Marsh Bulletin Issue 20 Volume 1 (April 2025): 1-11

MARSH BULLETIN
EISSN 2957-9848

The role of primary productivity of phytoplankton in the growth of common carp *Cyprinus carpio L.* in fertilized and unfertilized ponds

Adel K. Jassim
Department of Fisheries and Marine Resources, College of Agriculture, University of Basrah
E-mail: adel.jassinm@uobasrah.edu.iq

Abstract

Fertilization in fishponds is essential for good growth and production of fish, as it achieves primary productivity of phytoplankton, which is considered the natural and good food for fish, thus less use of industrial feed. This study aimed to know the role of fertilization of fishponds in primary productivity and then link it to their weight increase rate for each month. Five ponds were selected in the eastern Hammar Marsh, three of which were fertilized, and the rest were not. Some environmental factors were measured (temperature, salinity, permeability, pH, oxygen, ammonia, nitrates and phosphate). Transparent and opaque bottles were used to measure primary productivity, and the weight increase rate for each month of fish was measured for each month. A clear positive relationship was found between primary productivity and weight gain in fertilized ponds compared to unfertilized ponds, which reflected the role of fertilization in increasing fish production.

Keywords: Fertilization, unfertilization, primary production, phytoplankton
Received 12/2/2025 Accepted 16/3/2025 Published 4/4/2025

Introduction

Primary productivity, specifically in fishponds, plays a crucial role in the energy flow and overall functioning of aquatic ecosystems (Yao, 1993). The primary productivity of aquaculture ponds is essential for sustainable production and efficient functioning of the ecosystem (Diarte-Plata & Escamilla-Montes, 2019). Primary productivity, which refers to the rate at which energy is converted into organic substances through photosynthesis, is a key determinant of the natural food availability for fish in aquaculture ponds (Nurfadillah *et al.*, 2020). Therefore, understanding the factors that influence primary productivity, such as stocking patterns and fish output, is essential in optimizing fish production in ponds. (Bosma & Verdegem, 2011). The primary producers in aquaculture ponds, such as phytoplankton, periphyton, and macrophytes, play a vital role in supporting the food chain and providing essential nutrients for the cultured organisms (Qu *et al.*, 2017). It is influenced by factors such as the physicochemical characteristics of the water, the presence of primary producers such as phytoplankton, periphyton, and macrophytes, and the interactions between these factors. (Takarina & Runtuwene, 2019). Common carp are highly adaptable and have an omnivorous diet, allowing them to exploit a wide range of food sources, Aquaculture has become an increasingly important source of food production, with the cultivation of common carp playing a significant role in this industry. The relationship between primary productivity and the production of common carp in ponds is a crucial factor to consider when optimizing carp cultivation. (Rosidah *et al*., 2021). Maintaining a suitable level of primary productivity is essential for supporting the growth and health of common carp, which are known to be efficient filter feeders that rely on phytoplankton and other aquatic organisms as their primary source (Chen *et al.*, 1995).

The suitability of aquaculture ponds for common carp production is largely influenced by the primary productivity of the water, as well as other water quality parameters such as dissolved oxygen, pH, and temperature. Ponds with higher primary productivity can support a greater abundance of natural food sources, leading to improved growth and survival rates of common carp. (Chakrabarti and Jana, 1991) Additionally, the stocking model utilized in high-productivity regions tends to favor the cultivation of omnivorous carps, including the common carp, over filter-feeding fish species (Adámek *et al.*, 2019). Recently, the primary productivity of freshwater ponds has received much attention by various research (Paul *et al.* 2006; Verma and Srivastava, 2015; Deka, 2017).

Fertilization, the addition of organic or inorganic nutrients to the aquaculture environment, is one strategy that has been employed to enhance carp production. Fertilizers can increase the availability of nutrients in the water, stimulating the growth of phytoplankton and other primary producers that serve as food sources for carp and other cultured species. (Kestemont, 1995).

Fertilization, the process of adding nutrients such as nitrogen and phosphorus to aquatic environments, has been widely used in carp aquaculture to enhance primary productivity and support the growth of carp (Oyebamiji et al., 2023). Previous research has explored the impacts of different fertilization approaches on carp growth and yield. In extensive carp monoculture systems, the addition of organic or inorganic fertilizers has been shown to increase carp production compared to unfertilized ponds (Zhao *et al.*, 2020).

In this study, we aim to examine the impact of fertilization regimes on the primary productivity and growth performance of common carp in pond aquaculture systems.

Materials and Methods

Five common carp ponds were selected in the eastern Hammar Marsh, Al-Mashab area, Basra Governorate. Table (1). Figure (1).

Table 1: Area and coordinates of the five ponds.

