to the Ras al-Bisha area, reaching the city of Al-Faw, 110 km south of Basrah. This canal is lined with concrete to secure freshwater supply in Basrah and surrounding areas such as Abu al-Khasib and Al-Sayba(Figure 1).

Sample Collection and physicochemical Analysis:

Water temperature, pH, and conductivity at each fish farm site were measured by using a handheld Manta 2 (Eureka, USA). NO_3, PO_4, and SiO_3 were determined according to (APHA 2005). The salinity was calculated according to (Mackereth *et al.* 1978). Phytoplankton samples were collected during winter (January) and summer (July) of 2025 from four different artificial fish farms by filtering 40 liters of subsurface water through a phytoplankton net of 20 µm mesh diameter at a depth of approximately 20-30 cm. Collected samples were stored in plastic bottles, and preservative formalin (4%) was added (APHA, 2000).

Phytoplankton Identification and Diversity Index:

For non-diatom species, one drop was put on a glass slide and covered with a coverslip, and examined directly under a microscope with 40x magnification. For diatom species, all organic material and siliceous frustules were oxidized and removed to observe the structure through microscopic examining and species identification, based on (Al-Handal and Wulff ,2008). We mixed 10 mL of diatom suspension with 20 mL of H_2O_2 (30 %) and boiled it for 30-45 minutes until it returned to 10 mL; after that, we washed with distilled water and filtered it using filter paper (Whatman No. 1). To prepare permanent slides, we used Naphrax®. Permanent slides were examined under a microscope with 100x magnification. Algae were identified according to the classification systems of Desikachary (1959); Prescott (1982), and Guiry and Guiry (2019).

Shannon -Weiner diversity index (H`) Shannon and Wiener (1949)

H` =- Σpilnpi, Where:

‘pi’ equals ni/N.

ni: number of individuals in each species

N: the total number of individuals in the sample

Statistical analysis: A one-way analysis of variance (ANOVA) was used to test for significant differences at a probability level of $P < 0.05$, using Statistical Package for the Social Sciences (SPSS, version 26). All treatments were performed in triplicate.

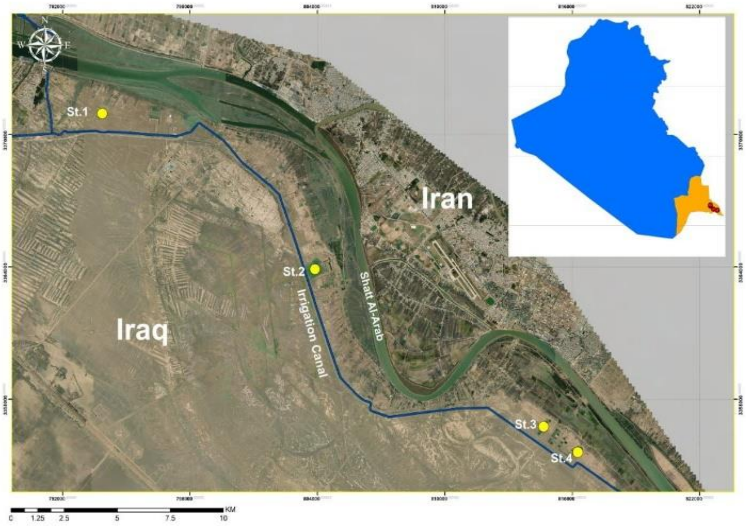

Figure (1): Shows sample collection sites from artificial fish farms in Basrah during winter (January) and summer (July) of 2025.

Results and Discussion

Water temperature ranged between 5 and 34ºC. Figure (2). These are within or slightly above the optimal range for phytoplankton growth, indicating that thermal conditions in the ponds were generally proper for assisting primary productivity during most of the study period. The optimal temperature for phytoplankton growth is 20-30°C. (Mesquita *et al.*, 2020). Thermal changes can enhance biodiversity in freshwater habitats by choosing more suitable groups, such as cyanobacteria and chlorophyta (Rasconi *et al.*,2017; Sarker *et al.*,2020). The result showed significant differences in temperature values among stations and seasons ($p < 0.05$). Salinity values ranged between 3.7 and 13.1. ppt Figure (3), it is one of the fundamental environmental factors that influences the occurrence and distribution of the planktonic community (Sridhar *etal.*,2006, Rahaman *etal.*,2013), diatoms are able to adapt to salinity stress through changes physiological pigment content, growth rate, and metabolism (Wen *etal.*,2023), The result showed significant differences in salinity values among stations and seasons ($p < 0.05$). proposition that osmotic stress probably shares in the change in phytoplankton abundance and their dominance, especially at sites with high salinity levels. pH values ranged between 7.8 and 8.5. Figure (4) shows no significant differences in pH values among stations and seasons ($p > 0.05$). The observed pH value is usually stable and doesn't change much. It is still in the range that phytoplankton needs to grow and thrive. A pH level below 7.0 or above 8.5 can inhibit phytoplankton from growing (Yang *et al.*, 2019). So, the pH range that was observed likely supported phytoplankton populations persistence and stability at all of the sampling sites. Reactive nitrate ranged from 1.3 to 4.2 µg /l (Figure 5), and reactive phosphate ranged from 0.02 to 0.11 µg/l (Figure 6).

