Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 12 [4] March 2023 : 49-52

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD

ORIGINAL ARTICLE **OPEN ACCESS**

Seasonal Variation of Pond Water Productivity In A Semi-Arid Region Of India

Sharda Rani[1], Lokesh Singh Chandolia[2], Pooja Devi[3], Arup Giri[1]*
[1,*]Department of Zoology, Baba Mastnath University, 124021, Haryana, India
[2]Okhla STP Lab, Delhi Jal Board, Mathura Road, 110025, New Delhi, India
[3]Dr.B.R. Ambedkar Government College, Kaithal, 136027, Haryana, India
***Corresponding Author:** Arup Giri
*E-mail: arupsatadal@gmail.com

ABSTRACT
The productivity of ponds is a crucial aspect of the functioning of aquatic ecosystems and is influenced by various factors, including temperature, nutrient availability, and water quality. In this study, we investigated the seasonal variation of pond productivity in several ponds located in Haryana, India. All the collected pond water samples were analyzed using the light and dark bottle methods to calculate the gross primary productivity (GPP), net primary productivity (NPP), and respiration (R). Our results showed significant differences in primary production between the different seasons, with the highest levels of productivity observed during the post-monsoon season. Our findings may have important implications for the management and conservation of ponds in Haryana and suggest that a multi-disciplinary approach is necessary to understand and sustain the productivity of these ecosystems.
Keywords: *Gross primary productivity, Net primary productivity, Pond ecosystem, Respiration rate*

Received 24.01.2023 Revised 11.02.2023 Accepted 12.03.2023

INTRODUCTION

Pollution is a significant challenge for water quality worldwide and has far-reaching consequences for human health, the environment, and the global economy [2, 3]. Chemical pollution [1], nutrient pollution [4, 5], pathogenic pollution [6, 7], sediment pollution [27, 47], microplastics [8, 9], etc., caused a significant impact on ground and surface water quality. Pollutants such as agricultural runoff [10], sewage discharge [50], and industrial waste [1] generally impact surface water. Pollution can have a significant negative impact on the productivity of pond water [49]. Contaminants such as chemicals [18], heavy metals [43], and pathogenic microorganisms [21] can accumulate in the water and harm aquatic life, reduce species diversity, and decrease the overall health of the pond ecosystem. Pollutants can lead to elevated nutrient levels, decreased dissolved oxygen levels, and pH imbalances, which can all impact aquatic life's health and reduce pond water's productivity [11-4].

Net Primary Production (NPP), Gross Primary Production (GPP), and respiration are all essential concepts in understanding the functioning of aquatic ecosystems, including pond water productivity [15]. Net Primary Production (NPP) refers to the amount of organic matter produced by photosynthetic organisms, such as algae and aquatic plants, in a given period. NPP is calculated as the difference between Gross Primary Production (GPP) and respiration. Gross Primary Production (GPP) refers to the total amount of organic matter produced by photosynthetic organisms through photosynthesis. GPP measures the total energy captured and stored by photosynthetic organisms in a given period. Respiration refers to the process by which photosynthetic organisms convert stored energy into usable energy, releasing carbon dioxide and other waste products. Respiration is an essential component of the overall energy balance in the pond ecosystem and can significantly impact NPP and the overall functioning of the pond ecosystem [16, 45].

Higher GPP caused eutrophication process. Eutrophication is the process by which a body of water becomes enriched with nutrients, typically nitrogen and phosphorus, leading to an increase in the growth of algae and other aquatic plants [17]. While some level of nutrient enrichment is natural and can support a healthy aquatic ecosystem, excessive nutrients can lead to a process called "cultural eutrophication." In cultural eutrophication, the excessive growth of algae and other aquatic plants can lead to several negative impacts on the pond ecosystem, including decreased water clarity, decreased dissolved oxygen levels, increased frequency of harmful algal blooms, and the death of fish and other aquatic species [18-20]. Weather and climate can significantly impact the NPP of pond water, affecting the growth and productivity of photosynthetic organisms and the overall health and functioning of the pond ecosystem. It is essential to monitor and understand the impact of weather and climate on NPP in pond water to support sustainable and resilient pond ecosystems [22, 23, 37].

Pond water productivity refers to the ability of a pond to support and sustain aquatic life and other beneficial uses, such as fishing, recreation, and the cultivation of aquatic plants. Various physical, chemical, and biological factors, such as temperature [24], dissolved oxygen levels [25], pH [26], nutrient levels [28], and the presence of pollutants [27], can influence the productivity of pond water. Pond water pollution can significantly impact human sustainability, and it is essential to take measures to reduce its impact and maintain pond water quality. By doing so, the benefits that the pond provides, such as fishing, recreation, and the cultivation of aquatic plants, can be sustained, and the health of the local communities and the environment can be protected.