Ponds	Area (Donum)	Coordinates
First	3.5	30°39'02.0"N 47°39'39.0"E
Second	3	30°39'02.0"N 47°39'39.0"E
Third	4	30°39'02.0"N 47°39'39.0"E
Fourth	3	30°39'02.0"N 47°39'39.0"E
Fifth	3.5	30°39'02.0"N 47°39'39.0"E

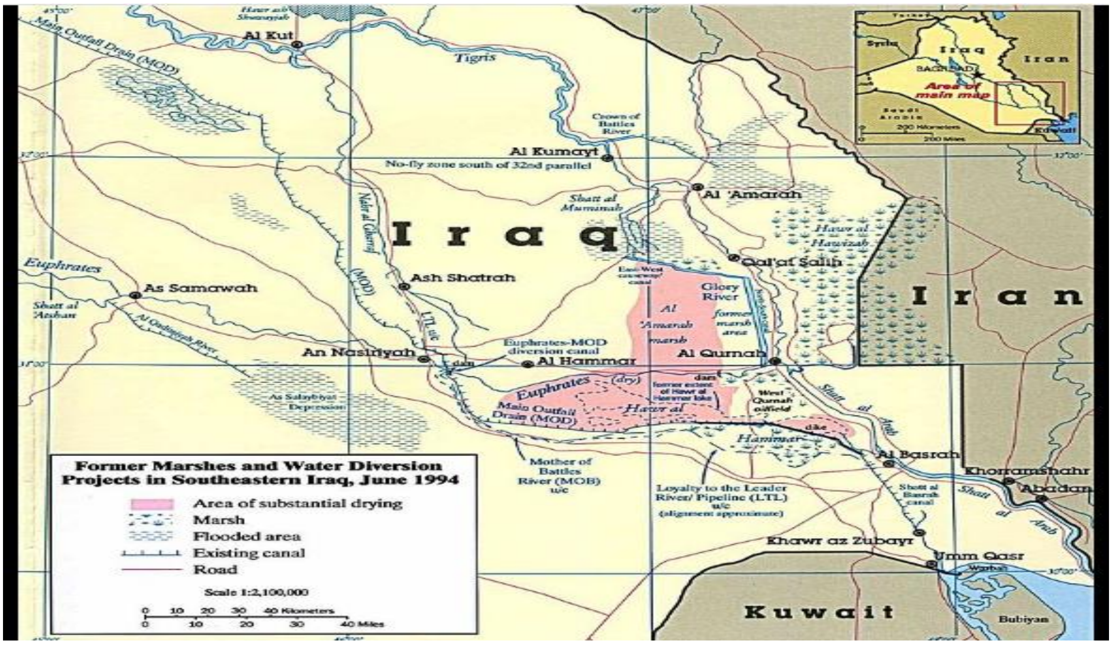

Fig:(1) Map of the five study ponds.

Fish farming from the beginning of March until the end of July 2024 with weights rate of 210-230 grams and a density of 2000 fish/ Donum. The ponds (first, third and fourth) were fertilized with poultry waste, while the other ponds were not fertilized. All ponds were fed with the same commercial feed and in the same proportions during their growth. The fish were fed the same artificial feed and the same quantity for all ponds.

The oxygen method was used to measure primary production by using light and dark bottles (Gardner and Gran, 1927). The bottles were suspended at a depth of 0.5 m for an incubation period of 4 h. Oxygen changes were estimated by the modified Winkler method (APHA, 2005). The productivity values were expressed as mg C/m^3/h. Calculate the equation below

P.P mg C m^{-3}. hr^{-1} = (L – D / T) X 0.375 X 1000
Where:
P.P = Primary Productivity
L = light bottle
D= dark bottle
T=time (hours)
0.375= from conversion Oxygen to Carbon 12/32

Some environmental parameters were measured monthly during the study period including water temperature (°C), salinity (ppt), pH and, NH_3 (mg/l) by meter light penetration (m) by Secchi disk, O_2 (mg/l), PO_4 (mg/L), NO_3(mg/L), and chlorophyll *a* (mg/m3), (APHA2005). The monthly weight changes of fish were calculated using a balance (g).

The weight increase rate for each month was calculated using the following equation:

GR= Average weight at the end of the month- Average weight at the beginning of the month.

Statistical analysis

One way analysis of variance (ANOVA) was used for statistical analysis of weight increase rate and primary production. The standard deviation (±SD.) of monthly weights was calculated and use correlation between primary production and weight increase rate 0.01.

Results and discussion

The water quality ranges of some environmental factors (water temperature, salinity, light penetration, pH and oxygen) in the ponds of the current study were (20-32 ºC, 1.5-4.2 p.p.t, 0.2-0.45 m, 7.8-8.3 and 5-9.2) respectively, Table(2). There were no significant differences ($P>0.05$) between fertilized and unfertilized ponds.

Table 2. Water temperature, salinity, light penetration and pH values of fishponds during the study months (2023).