S1 and S2 had more diversity in species due to their proximity to agricultural lands, where phosphate is very important for phytoplankton in metabolic processes (Lin *et al.* 2016). High nitrate levels stimulate phytoplankton growth (Cira *et al.* 2016; Takarina *et al.* 2019), which provides nutrient inputs, whereas the reactive silicate ranged from 31.5 to 90.4 µg/l (Figure 7). The high levels of SiO_3 in summer indicate that temperature can make silicate dissolve and release from the bottom sediments into the water systems. (Frings *et al.*, 2016; Beusen *et al.*, 2022). Both NO_3, PO_4, and SiO_3 recorded significant differences in all sites and seasons ($p < 0.05$). Highlighting the role of nutrient dynamics affect the structure of phytoplankton. The Shannon- Weiner index (H`) values ranged from 1.2 to 2.1 (Figure 8), with the highest in S2 in summer at 2.1 and the lowest in S2 in winter at 1.2, and recorded significant differences in all sites and seasons ($p < 0.05$). Due to suitable environmental conditions such as available nutrients and little pollution, or zooplankton nutrition (Ghosh *etal*.,2012; Akter *etal*.,2015).

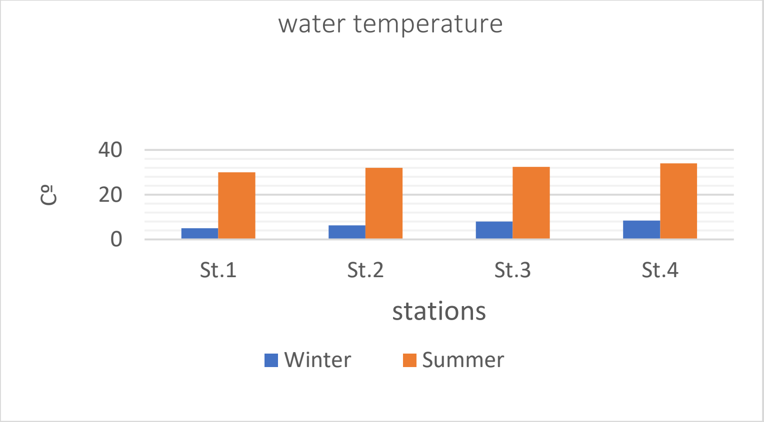

Figure (2): Water temperature recorded in artificial fish farms during winter (January) and summer (July) of 2025.

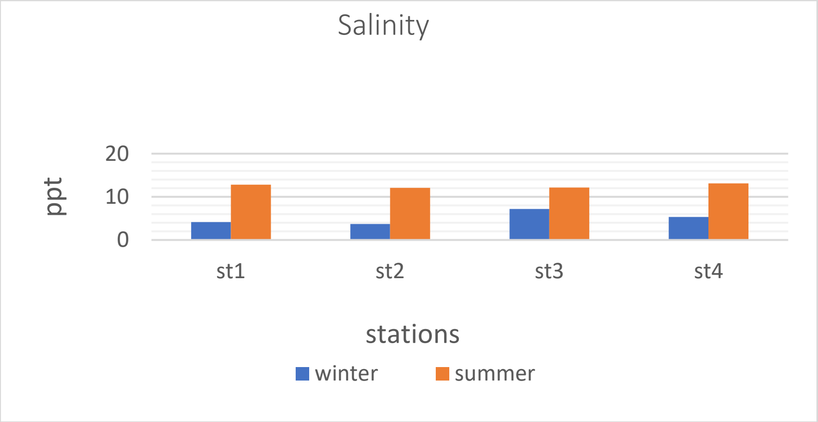

Figure (3): Salinity recorded in artificial fish farms during winter (January) and summer (July) of 2025.

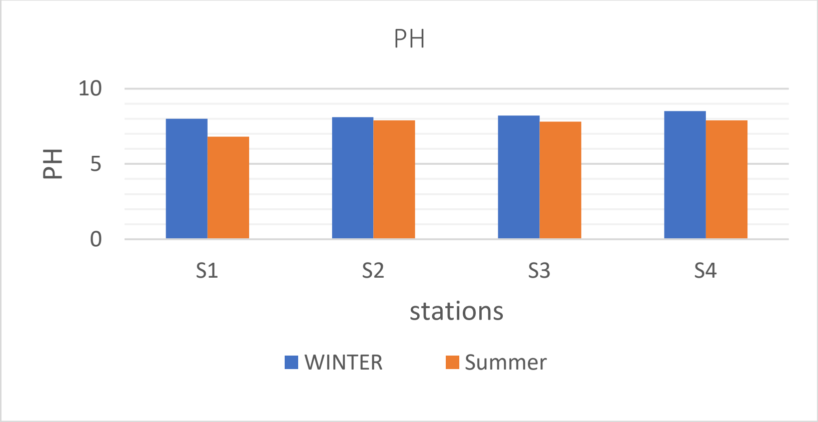

Figure (4): PH recorded in artificial fish farms during winter (January) and summer (July) of 2025.