Northern India is experiencing higher levels of heavy metals in soil and higher consequence of heavy metals in the food chain [29]. Groundwater [30, 31] and surface water [32] in Haryana has ample heavy metals level. Agricultural fields in some pockets of Haryana showed the presence of heavy metals [33-40]. This is hard to find reported research on pond water productivity in different seasons in Haryana; a semiarid region. However, till now, little work has been done to measure the seasonal variation of pond water productivity. Therefore, this study has been designed to know the seasonal variation of pond productivity in terms of NPP, GPP, and respiration. This research may provide selective information about the pond water quality to assess the pond water ecosystem.

MATERIALS AND METHODS

Study area:

This is a semi arid region. Here, summer time maximum daytime temperatures range from 40 to 46 degrees Celsius. It fluctuates between 1.5 and 4 degrees in the winter. Around 450 mm of rain fall on average each year, with 133.4 and 116.2 mm of that falling on average each month in the months of July and August. The average monthly rainfall in June is 49.8 mm, and 54.5 mm in September. During the monsoon season, there is an average rainfall of 354 mm.

The Yamuna, Ghaggar, Sarswati, Dohan, Tangri, Krishmawati, Sahibi, and Markanda are the eight principal rivers in Haryana. Other sources of water include groundwater, pond, lake, and canal water. Ground water in some areas of this region has greater salinity, fluoride, chloride, iron, and nitrate levels of contamination. Alluvium soil predominates in the Haryana region. Haryana is situated close to the Ganges and Indus river depressions. The wide plain of Haryana has wet land. The majority of the state is made up of old-style alluvium, which includes sand, clay, silt, and kantars .

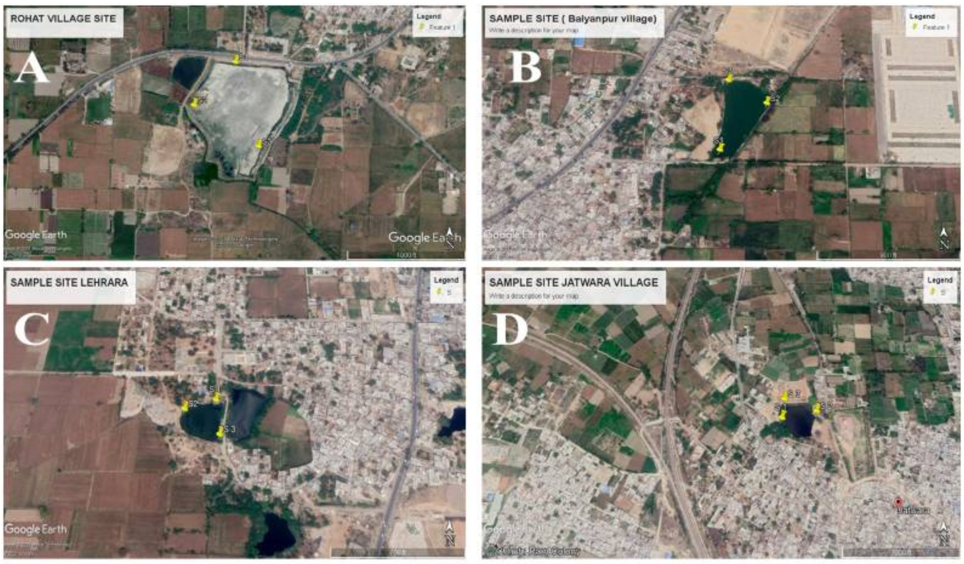


Figure 1: (A, B, C, D): Location of the different villages' study sites, in Sonipet district.

The study was carried out in four different ponds: Rohat village of Rohtak district, Bhaiyanpur and Lehrara village of Sonipat district, and Jatwara village of Jajjhar district, Haryana, India. The details of the sampling location are presented in Table 1. The physical map of the ponds in the respective villages showed in Figure 1.

Table 1: The longitude and latitude of different pond water sampling locations

S. No	Village name	Site	Longitude	Latitude
1.	Rohat village	Site 1	76°58'15.90''E	28°55'54.32''N
		Site 2	76°58'11.93''E	28°55'55.63''N
		Site 3	76°58'18.10''E	28°55'47.09''N
2.	Baiyanpur village	Site 1	77°0'37.77''E	28°57'53.70''N
		Site 2	77°0'41.32''E	28°57'57.01''N
		Site 3	77°0'38.44''E	28°57'58.68''N
3.	Lehrara village	Site 1	77°0'25.44''E	28°58'13.12''N
		Site 2	77°0'23.30''E	28°58'12.56''N
		Site 3	77°0'25.74''E	28°58'11.01''N
4.	Jatwara village	Site 1	77°0'43.37''E	29°0'24.80''N
		Site 2	77°0'47.19''E	29°0'25.44''N
		Site 3	77°0'43.78''E	29°0'26.62''N

Experimental design and sample collection

The water samples were collected from the ponds mentioned above in light and dark bottles to preserve the photosensitive fauna of the water, essentially following the 'light and dark bottle method' [5, 47]. The collections were made from March 2021 to April 2022 at different intervals to consider the seasonal variations (summer: March to June; rainy: July to October; winter: November to February).