Ponds	Months	Tem (ºC)	Salinity (p.p.t)	light penetration (m)	pH	Oxygen (mg/l)
First	March	20	1.5	0.2	7.8	8.7
Second		21	1.5	0.38	8	9.2
Third		20	1.5	0.21	8	8.5
Fourth		21	1.6	0.23	7.9	8.7
Fifth		21.5	1.52	0.4	8.1	9
First	April	22	2	0.3	8.1	8
Second		22.3	2.5	0.4	8.2	8.3
Third		22	2.4	0.34	8.1	8
Fourth		22	2	0.34	8.1	8.5
Fifth		22.3	2.5	0.44	8.1	8.5
First	May	23.5	2.6	0.35	8	7.5
Second		23.5	2.8	0.44	8.2	7.5
Third		23	2	0.33	8.1	6.8
Fourth		23.5	2.5	0.45	8	7.8
Fifth		23.5	3	0.36	8.2	7.2
First	Jun	27	3.4	0.32	8.2	6.6
Second		27.5	3.8	0.35	8.3	6.8
Third		27	3.5	0.28	8.2	6
Fourth		27.5	3.5	0.31	8.2	5.4
Fifth		27.6	3.8	0.22	8.3	6.2
First	July	31	3.5	0.27	8.3	5.5
Second		31.5	4.2	0.28	8.3	5.3
Third		31	4	0.33	8.2	5
Fourth		31	3.8	0.27	8.3	5
Fifth		32	4.2	0.25	8.3	6.1

Fertilized ponds recorded higher concentrations of nitrate and phosphate nutrients compared to unfertilized ponds, especially in the first months Figures (2& 3).

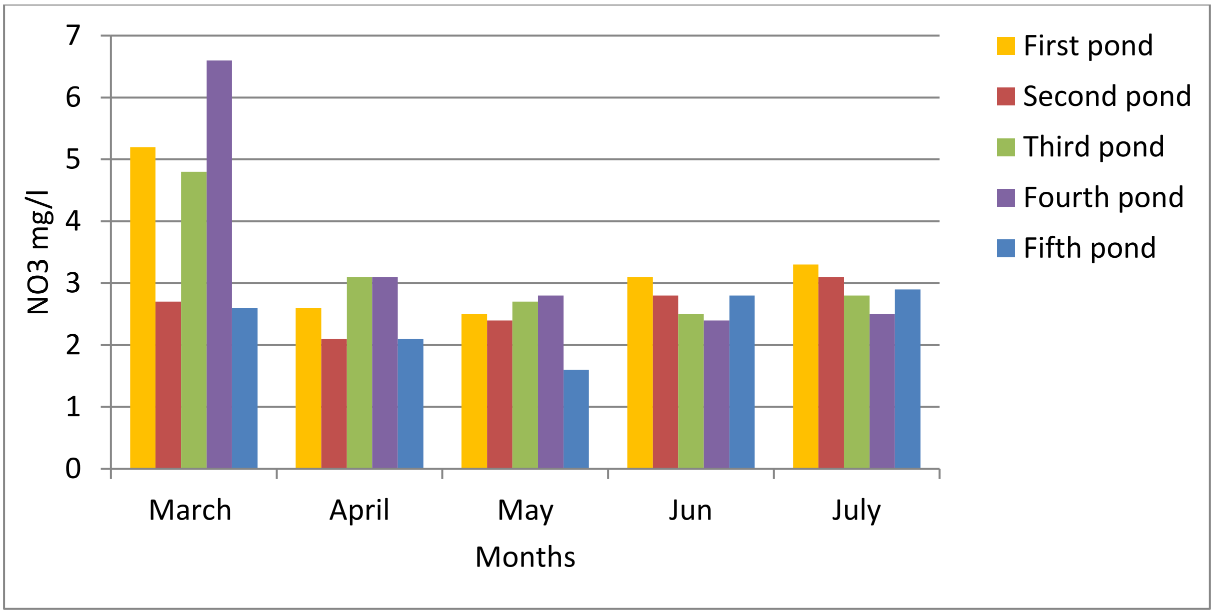

Figure .2. Monthly changes in nitrate concentrations in fishponds.