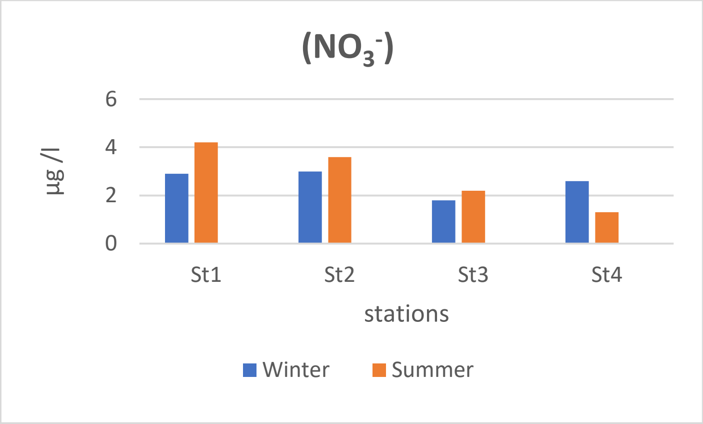

Figure (5): Reactive Nitrate recorded in artificial fish farms during winter (January) and summer (July) of 2025.

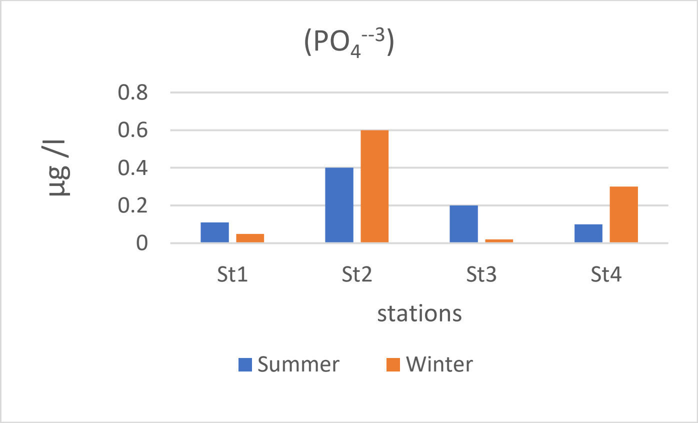

Figure (6): Reactive Phosphate recorded in artificial fish farms during winter (January) and summer (July) of 2025

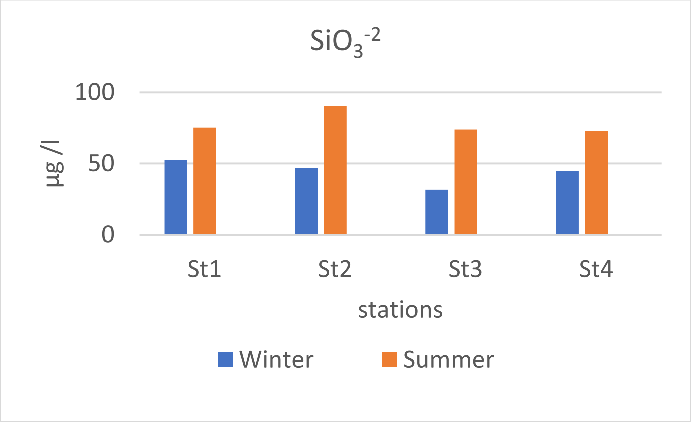

Figure (7): Reactive Silicate recorded in artificial fish farms during winter (January) and summer (July) of 2025.

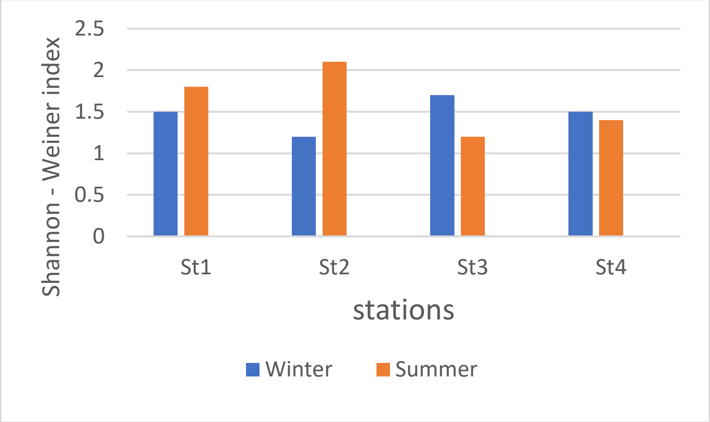

Figure (8): Shannon -Weiner index recorded in artificial fish farms during winter (January) and summer (July) of 2025.