Pond water samples were collected in the morning hours ranging from 4:00 a.m. to 8:00 a.m. The water samples from each pond at each time point were collected in three bottles in three replicates; namely, a transparent bottle labeled as 'Light Bottle' (LB) to allow the progression of photosynthesis, a dark bottle covered with a dark cloth cover labeled as 'Dark Bottle' (DB). An 'Initial Bottle' (IB) in the transparent bottle was used immediately for the analysis. The water samples in the bottles were transported to the laboratory and incubated for a certain period until further use.

Pond water sample analysis for productivity

The primary production estimation in the collected water samples was carried out essentially following the "light and dark bottle method" (Sharma & Giri, 2018). The consumption of oxygen and primary production were estimated using Winkler's titration method (Winkler et al., 1888; Sharma & Giri, 2018). The estimated dissolved oxygen level in the different bottles was used to estimate NPP, GPP, and R. The Net Primary Productivity (NPP), Gross Primary Productivity (GPP), and Respiration (R) were calculated using the following formulae:

Net Primary Productivity = (LB-IB)/T×0.375/PQ×1000 mgc/m^3/hr

Gross Primary Productivity = (LB-DB)/T×0.375/PQ×1000 mgc/m^3/hr

Respiration = (IB-DB)/T×0.375/PQ×1000 mgc/m^3/hr

Where: IB = Initial bottles; DB = Dark bottle; LB = Light bottles; T = Time of incubation; PQ = Photosynthesis Quotient (1.25); RQ = Respiratory Quotient (1), and Value 0.375 represents the correction factor [47, 48].

STATISTICAL ANALYSIS:

The statistical Package for Social Science (SPSS), IBM, 23.0 version was used for statistical analysis. One-way ANOVA test was implicated to find the seasonal variation of productivity in different ponds. The significance level was set at $p<0.05$.

RESULTS

Variation of GPP, NPP, R pond located in different locations

The annual productivity of the four ponds was calculated to understand the overall primary productivity of each pond and compare the differences. The values of GPP, NPP, and R obtained from the calculations for the samples from the four different ponds are shown as Mean±SD (Standard Deviation) in Figures 1 to 3. The GPP of the Jatwara pond in the study period (March 2021 to February 2022) was maximum with a mean annual GPP (327.42±75.70 mgc/m^3/hr) followed by Lehrara pond (GPP-268.33±92.92 mgc/m^3/hr), Rohat pond (GPP-220.83±83.49 mgc/m^3/hr), and Baiyanpur pond (GPP-189.17±46.21 mgc/m^3/hr) (Figure 1A). The annual net primary productivity of the four ponds followed a similar trend with a maximum annual NPP (192.50±68.37 mgc/m^3/hr) noticed in the Jatwara pond followed by Lehrara pond (139.17±56.48 mgc/m^3/hr), Rohat pond (125.00±61.42 mgc/m^3/hr), and Baiyanpur pond

(93.33±32.57 mgc/m³/hr) (Figure 1B). The respiration of Jatwara pond was maximum (168.65±47.18 mgc/m³/hr) followed by the respiration rate of the Lehrara pond (161.46±58.98 mgc/m³/hr), Baiyanpur pond (141.67±58.98 mgc/m³/hr), and Rohat pond (118.75±37.88 mgc/m³/hr) (Figure 1C).

Seasonal variations of pond water productivity

One-way ANOVA revealed significant differences in the annual gross and net primary productivity of the four ponds. The Post-hoc HSD Tukey's test revealed significant differences between the annual GPP. The GPP of the Jatwara pond was significantly *(p<0.05*) higher from the productivity of the Rohat and Baiyanpur ponds. However, there was no significant (*p>0.05*) difference among the pond for respiration rate.