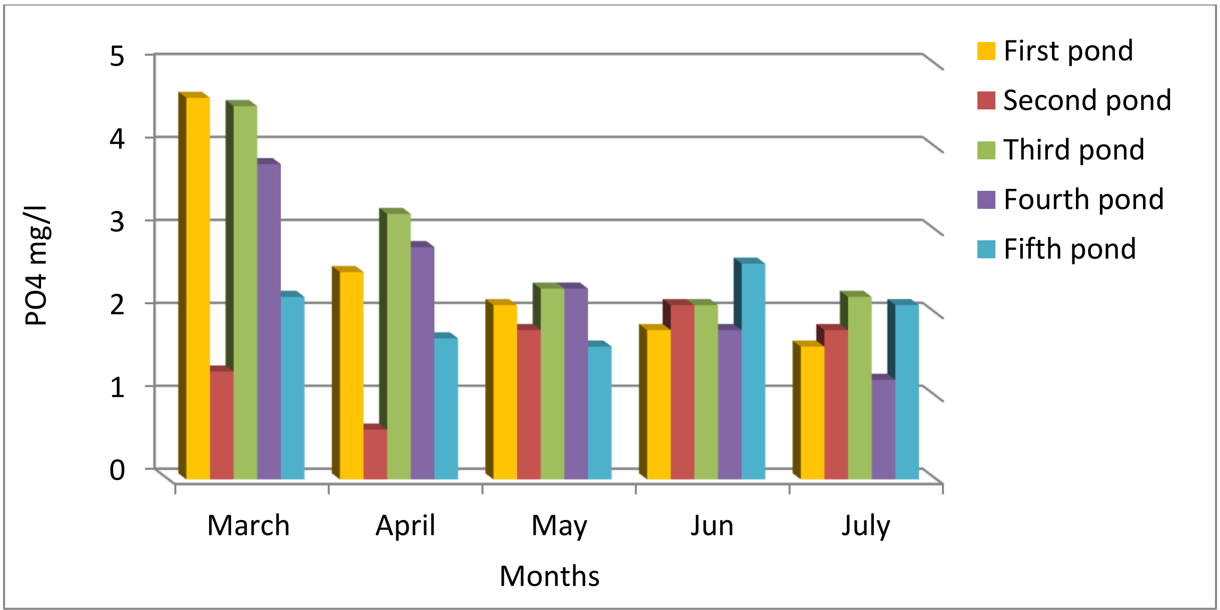

Figure .3. Monthly changes in phosphate concentrations in fishponds.

The beginning of fish farming was in the spring, March. The concentration of ammonia was low, with a range of (0.01-0.035) mg/l in all ponds. After that, there was a gradual increase, especially in the summer, July, with a range of (0.28-0.42) mg/l in all ponds as Figure (4).

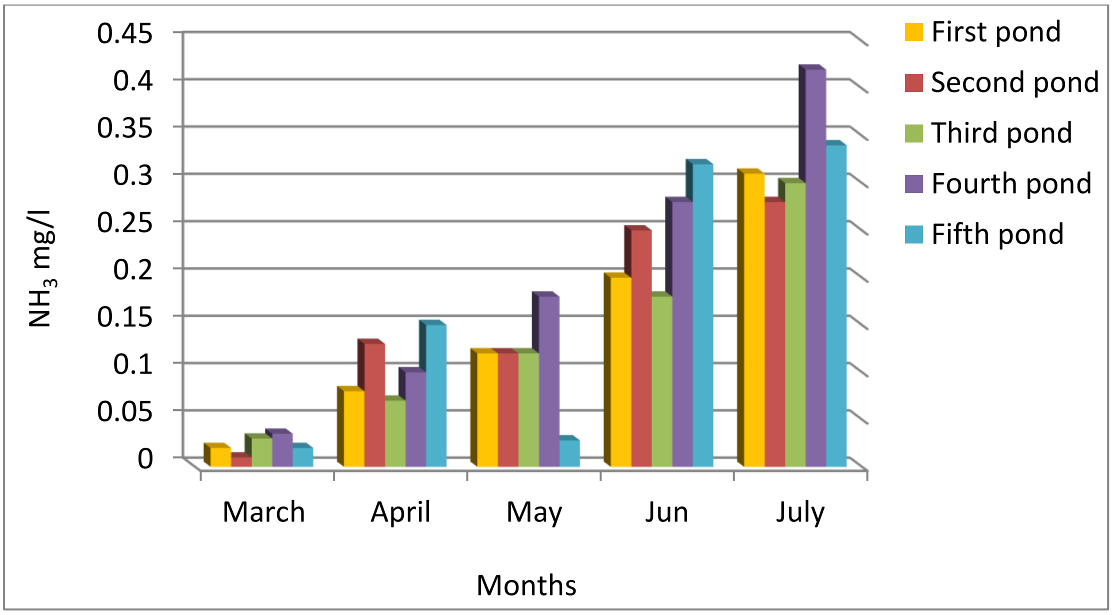

Figure 4. Monthly changes in ammonia concentrations in fishponds.

A gradual decrease in chlorophyll *a* concentration was observed in all ponds from the beginning to the end of the study. Fertilized basins recorded high concentrations at the beginning of the study, reaching their highest in spring in the fourth pond (22.1 mg/m ^{3}), compared to unfertilized ponds, which had their highest (10.1 mg/m^{3}) in the fifth pond. (Figure 5).