Based on observation and identification of phytoplankton, 53 species belonging to 29 genera were recorded from four stations. There were 5 phyla, namely Bacillariophyta (17 genera, 59%), Chlorophyta (5 genera, 17%), Cyanophyta (4 genera, 14%), Dinophyta (Miozoa) (2 genera, 3%), and Euglenophyta (1 genus, 7%). This study discovered that Bacillariophyta possessed the highest number of genera among phytoplankton classes because they can adapt to a wide range of environments compared to genera from other groups. They have a shorter life cycle and reproduce faster. Genera such as *Nitzschia* was one of the most common genera recorded (5 species) at all sites due to tolerance of environmental conditions Lavoie *etal* .(2017). Significant differences in algae among stations and seasons ($p < 0.05$) as shown in Figure 9. Diatom species are more sensitive to changes in their environment and can quickly adapt (Prelle *et al.* 2019). Also, changes in the structure of phytoplankton communities are reliable indicators of water quality and ecosystem health because they demonstrate how quickly and in a complicated way they respond to changes in the environment, such as *Chlorella vulgaris* appearing in all sites and seasons. It has adapted to the environment, which makes it a major subject for researching how stress resistance works at the single-cell level (Mu *et al.*, 2016). Species that appeared in summer were *Anabaena flos-aquae, Scenedesmus quadricauda, Euglena gracilis, Euglena polymorpha, Euglena sanguinca, Euglena viridis, Epithemia adnate, Navicula viridula, Nitzschia palea,* and *Thalassiosira spinose* (Table 1). *Euglena sp*. occurred at the study sites due to its high adaptability to elevated temperatures and availability of nutrients and organic matter (Graham *etal*.,2016).S_1 and S_2 had more diversity in species due to their proximity to agricultural lands, which provide nutrient inputs and reflect favorable thermal and nutrient conditions, while *Halamphora veneta* appeared in winter at the study sites due to its tolerance of nutrient-rich waters, moderate temperatures, slightly alkaline pH, and variable salinity (Reynolds, 2006).

Water quality is also affected by nutrient content discharged from aquatic waste around the farming site (Adhikari *et al*. 2017; Emabye and Alemayo 2020). The results showed that environmental parameters across the study sites played an important role in determining the structure of phytoplankton, which is consistent with the results of Wen *et al*. (2020) considering the phytoplankton's sensitivity to delicate changes in salinity and dissolved oxygen. The lower phytoplankton density observed at sites with high salinity can be explained by the reduced tolerance of many species to osmotic stress. The results are also inconsistent with international studies such as Smith *et al*. (2021), which demonstrated that aquatic systems affected by thermal fluctuations and salinity variations often These results indicated that phytoplankton structure in Basrah is strongly influenced by subtle environmental variations, highlighting the importance of monitoring water quality experience shifts in species dominance and the appearance of indicator species reflecting water quality.

in fish ponds due to its role in supporting the food chain and determining aquaculture productivity.

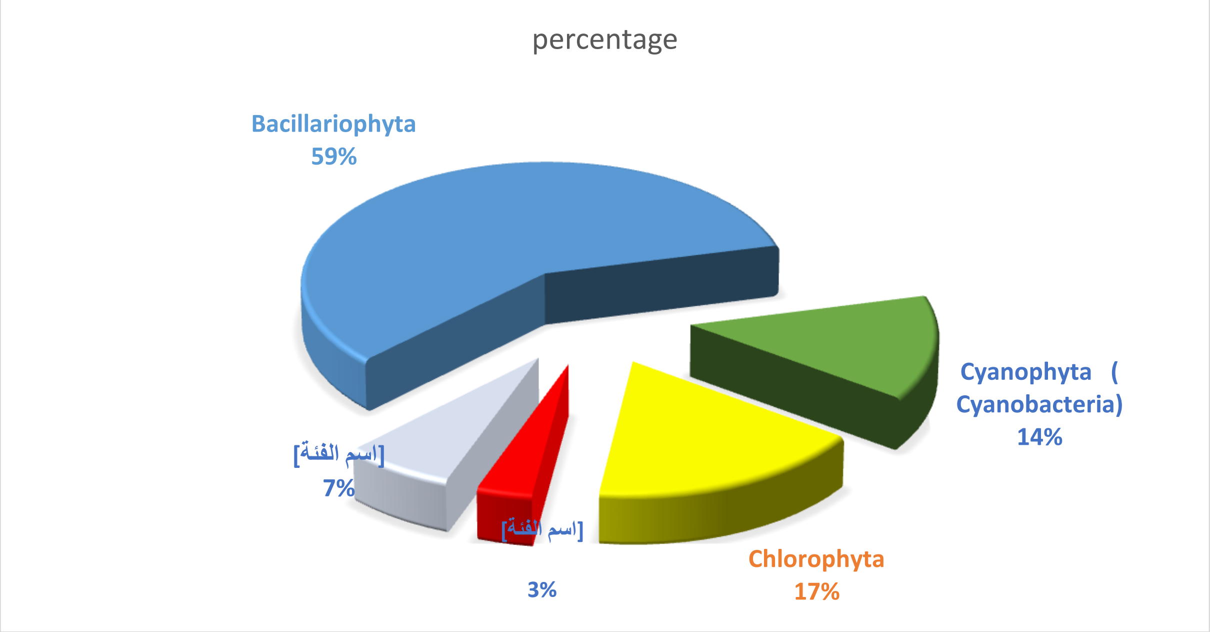

Figure 9: Phytoplankton percentage recorded in artificial fish farms during winter (January) and summer (July) of 2025.

Table (1): Phytoplankton species recorded in artificial fish farms during winter (January) and summer (July) of 2025.