Evaluation of the monthly variations of the gross and net primary productivity and respiration rate explains in the seasonal variation data. The GPP of the Rohat pond varied from 100.00±45.82 mgc/m³/hr in September to 380.00±17.32 mgc/m³/hr in March. Meanwhile, the mean GPP of the Baiyanpur pond ranged from 130.00±17.32 mgc/m³/hr in March to 250.00 ±135.27 mgc/m³/hr in September. In Jatwara pond, the mean GPP ranged from 210.00±79.37 mgc/m³/hr in March to 480.00±130.76 mgc/m³/hr in November, and in Lehrara pond, the mean GPP ranged from 170.00±45.83 mgc/m³/hr in April to 490.00 ±62.45 mgc/m³/hr in December (Figure 3A). The NPP of the Rohat pond varied from 40.00 ±17.32 mgc/m³/hr in Sept to 270.00±60.00 mgc/m³/hr in March, while the mean NPP of the Baiyanpur pond ranged from 50.00±17.32 mgc/m³/hr in January to 160.00±45.83 mgc/m³/hr in June. In Jatwara pond, the mean NPP ranged from 100.00±79.37 mgc/m³/hr in May to 320.00±242.49 mgc/m³/hr in January, and in Lehrara pond, the mean NPP ranged from 70.00±34.64 mgc/m³/hr in April to 260.00±96.43 mgc/m³/hr in December (Figure 3B). The R of the Rohat pond varied from 62.50±21.65 mgc/m³/hr in August to 200.00±120.55 mgc/m³/hr in June, while the mean R of the Baiyanpur pond ranged from 62.50±21.65 mgc/m³/hr in March to 300.00±194.85 mgc/m³/hr in September. In Jatwara pond, the mean R ranged from 100.00±43.30 mgc/m³/hr in October to 212.50±78.06 mgc/m³/hr in March, and in Lehrara pond, the mean R ranged from 75.00±37.50 mgc/m³/hr in July to 287.50±114.56 mgc/m³/hr in December (Figure 3C).

Based on the season-wise analysis of primary productivity, the Rohat pond showed the highest GPP (310.00±73.85 mgc/m³/hr) during the summer season followed by Jatwara pond with a mean GPP of 265.25±97.97 mgc/m³/hr, Lehrara pond with mean GPP 210.00±58.62 mgc/m³/hr, and Baiyanpur pond 167.50±65.80 mgc/m³/hr (Figure 2A). Whereas, in the rainy and winter season, the Jatwara pond had the highest mean GPP (summer-320±89.85 mgc/m³/hr; winter-395±129.08 mgc/m³/hr), followed by Lehrara pond (summer-260.00±53.26 mgc/m³/hr; winter-335.00±142.35 mgc/m³/hr), Baiyanpur pond (summer-210.00±90.45 mgc/m³/hr; winter-210.00±90.45 mgc/m³/hr), and Rohat pond (summer-152.50±88.12 mgc/m³/hr; winter-200.00±52.70 mgc/m³/hr). The NPP of the Rohat pond was maximum in the summer season with a mean NPP of 187.5±80.02 mgc/m³/hr, followed by Jatwara pond with a mean NPP of 125.00±49.27 mgc/m³/hr (Figure 2B), Lehrara pond with mean NPP 100.00±29.54 mgc/m³/hr, and Baiyanpur pond with mean NPP of 97.50±61.52 mgc/m³/hr. In the rainy season, the NPP of the Jatwara pond was maximum with an NPP of 195.00±118.28 mgc/m³/hr followed by the Lehrara pond (135.00±41.45 mgc/m³/hr), Baiyanpur pond (105.00±56.49 mgc/m³/hr) and Rohat pond (77.5±48.64 mgc/m³/hr). Whereas, the highest NPP was observed in the Jatwara pond (257.50±134.44 mgc/m³/hr) in the winter season followed by Lehrara pond (182.50±105.84 mgc/m³/hr), Rohat pond (110.00±46.70 mgc/m³/hr) and Baiyanpur pond (77.50±65.79 mgc/m³/hr). The results of the respiration (R) of the four ponds revealed that in the summer season, mean R of Jatwara pond was 177.81 ±98.96 mgc/m³/hr which was the highest GPP followed by Rohat pond with 153.13 ±82.25 mgc/m³/hr, and Lehrara pond with 137.5 ±43.30 mgc/m³/hr. At the same time, the mean R of the Baiyanpur pond was the lowest (87.5 ±56.16 mgc/m³/hr) (Figure 2C). In the rainy season, the R of the Baiyanpur pond was maximum (171.88 ±119.08 mgc/m³/hr), followed by Jatwara pond (156.25 ±85.86 mgc/m³/hr), and Lehrara pond (156.25 ±79.68 mgc/m³/hr). Rohat pond had minimum R values (93.95 ±76.61 mgc/m³/hr). Whereas, in the winter season highest R was observed in the Lehrara pond (190.63 ±107.81 mgc/m³/hr) followed by Jatwara pond (171.88 ±72.33 mgc/m³/hr), Baiyanpur pond (165.63 ±106.62 mgc/m³/hr), and Rohat pond (109.38 ±29.74 mgc/m³/hr).