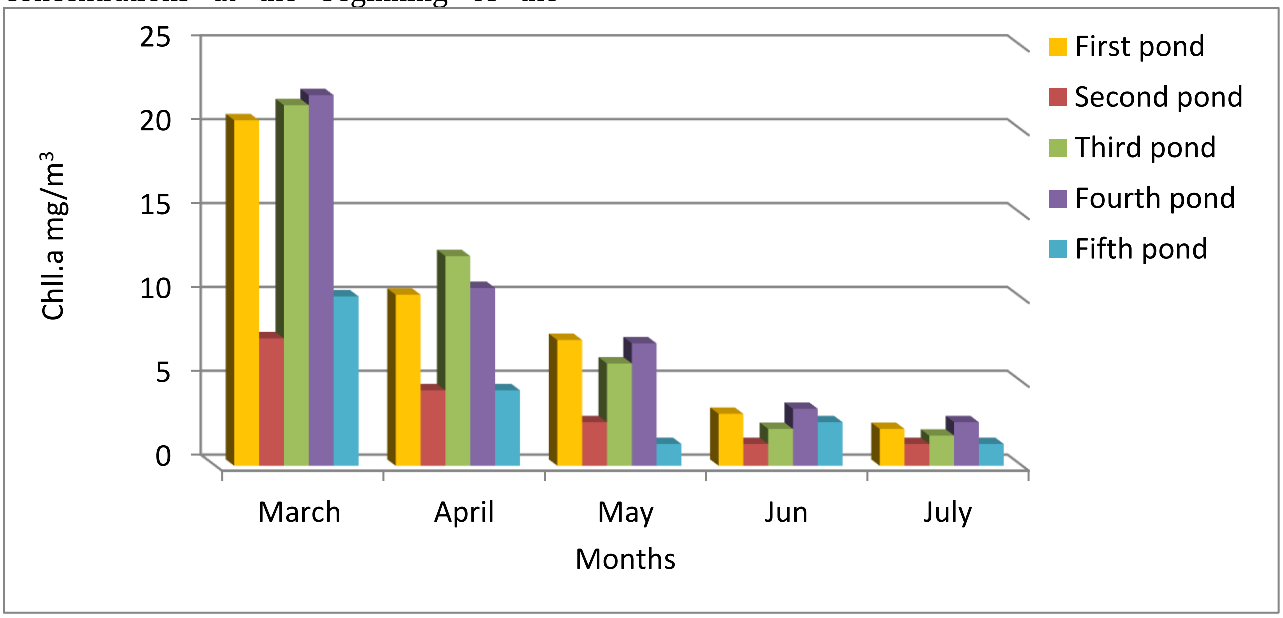

Figure 5. Monthly changes in chlorophyll *a* concentration in fishponds.

A significant difference ($P \leq 0.05$) was observed between fertilized and unfertilized basins in the initial productivity values, as their values were higher in fertilized basins, especially in March (Figure 6).

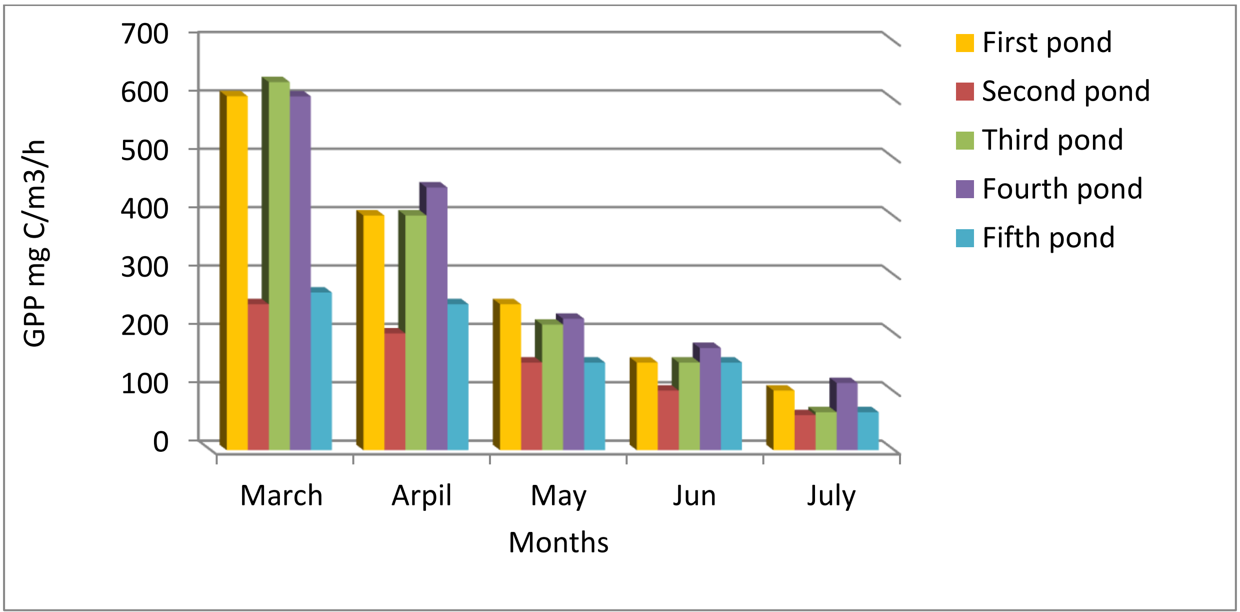

Figure 6. Monthly changes in primary production in fishponds.

Table. (3) shows the changes over five months in fishponds. The highest weight reached 1270 g in fertilized ponds, while the highest weight reached (915 g) in unfertilized ponds.