No.	Species **stations**	S1-w	S1-s	S2-w	S2-s	S3-w	S3-s	S4-w	S4-s
	Cyanophyta (cyanobacteria)								
1	*Anabaena flos-aquae*(Bornet&Flahault) Elenkin	-	+	-	+	-	-	-	+
2	*Arthrospira jenneri* Forti,	-	-	+	-	-	-	-	-
3	*Phormidium ambiguum* Gomont	+		+	-	+	+	-	+
4	*Oscillatoria limosa* C.Agardh ex Gomont,	-	+	+	+	-	-	+	-
5	*O. pulrida* Lemm.	+	-	-	-	+	-	-	-
6	*O. tennis* Lemmermann,	-	-	+	+	-	+	-	+
	Chlorophyta								
7	*Ankistrodesmus falcatus* (Corda) Ralfs	-	+	-	-	-	-	+	-
8	*Carteria cordiformis* (H.J.Carter) Diesing	+	+	+	-	-	-	+	-
9	*C. klebsii* Klebs	-	+	-	+	+	-	+	-
10	*Chlamydomonas angulosa* O.Dill	-	+	+	-	-	+	+	-
11	*Chlorella vulgaris* Beijerinck	+	+	+	+	+	+	+	+
12	*Scenedesmus quadricauda* (Turpin) Brébisson,	-	+	-	-	-	-	-	+
	Euglenophyta (Euglenozoa)								
13	*Euglena gracilis* Ehrenberg	-	+	-	-	-	+	-	+
14	*E.polymorpha P.A.Dangeard*	-	+	-	-	-	+	-	+

15	*E. sanguinca* Ehrenberg	-	+	-	-	-	+	-	-
16	*E. viridis* Ehrenberg	-	+	-	-	-	-	-	+
	Dinophyta**(Miozoa)**								
17	*Glenodinium* pulvisculus Stein	-	+	+	+	-	-	-	-
18	*Peridinium gatunense* Nygaard	+	+	-	-	-	-	-	-
	Bacilariophyta								
19	*Bacillaria paxillifera* (O.F.Müller)T.Marsson	-	-	+	+	-	-	-	+
20	*Caloneis amphisbaena* (Bory)Cleve	+	+	-	-	+	+	+	+
21	*C. latiuscula*(Krasske)Hustedt	-	+	-	-	-	-	+	-
22	*C. permagna (Bailey) Cleve*	+	+	-	-	-	-	-	+
23	*Campylodiscus cf. bicostatus* W.Smith ex Roper	-	+	-	+	-	+	+	-
24	*Coscinodiscus oculus* Ehrenberg	-	-	+	+	-	+	-	+
25	*C. symbolophorus* Grunow	-	-	+	+	-	+	-	-
26	*Cyclotella meneghiniana* Kützing,	-	+	+	+	+	+	+	+
27	*Diploneis smithii* (Brébisson)Cleve	-	-	-	+	-	-	+	+
28	*Epithemia adnata*(Kütz.)Brebisson	-	+	-	-	-	-	-	-
29	*Gomphonema parvulum* (Kützing) Kützing,	+	-	-	+	-	-	–	-
30	*Gyrosigma scalproides* (Rabenhorst) Cleve	-	+	+	+	+	-	+	+
31	*G. attenuatum* (Kützing) Rabenhorst	+	+	+	+	-	-	-	+
32	*G. acuminatum* (Kützing) Rabenhorst	-	+	-	-	+	+	+	-
33	*G. fasciola* (Ehrenberg) Griffith & Henfrey	+	-	+	+	-	-	-	-
34	*G. eximium* (Thwaites) Boyer	-	-	-	+	-	+	+	+
35	*G. macrum* (W.Smith) Griffith & Henfrey	+	-	-	-	-	+	-	-
36	*Halamphora veneta* (Kützing) Levkov	+	-	-	-	-	-	-	-
37	*Navicula cryptocephala* Kützing,	+	+	+	-	+	+	-	-
38	*N. digitoradiata* (Gregory) Ralfs	-	+	-	+	+	-	+	+
39	*N. salinarum* Grunow	+	-	+	-	-	+	-	+
40	*N. viridula*(Kützing)	-	+	-	+	-	-	-	-
41	*Nitzschia acicularis* (Kützing)	+	-	-	+	-	-	+	-
42	*N. clausii Hantzsch*(Gregory) W.Smith	-	-	+	-	+	+	+	-
43	*N. filiformis (W.Smith)Hustedt*	-	+	+	+	+	-	-	+
44	*N. obtusa W.Smith*	+	-	+	+	-	+	+	-
45	*N. palea (Kützing) W.Smith*	-	+	-	+	-	+	-	+
46	*Surirella tenera* W.Gregory	-	-	+	+	-	-	-	-
47	*Tabularia tabulata* (C.Agardh)Snoeijs	+	-	-	+	+	+	-	-
48	*Thalassiosira spinose*(Cleve)Hasle	-	+	-	-	-	+	_	+
49	*Tryblionella calida*(Grunow) Hustedt	+	-	+	+	-	-	-	-
50	*T. granulata*(Ehrenberg) Hustedt	-	+	-	-	+	+	-	-
51	*T.compressa*(Grunow) Hustedt	+	-	-	+	-	+	+	+
52	*Ulnaria ulna*(Nitzschia)Compere	-	+	-	-	-	+	+	-
53	*U. delicatissima* var. *angustissima(* Hustedt)H.Lange-Bertalot	-	-	+	+	+	-	-	+
	Total score	19	31	23	28	15	25	20	24

Conclusions

Temperature, salinity, and nutrient availability are the main environmental factors that affect phytoplankton diversity and community structure in artificial fish farms in Basrah, Iraq. The Bacillariophyta, Chlorophyta, and Cyanophyta were predominant in the summer season, reflecting favorable thermal and nutrient conditions. This study shows that statistical analyses for seasonal and spatial variation in temperature, salinity, and phytoplankton abundance, while pH levels exhibited relative stability across locations and seasons.