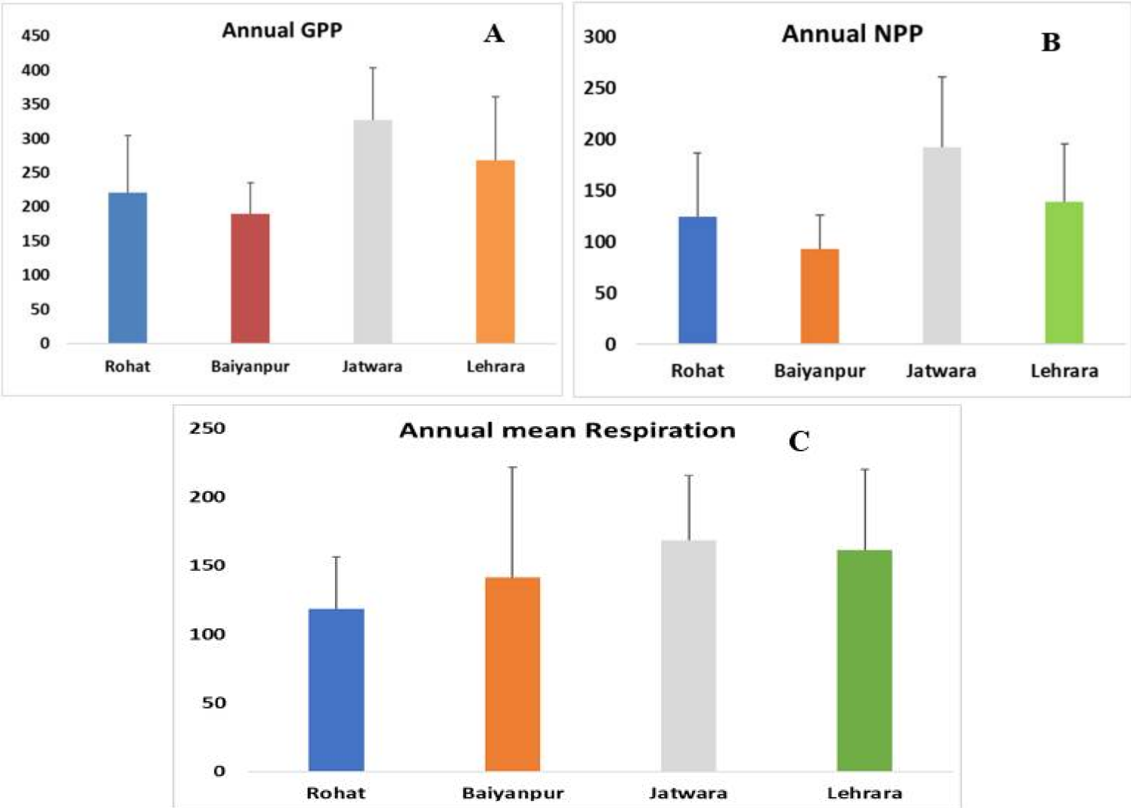
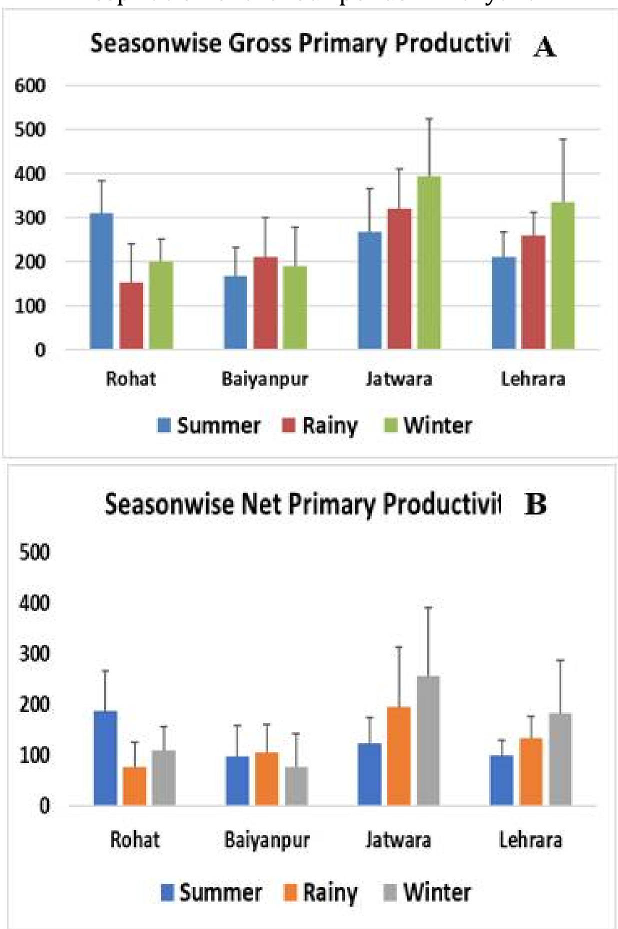


Figure 2 (A-C): Annual (A) Gross primary productivity (GPP), (B) Net Primary Productivity, (C) Respiration of the four ponds in Haryana.