Table. (3): The changes over five months in fishponds (Mean ±SD)

Ponds	Mean values ±SD monthly of fish weights				
	March	April	May	Jun	July
First pond	210±29.88	570±35.78	840±43.89	1020±52.82	1255±53.66
Second pond	222±31.32	412±45.67	592±38.06	722±42.04	907±46.012
Third pond	215±34.58	565±28.88	830±35.66	1030±46.76	1270±56.04
Fourth pond	230±42.22	530±24.35	790±26.19	945±39.07	1160±58.60
Fifth pond	220±26.61	440±37.15	610±34.05	725±29.98	915±47.03

The fertilized ponds achieved a monthly weight increase rate for fish higher than the unfertilized ponds, especially in the months of April and May (360 and 270) gm respectively in the first pond, while the highest increase was in the same months (220 and 170) gm respectively in the fifth and second ponds, as significant differences ($P \leq 0.05$)were found between the fertilized and unfertilized ponds (Figure7).

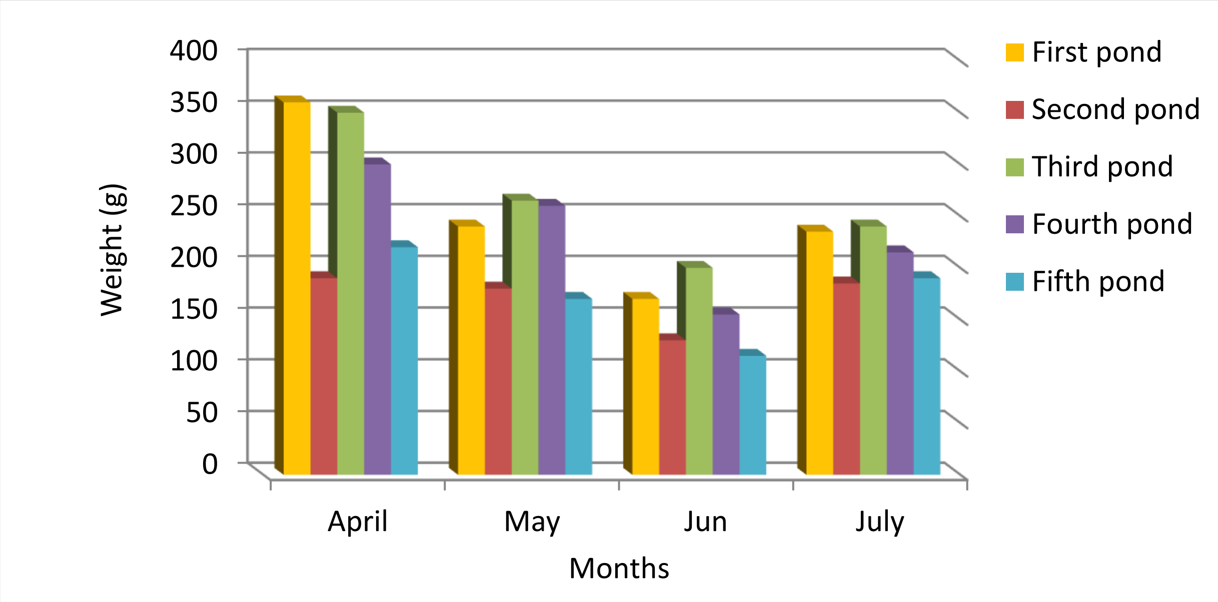

Figure7. weight increase rate of fishes per month in ponds.

Effective fish farming requires a delicate balance between water quality, nutrient availability, and the health of the fish population. Carp, a versatile and hardy species, have become a popular choice for pond aquaculture due to their fast growth and resilience (Føre, *et al*,.018). One crucial aspect in carp farming is the use of fertilizers to enhance primary productivity and, ultimately, fish yield (Zhang *et al.*, 2016).

Temperatures were suitable for good fish growth throughout the study period, although summer temperatures reached 32°C. Howe explained that the optimum temperatures for common carp growth are between 23 and 32 °C When the temperature is >35 °C or <15 °C, its growth slows down significantly, and when it is less than 10 °C the carp stops eating.

The current study showed a positive relationship (0.75-0.91) between primary productivity and weight increase rate of fishes per month in fertilized ponds, while there was no clear relationship in unfertilized ponds. The weight gain of fish in the fertilized ponds in April reached (306, 350 and 300) g in the first, third and fourth ponds respectively, compared to the unfertilized ponds (208 and 220) g in the second and fifth ponds respectively. Fertilizing fishponds enhances primary productivity, which positively affects fish growth. In common carp farming, organic and mineral fertilization is used to provide natural food, in addition to supplementary feed (Garg and Bhatnagar 1996).