The results show that aquaculture ponds are sensitive to seasonal and climatic variations, which directly affect primary productivity. Understanding the correlation between environmental factors and phytoplankton structure is essential to prevent harmful cyanobacterial blooms and maintain balanced phytoplankton communities that support healthy fish production. Therefore, to be sure that artificial fish farming systems in southern Iraq can last for a long time, continuous monitoring of physicochemical parameters is strongly recommended, especially in the summer.

Reference

Akter, S., Rahman, M. M., & Akter, M. (2015). Composition and abundance of phytoplankton population in fish ponds of Noakhali District, Bangladesh. American-Eurasian Journal of Agricultural & Environmental Sciences, 15(11), 2143–2148. https://doi.org/10.5829/idosi.aejaes.2015.15.11.95317

Al-Handal AY, Wulff A. Marine epiphytic diatoms from the shallow sublittoral zone in Potter Cove, King George Island, Antarctica Bot Mar. 2008; 51: 411-435.

APHA (Standard methods for the examination of water and wastewater) 2000. 20th ed, Washington DC: American Public Health Association.

APHA. (Standard methods for examination of water and wastewater)2005. 21th ed, Washington D C. American Public Health Association.

Bichsel, D., De Marco, P., Bispo, A.Â., Ilg, C., Dias-Silva, K., Vieira, T.B., Correa, C.C., Oertli, B., 2016. Water quality of rural ponds in the extensive agricultural landscape of the Cerrado (Brazil). Limnology (Tokyo) 17, 239–246, http://dx.doi.org/10.1007/s10201-016-0478-7

Bolgovics, Á., B-Béres, V., Várbíró, G., Krasznai-K., E.Á., Ács, É., Kiss, K.T., Borics, G., 2019. Groups of small lakes maintain larger microalgal diversity than large ones. Sci. Total Environ. 678, 162–172, http://dx.doi.org/10.1016/j.scitotenv.2019.04.309 Bronmark C, Hansson LA (2005). The Biology of Lakes and Ponds. Oxford University Press, Oxford P 285.

Bwala RI, Ogunfowara OO, Uka UN, Ifejike PI (2009). Studies on primary productivity of ponds fertilized with pig dung at varying level of concentration. Best Journal 6(1):111-115

Carneiro, F. M., Santos, A. M. C., Garcia Medina, N., De Marco Júnior, P., & Hortal, J. (2024). Drivers of phytoplankton diversity in tropical artificial ponds. Perspectives in Ecology and Conservation, 22(2024), 167–176. https://doi.org/10.1016/j.pecon.2024.03.001

Carneiro, F. M., Santos, A. M. C., Medina, N. G., De Marco Júnior, P., & Hortal, J. (2024). Drivers of phytoplankton diversity in tropical artificial ponds. Perspectives in Ecology and Conservation, 22, Article 15. https://www.sciencedirect.com/science/article/pii/S253006442400018X

Cira EK, Paerl HW, Wetz MS. 2016. Effects of nitrogen availability and form on phytoplankton growth in a eutrophied estuary (Neuse River Estuary, NC, USA). PloS One 11 (8): e0160663. DOI: 10.1371/journal.pone.0160663.

Dinh NV, Casareto BE, Niraula MP, Toyoda K, Meekaew A, Suzuki Y. 2021. Effect of diatom abundance and biogenic silica availability on the population growth of tintinnid ciliates at Suruga Bay. J Oceanogr 77: 307-321. DOI: 10.1007/s10872-020-00569-z.

Garlock, T., Asche, F., Anderson, J., Ceballos-Concha, A., Love, D.C., Osmundsen, T.C. and Pincinato, R.B.M. (2022). Aquaculture: The missing contributor in the food security agenda. Global Food Security 32:100620. Doi.org/10.1016/j.gfs.2022.100620

Ghosh, S.;Barinova, S. and Keshri, J.P. (2012) Diversity and seasonal variation of phytoplankton community in the Santragachi Lake,West Bengal, India.QScinece Connect,3:1-19

Graham, L. E., Graham, J. M., & Wilcox, L. W. (2016). Algae (3rd ed.). Pearson Education.

Hua, K., Cobcroft, J.M., Cole, A., Condon, K., Jerry, D.R., Mangott, A. and Strugnell, J. M. (2019). The future of aquatic protein: Implications for protein sources in aquaculture diets. One Earth., 1 (3): 316 – 329. Doi.org/10.1016/j.oneear.2019.10.018

Kang J. J., Joo H., Lee J. H., Lee J. H., Lee H. W., Lee D., et al. (2017). Comparison of biochemical compositions of phytoplankton during spring and fall seasons in the northern East/Japan Sea. *Deep-Sea Res. Part II-Top Stud. Oceanogr.*, 143:73–81. doi: 10.1016/j.dsr2.2017.06.006

Kling, J. D., Lee, M. D., Fu, F., Phan, M. D., Wang, X., Qu, P., & Hutchins, D. A. (2020). Transient exposure to novel high temperatures reshapes coastal phytoplankton communities. ISME Journal, 14, 413–424. https://doi.org/10.1038/s41396-019-0525-6

Lavoie, I., Hamilton, P. B., Campeau, S., Grenier, M., & Dillon, P. J. (2017). Diatoms as indicators of environmental change in aquatic ecosystems. Ecological Indicators, 75, 133–146.