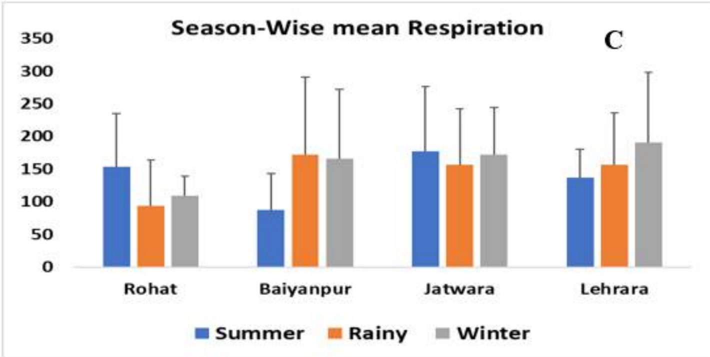


Figure 3(A-C): Seasonal variations of (A) Gross primary productivity (GPP), (B) Net Primary Productivity, and (C) Respiration of the four ponds in Haryana.

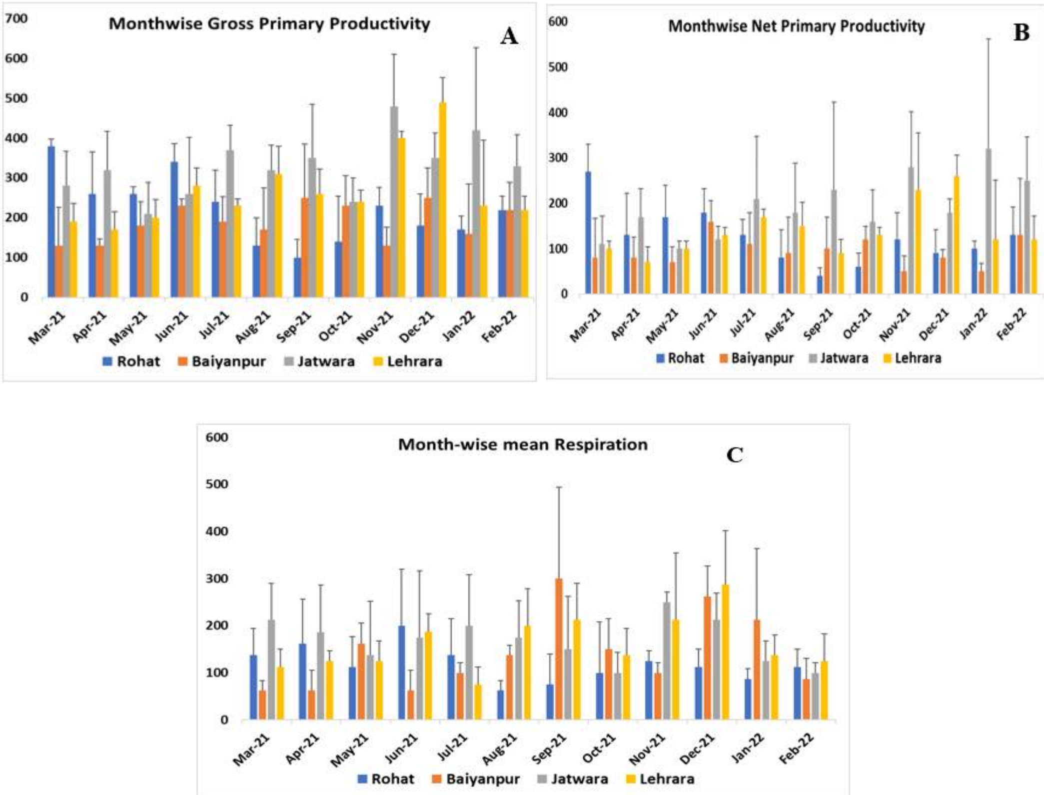


Figure 4 (A-C). Monthly variations of (A) Gross primary productivity (GPP), (B) Net Primary Productivity, and (C) Respiration of the four ponds in Haryana.

DISCUSSION:

Pond water productivity is the rate at which primary pond producers (e.g., algae and aquatic plants) convert solar energy into organic matter through photosynthesis. There are three main components of pond water productivity: GPP, NPP, and R [40]. GPP is the rate at which primary producers convert solar energy into organic matter through photosynthesis. It represents the total amount of organic matter produced by primary producers in a given period. NPP is the rate at which primary producers store organic matter after accounting for the energy they use during cellular respiration. It represents the amount of organic matter available to support other trophic levels (e.g., herbivores and carnivores) in the ecosystem. Respiration (R) is the rate at which primary producers use stored organic matter to power their cellular processes. It represents the energy lost by the ecosystem and is a component of GPP [41, 2]. Gross primary productivity equals net primary productivity plus respiration.