The primary productivity values of phytoplankton in the current study were ideal, especially in the first months. The primary productivity values of phytoplankton in the present study were ideal especially in the first months. Anita and Pooja (2013) showed that the ideal values of primary productivity are (1000-2500) mg/m3/day in fishponds with good productivity. The primary productivity of phytoplankton in fertilized ponds remained higher for most months compared to unfertilized ponds due to the nature of common carp in the pits and thus increased the availability of nutrients for phytoplankton, which led to enhanced fish production (Milstein *et al.*, 2006). On the positive side, common carp can enhance the availability of nutrients in the water column through their feeding behaviors, which involve the bioturbation of benthic sediments and the release of organic matter and nutrients into the water This increase in nutrient availability can stimulate photosynthesis and plankton production, thereby increasing the overall productivity of the system (Rahman, 2015).Chlorophyll *a* concentrations were good in the fertilized ponds, especially in the first and second months of the study, compared to the unfertilized ponds, which achieved an increase in the weight of the fish and an increase in phytoplankton, thus providing natural food for carp, which enhances their growth and improves food conversion rates and provides a suitable environment for fish growth (Tidwell, 2012). Chlorophyll a concentration was moderate in fertilized ponds which gave good fish production compared to unfertilized ponds as (Tucker, and Hargreaves, 2004) considered the range of chlorophyll a 10 to 50 µg/L suitable for good production without causing environmental problems.

Nutrients were good throughout the study period, especially in the first months in the fertilized ponds, which provided good primary productivity in these ponds. This is also due to the nature of these fish, as these fish play an important role in the nutrient cycle within aquatic ecosystems through their feeding behaviors and locomotor activities. Being a bottom fish that feeds on sediments, the common carp performs a process known as "bioturbation," where it stirs up the bottom sediments while searching for food. This stirring leads to the resuspension of organic matter and nutrients, such as nitrogen and phosphorus, in the water column, making them available to other organisms, including algae and aquatic plants (Rahman, 2015).

The study showed good growth of fish in all months for all ponds despite the high salinity in recent months, which reached more than 4 parts per thousand, because these fish could adapt and grow in salinity concentrations reaching more than 7 parts per thousand (Malik, *et al.*2018). Both the oxygen and ammonia concentrations were good throughout the study period and did not reach critical levels due to the presence of water pumps in the ponds.

Conclusion

Fertilization had a clear effect on the primary productivity of phytoplankton in fertilized ponds and achieved a clear monthly weight gain rate for fish compared to unfertilized ponds that continued throughout the study period. The productivity rate was moderate in fertilized ponds and resulted in good growth of fish.

Acknowledgment

This research was conducted in cooperation with one of the fish farm owners in the Al-Mashab area in the Al-Hammar Marsh, Ali Mustafa. Thanks to the Department of Fish and Marine Resources for measuring the environmental factors.

References

Adámek, Z., Mössmer, M., & Hauber, M. (2019). Current principles and issues affecting organic carp (*Cyprinus carpio*) pond farming. *Aquaculture*, *512*, 734261.

American Public Health Association. (2005). Standard method for the examination of water and wastewater (21st ed.). Washington, DC: APHA Press

Anita Bhatnagar, A. B., & Pooja Devi, P. D. (2013). Water quality guidelines for the management of pond fish culture.

Bosma, R. H., & Verdegem, M. C. (2011). Sustainable aquaculture in ponds: Principles, practices and limits. *Livestock science*, *139*(1-2), 58-68.

Chakrabarti, R., & Jana, B. B. (1991). Plankton intake as a function of body weight by common carp fry in different feeding conditions. *Aquaculture*, *93*(1), 21-34.

Chen, H., Hu, B., & Charles, A. T. (1995). Chinese integrated fish farming: a comparative bioeconomic analysis. *Aquaculture research*, *26*(2), 81-94.

Deka, P. (2017). An assessment on the primary productivity of two freshwater aquaculture ponds at Guwahati with reference to physicochemical parameters. *International Journal of Fauna and Biological Studies*, *4*(2), 101-104.

Diarte-Plata, G., & Escamilla-Montes, R. (Eds.). (2019). *Aquaculture: Plants and Invertebrates*. BoD–Books on Demand.

Føre, M., Frank, K., Norton, T., Svendsen, E., Alfredsen, J. A., Dempster, T., ... & Berckmans, D. (2018). Precision fish farming: A new framework to improve production in aquaculture. *biosystems engineering*, *173*, 176-193

Garg, S. K., & Bhatnagar, A. (1996). Effect of varying closes of organic and inorganic fertilizers on plankton production and fish biomass in brackish water fishponds. *Aquaculture research*, *27*(3), 157-166.

Kestemont, P. (1995). Different systems of carp production and their impacts on the environment. *Aquaculture*, *129*(1-4), 347-372.

Malik, A. B. D. U. L., Abbas, G. H. U. L. A. M., Jabbar, A. B. D. U. L., Sajjad Shah, S., & Ali Muhammad, A. (2018). Effect of different salinity level on spawning, fertilization, hatching and survival of common carp, Cyprinus carpio (Linnaeus, 1758) in semi-artificial environment. *Iranian Journal of Fisheries Sciences*, *17*(4), 790-804.