Lee J. H., Kang J. J., Jang H. K., Jo N., Lee D., Yun M., et al. (2020). Major controlling factors for spatio-temporal variations in the macromolecular composition and primary production by phytoplankton in garolim and asan bays in the yellow Sea. *Reg. Stud. Mar. Sci.*, 36:101269. doi: 10.1016/j.rsma.2020.101269.

Lin S, Litaker RW, Sunda WG. 2016. Phosphorus physiological ecology and molecular mechanisms in marine phytoplankton. J Phycol 52 (1): 10-36.

Mackereth, F.J.H., Heron,J.and Talling, J.T.(1978).Water analysis some revised method for liminologist, Sci. Publ. Fresh water, Biol. Ass.(England) 36: 1-120.

Mesquita M.C., Prestes A.C.C., Gomes A.M., Marinho M.M. 2020. Direct effects of temperature on growth of different tropical phytoplankton species. Microb Ecol 79: 1-11. DOI: 10.1007/s00248-019-01384-w

Mu Y, Wang WL, Li H, Yan G, Wang HM, Gao JF. 2016. Effects of PEG6000 on growth

Neori A, Holm-Hansen O. 1982. Effect of temperature on rate of photosynthesis in Antarctic phytoplankton. Polar Biol 1: 33-38.

Oertli, B., Parris, K.M., 2019. Review: toward management of urban ponds for freshwater biodiversity. Ecosphere 10, http://dx.doi.org/10.1002/ecs2.2810.

Palupi, M., Fitriadi, R., Wijaya, R., Raharjo, P., & Nurwahyuni, R. (2022). Diversity of phytoplankton in the whiteleg (Litopenaeus vannamei) shrimp ponds in the south coastal area of Pangandaran, Indonesia. Biodiversitas Journal of

Biological Diversity, 23(1), 118-124. https://doi.org/10.13057/biodiv/d230117

Prelle LR, Graiff A, Gründling-Pfaff S, Sommer V, Kuriyama K, Karsten U. 2019. Photosynthesis and respiration of Baltic Sea benthic diatoms to changing environmental conditions and growth responses of selected species as affected by an adjacent peatland (Hütelmoor). Front Microbiol 10: 1500. DOI: 10.3389/fmicb.2019.01500.

Rahaman SMB, Golder J, Rahaman MS, Hasanuzzaman AFM, Huq KA, et al. (2013) Spatial and Temporal Variations in Phytoplankton Abundance and Species Diversity in the Sundarbans Mangrove Forest of Bangladesh. J Marine Sci Res Dev 3: 126. doi:10.4172/2155-9910.1000126

Rasconi, S., Winter, K., & Kainz, M. J. (2017). Temperature increase and fluctuation induce phytoplankton biodiversity loss—Evidence from a multi-seasonal mesocosm experiment. Ecology and Evolution, 7(9), 2936–2946. https://doi.org/10.1002/ece3.2889

Reynolds, C. S. (2006). The Ecology of Phytoplankton. Cambridge University Press.

Sarker, S., Yadav, A. K., Akter, M., Shahadat Hossain, M., Chowdhury, S. R., Kabir, M. A., & Sharifuzzaman, S. M. (2020). Rising temperature and marine plankton community dynamics: Is warming bad? Ecological Complexity, 43, 100857. https://doi.org/10.1016/j.ecocom.2020.100857.

Scheffer, M., Van Geest, G.J., Zimmer, K., Jeppesen, E., Søndergaard, M., Butler, M.G., Hanson, M.A., Declerck, S., De Meester, L., 2006. Small habitat size and isolation can promote species richness: second-order effects on biodiversity in shallow lakes and ponds. Oikos., http://dx.doi.org/10.1111/j.0030-1299.2006.14145.x.

Shannon CE, Wiener W. The mathematical theory of communication. Urbana university of Illinois Press,Chicago, USA; 1949. 117 p.

Sridhar R, Thangaradjou T, Kumar SS, Kannan L (2006) Water quality and phytoplankton characteristics in the Palk Bay, southeast coast of India. J Environ Biol 27: 561-566.