The ratio of NPP to GPP is called photosynthetic efficiency, reflecting primary producers' efficiency in converting solar energy into stored organic matter [52, 43]. This study used the initial dissolved oxygen (DO) level in the water and the dissolved oxygen level after experimental incubation. DO is an essential parameter of water quality [44, 45]. Various factors affecting the dissolved oxygen in a water body include the temperature, salinity, flow, and photosynthetic or respiratory activity in the water body [46-50]. The relationship between pond productivity and dissolved oxygen can be complex. It can vary depending on a range of factors, including the rate of photosynthesis, respiration, nutrient availability, temperature, and amount of water [4-6]. During the daytime, photosynthesis by primary producers can result in the production of oxygen as a byproduct. This can lead to increased levels of dissolved oxygen in the pond water. However, at night, respiration by primary producers and other organisms can consume oxygen, leading to a decrease in dissolved oxygen levels. High levels of primary productivity can result in excess organic matter in the water, which bacteria can decompose. This decomposition process consumes oxygen, leading to a decrease in dissolved oxygen levels.

Additionally, excessive nutrient inputs into a pond can lead to eutrophication [51, 52], which can decrease dissolved oxygen levels due to the growth and respiration of large algal blooms [53]. Therefore, high productivity levels in a pond can lead to increases and decreases in dissolved oxygen levels, depending on the balance between photosynthesis and respiration, as well as the amount of organic matter and nutrients in the pond. Maintaining a balance in the ecosystem is important to ensure a healthy level of dissolved oxygen to support the organisms living in the pond. In this study, among all four ponds, the Jatwara pond had maximum activity in terms of GPP, NPP, and respiration rate, followed by Lehrara, Rohat, and Biyanpur ponds in decreasing order. As the GPP of the Jatwara pond was above 300 mgc/m^3/hr, this pond lies in mesotrophic condition. However, other pond lies in oligotrophic status. There could be several reasons behind the higher productivity in Jatwara village pond. Some possible reasons could include a high nutrient concentration in the water due to agricultural runoff, a high level of sunlight exposure due to lack of shading, and a large population of aquatic plants or algae that photosynthesize rapidly (Wyatt et al., 2012). Additionally, the pond may have a diverse ecosystem with a high abundance of microorganisms and invertebrates that support the food chain and contribute to high GPP (Jeffres et al., 2020).

Seasonal variations of pond water productivity

The overall primary productivity of Rohat pond was highest in the winter season among the four ponds studied. On the other hand, in the winter and rainy seasons, Jatwara pond had the highest productivity, and Rohat pond had very low primary productivity. Among all the seasons studied, the maximum productivity was noticed during the post-monsoon season. Monsoons bring rain in India, and the advent of monsoons is correlated with increased agriculture production. Monsoon season, however, could be more productive for ponds. The biotic index decreased during monsoon and increased post-monsoon. The post-monsoon period was reported to have the best water quality and zooplankton productivity (Reda & Parveen, 2014). Limited monsoon productivity may result from the limited sunlight and silt in the catchment areas (Lohani et al., 2020). Other workers have reported the effect of different seasons on pond productivity (Rathod et al., 2016; Lohani et al., 2020). Post-monsoon has been reported to be best for the productivity of a pond. The increased activity during post-monsoon was attributed to the allochthonous nutrient content received from the catchment area during heavy rains during the monsoon season (Lohani et al., 2020). The increasing phytoplankton concentration in a pond is directly proportional to the productivity in the pond (Patel et al., 2012).

However, water temperature is a key factor that affects the metabolic rates of aquatic organisms and the rate of chemical reactions, and thus can impact the productivity of pond water. Warmer temperatures during summer can enhance metabolic processes, leading to higher productivity levels [54]. This region experienced high temperatures (40 to 46^0C) during the peak summer season. At this temperature, most of the pond water level decreased. This might be the possible reason for the low productivity level in most ponds in the summer season. However, in post-monsoon and winter seasons, the temperature is ambient (20-35^0C) for higher diversity in the pond. Therefore, this might be the most probable reason for higher GPP post-monsoon. However, nutrient availability, seasonal cycles of aquatic organisms, and water level also affects the variability of pond productivity.