Milstein, A., Valdenberg, A., & Harpaz, S. (2006). Fish larvae: zooplankton relationships in microcosm simulations of earthen nursery ponds. II. brackish water system. *Aquaculture International*, *14*, 431-442.

Nurfadillah, N., Dewiyanti, I., Yunizar, S., Mellisa, S., & Arisa, I. I. (2020, May). Suitability analysis of aquaculture ponds based on primary productivity parameters in mangrove area of Banda Aceh. In *IOP Conference Series: Earth and Environmental Science* (Vol. 493, No. 1, p. 012019). IOP Publishing.

Oyebamiji, O., Balogun, P., Stephen, E., Oladosu, N., & Adeoso, A. (2023). Comprehensive treatment and analysis of Fishpond sediments as a source of organic fertilizers. *arXiv preprint arXiv:2304.07630*.

Paul, A., Das, B. P., & Sharma, R. (2006). Seasonal fluctuation in primary production in relation to the physicochemical parameters of two weed-infested ponds of Kalyani, West Bengal

Qu, J., Zhang, Q., Jia, C., Liu, P., & Yang, M. (2017,). The study of recirculating aquaculture system in pond and its purification effect. In *IOP Conference Series: Earth and Environmental Science* (Vol. 67, No. 1, p. 012028). IOP Publishing.

Rahman, M. M. (2015). Role of common carp (Cyprinus carpio) in aquaculture production systems. *Frontiers in Life Science*, *8*(4), 399-410.

Rahman, M. M. (2015). Effects of co-cultured common carp on nutrients and food web dynamics in rohu aquaculture ponds. *Aquaculture Environment Interactions*, *6*(3), 223-232.

Rosidah, R., Mulyani, Y., Pratiwy, F. M., Shabirah, A., & Sinaga, J. A. (2021). Effectiveness of lactic acid bacteria to increase the body resistance of common carp, Cyprinus carpio Linnaeus, 1758 against Aeromonas hydrophila. *Jurnal Iktiologi Indonesia*, *21*(3), 291-304.

Takarina, N. D., & Runtuwene, D. O. (2019, August). Primary Productivity of Blanakan Fishpond at Subang, West

Java. In *Journal of Physics: Conference Series* (Vol. 1245, No. 1, p. 012034). IOP Publishing.

Tidwell, J. H. (2012). Functions and characteristics of all aquaculture systems. *Aquaculture production systems*, 51-63.

Tucker, C. S., & Hargreaves, J. A. (Eds.). (2004). *Biology and culture of channel catfish*. Elsevier.

Verma, B. S., & Srivastava, S. K. (2016). Study of factors affecting phytoplankton primary productivity in a pond of Patna, Bihar, India. *Nature Environment and Pollution Technology*, *15*(1), 291.

Yao, H. (1993). Phytoplankton production in integrated fish culture high-output ponds and its status in energy flow. *Ecological Engineering*, *2*(3), 217-229.

Zhang, J., Hu, L., Ren, W., Guo, L., Tang, J., Shu, M., & Chen, X. (2016). Rice-soft shell turtle coculture effects on yield and its environment. *Agriculture, Ecosystems & Environment*, *224*, 116-122.

Zhao, Z. B., He, J. Z., Quan, Z., Wu, C. F., Sheng, R., Zhang, L. M., & Geisen, S. (2020). Fertilization changes soil microbiome functioning, especially phagotrophic protists. *Soil Biology and Biochemistry*, *148*, 107863.

دور الانتاجية الاولية للهائمات النباتية في نمو اسماك الكارب الشائع *Cyprinus carpio L.* في الاحواض المسمدة والغير مسمدة

عادل قاسم. جاسم

، قسم الثروة السمكية والموارد البحرية، كلية الزراعة، جامعة البصرة

[1]E-mail: adel.jassinm@uobasrah.edu.iq

تعد عملية التسميد في الاحواض الاسماك من الامور الضرورية لإعطاء نمو وانتاج جيد للأسماك اذ يحقق انتاجية اولية للهائمات النباتية والتي تعتبر الغذاء الطبيعي والجيد للأسماك بالتالي استخدام اقل للأعلاف الصناعية. فهدفت هذه الدراسة لمعرفة دور تسميد الاحواض الاسماك بالإنتاجية الاولية وثم ربطها في الزيادة الوزنية لها. تم اختيار خمس احواض في هور الحمار الشرقي ثلاثة كانت مسمدة والباقي غير مسمد، وتم قياس بعض العوامل البيئة (درجة الحرارة والملوحة والنفاذية والاس الهيدروجيني والاوكسجين والامونيا والنترات والفوسفات) واستدمت القناني الشفافة والمعتمة لقياس الإنتاجية الاولية وتم قياس الزيادة الوزنية لأسماك لكل شهر. اذ وجد علاقة موجبة واضحة بين الانتاجية الاولية والزيادة الوزنية في الاحواض المسمدة مقرنتا بالأحواض غير المسمدة، مما عكس دور التسميد في زيادة الانتاج السمكي