Takarina, N. D., Nurliansyah, W., & Wardhana, W. (2019). Relationship between environmental parameters and the plankton community of the Batuhideung Fishing Grounds, Pandeglang, Banten, Indonesia. Biodiversitas, 20(1), 171-180. https://smujo.id/biodiv/article/view/3403

Takarina, N. D., Utomo, S. W., Susanti, L., Rochman, N. T., Cahyadi, D., Junaedi, H., Saputra, H. K. H., & Saputra, R. N. (2020). Phytoplankton biodiversity trends in nanobubble aerated shrimp farming at Probolinggo coast, East Java, Indonesia. Biodiversitas, 21(12), 5906-5914. https://scholar.ui.ac.id/en/publications/phytoplankton-biodiversity-trends-in-nanobubble-aerated-shrimp-fa

Tambaru, R., Burhanuddin, A. I., Haris, A., Amran, M. A., Massinai, A., Muhiddin, A. H., Yaqin, K., Firman, & Yuliana. (2024). Diversity and abundance of phytoplankton in Bone Bay, South Sulawesi, Indonesia and its relationship with environmental variables. Biodiversitas, 25(2), 624-631. https://smujo.id/biodiv/article/view/16304

Tulsankar, S.S., Cole, A.J., Gagnon, M.M., Fotedar, R., 2020. Effects of seasonal variations and pond age

on trace elements and their correlations with plankton productivity in commercial freshwater crayfish (cherax cainii austin,

2002) earthen ponds. Aquac. Res. 51, 1913–1922, "http://dx.doi.org/10.1111/are.14542.

Wen, Z., Guo, R., Xu, K., Wu, Y., & Li, Y. (2023). Review of phenotypic response of diatoms to salinization with biotechnological relevance: Effects of changes in salinity [Review Paper]. Hydrobiologia, 850, 4665–4688. https://doi.org/10.1007/s10750-023-05194-7.

Yang L, Li H, Zhang Y, Jiao N. 2019. Environmental risk assessment of triazine herbicides in the Bohai Sea and the Yellow Sea and their toxicity to phytoplankton at environmental concentrations. Environ Intl 133: 105175. DOI: 10.1016/j.envint.2019.105175.

Yisa M (2006). Physical and chemical water quality parameter in fishpond management: A review. Best Journal 4(1):142-147.

تأثير درجة الحرارة والملوحة والمغذيات في تنوّع وتركيب مجتمع الهائمات النباتية في مزارع الأسماك الاصطناعية في البصرة، العراق

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المستخلص

هدفت هذه الدراسة إلى مناقشة تأثير درجة الحرارة والملوحة والمغذيات على التنوع الحيوي وتركيب مجتمع العوالق النباتية في مزارع الأسماك الاصطناعية في محافظة البصرة، العراق. أُجريت الدراسة في أربع مزارع سمكية، اثنتان منها تقعان في قضاء أبي الخصيب واثنتان في منطقة السيبة، خلال فصلي الشتاء (كانون الثاني) والصيف (تموز) من عام 2025. تم قياس درجة حرارة المياه والملوحة والأس الهيدروجيني (pH) وتركيز المغذيات (النترات NO_3، الفوسفات PO_4، والسيليكات SiO_3) في المزارع السمكية. جُمعت عينات العوالق النباتية باستخدام شبكة ذات قطر فتحات 20 ميكرومتر.

أظهرت النتائج وجود تباينات موسمية واضحة في وفرة العوالق النباتية وتركيبها النوعي. تم تسجيل 53 نوعًا من العوالق النباتية، إذ سادت شعبة الدياتومات (Bacillariophyta) بنسبة 59% ممثلة بـ 35 نوعًا، تلتها الطحالب الخضراء (Chlorophyta) بنسبة 17% (6 أنواع)، ثم الطحالب الخضر المزرقة (Cyanophyta) بنسبة 14% (6 أنواع)، فشعبة اليوجلينات (Euglenozoa) بنسبة 7% (4 أنواع)، وأخيرًا السوطيات الدوارة (Dinophyta) بنسبة 3% (نوعان).

تراوحت درجة حرارة المياه بين 5 و34°م، والملوحة بين 3.7 و13.1 جزءًا بالألف (ppt)، في حين تراوحت قيم الأس الهيدروجيني بين 7.8 و8.5. أظهر التحليل الإحصائي وجود فروق معنوية في تركيب العوالق النباتية ودرجة حرارة المياه والملوحة بين المواقع المختلفة وبين المواسم ($p < 0.05$)، في حين لم تُسجل فروق معنوية في قيم الأس الهيدروجيني بين المواقع والمواسم ($p > 0.05$).

تراوحت تراكيز النترات بين 1.3 و4.2 ميكروغرام/لتر، في حين تراوحت تراكيز الفوسفات بين 0.02 و0.11 ميكروغرام/لتر، أما السيليكات فقد تراوحت بين 31.5 و90.4 ميكروغرام/لتر. وسجلت المغذيات الثلاث (NO_3، PO_4، SiO_3) فروقًا معنوية بين جميع المواقع والمواسم ($p < 0.05$).

تراوحت قيم دليل شانون– وينر للتنوع الحيوي (H') بين 1.2 و2.1، مع تسجيل فروق معنوية بين المواقع والمواسم كافة ($p < 0.05$). وارتبطت الارتفاعات في درجات الحرارة والملوحة خلال فصل الصيف بزيادة سيادة الدياتومات والطحالب الخضراء والخضر المزرقة.

تشير التحليلات الإحصائية إلى أن درجة الحرارة والملوحة والمغذيات تُعد العوامل الرئيسة المؤثرة في توزيع العوالق النباتية وتنوعها. وتبرز نتائج هذه الدراسة أهمية المراقبة المستمرة للمعايير البيئية من أجل الحفاظ على التوازن البيئي وتعزيز الإنتاجية في نظم الاستزراع السمكي الاصطناعي.