Significance of this study

This research work on the seasonal variation of pond water productivity in Haryana will be helpful for water management, enhance the agricultural practice, increase the yield of fishery industry, and will be helpful for a construction of better policy to incur environmental sustainability. Understanding the seasonal changes in water productivity in ponds will be helpful for better water management, particularly in areas where water is a scarce resource. This information can be used to optimize water usage for agriculture, fishing and other activities, leading to a more sustainable use of water resources. However, Haryana is an agricultural state and ponds play a crucial role in supporting the agriculture sector by providing water for irrigation. Understanding the seasonal variations in pond water productivity can help farmers to plan their crop cycle and make informed decisions about when to plant and harvest their crops. Meanwhile, ponds are also an important source of fish in Haryana, and this research on seasonal variation in water productivity can help in better management of the fishery industry. This information can be used to determine the best times to stock ponds with fish and to optimize the conditions for fish growth and survival. However, ponds play a vital role in maintaining the ecological balance in the region, and research on the seasonal variation in water productivity can help in preserving the biodiversity in and around the ponds. This information can also be used to identify and mitigate the impact of any human activities that may be harmful to the environment. Therefore, the findings of this research can also include in policy making related to water management and conservation in Haryana. This information can be used to develop and implement policies that are aimed at improving water management and preserving the environment. Therefore, this research work has a great importance for the sustainable use of water resources, the development of agriculture and fisheries, environmental conservation, and policy making towards better human sustainability in terms of food, health, economy, etc.

Conclusion and futuristic approach:

This study suggests that the productivity level of ponds varies seasonally and is highest in the post-monsoon season. The study also recommends that the pond water should be cleaned regularly to maintain its productivity and improve its suitability for drinking. This information can be useful for managing the ponds in this region and for ensuring that the local communities have access to clean water. Additionally, it highlights the importance of monitoring and understanding the seasonal variation in pond productivity and taking appropriate measures to improve the water quality in these systems.

A futuristic approach to the seasonal variation of pond productivity in the semiarid region could involve implementing new technologies and techniques to better manage these systems. For example, incorporating smart monitoring systems that can track changes in water quality and productivity in real-time would allow for timely interventions and improvements. Additionally, implementing sustainable practices such as rainwater harvesting and incorporating constructed wetlands, can help improve the overall health of the ponds and reduce their dependence on external inputs. Another important aspect would be to focus on education and awareness among the local communities, encouraging them to adopt best practices for pond management and water conservation. This could involve educating them on the importance of reducing pollution and preserving the ecosystem around the ponds. In the future, it would also be important to carry out more research and studies on pond productivity in the region, in order to better understand the underlying factors that contribute to seasonal variations and to develop more effective management strategies. By taking a multi-disciplinary and proactive approach, it should be possible to ensure that the ponds in the semiarid region of India remain productive and sustainable for generations to come.

ACKNOWLEDGMENTS

First author is highly grateful to Dr. Suman Lata, Professor and Chairperson, Department of Chemistry, DCRUST, Murthal, and Dr. Anil Sindhu, Professor and Ex. Chairperson Department of Biotechnology, DCRUST, Murthal, for providing the laboratory facility.

LIMITATIONS:

Due to a lack of logistical support and funds, we could not carry out some important water quality related (organic content, minerals profiling, and complete physico-chemical analysis) over the study period. Despite this, we found unique and significant results on the seasonal variation of pond water productivity in the semi-arid region of India.

Author Contribution:

SR collected all the samples, performed all the analysis part with the help of LSC and PD. SR also compiled all the data, data analysis, an prepared the draft with the help of PD. AG designed and coordinated the study, compiled all the data, data analysis and final manuscript preparation. All authors read and approved the final manuscript.

Conflict of interest:

The authors declare that there is no conflict of interest.

Data availability statement

Data will be available from the corresponding author upon good scientific reason and request.

Ethics declarations

Ethics approval and consent to participate
Not applicable.
Consent for publication
Not applicable.
Completing interests
All authors declare that they have no proprietary, financial, professional, nor any other personal interest of any kind in any product or services and/or company that could be construed or considered to be a potential conflict of interest that might have influenced the views expressed in this manuscript.

REFERENCES

1. Afrad, M. S. I., Monir, M. B., Haque, M. E., Barau, A. A., & Haque, M. M. (2020). Impact of industrial effluent on water, soil and Rice production in Bangladesh: a case of Turag River Bank. Journal of environmental health science & engineering, 18(2), 825–834. https://doi.org/10.1007/s40201-020-00506-8
2. Central Ground Water Board, 2023. Ground Water Scenario of Haryana. Ministry of Water Resources Government of India. http://cgwb.gov.in/gw_profiles/st_Haryana.htm (Accessed on 15/02/2023)
3. Agrawal, A., & Gopal, K. (2013). Measurement of Primary Productivity in Relation to Food Chain. Biomonitoring of Water and Waste Water, 1-13. https://doi.org/10.1007/978-81-322-0864-8_1
4. Ayele, H. S., & Atlabachew, M. (2021). Review of characterization, factors, impacts, and solutions of Lake eutrophication: lesson for lake Tana, Ethiopia. Environmental Science and Pollution Research, 28(12), 14233-14252. https://doi.org/10.1007/s11356-020-12081-4
5. Baxa, M., Musil, M., Kummel, M., Hanzlík, P., Tesařová, B., & Pechar, L. (2021). Dissolved oxygen deficits in a shallow eutrophic aquatic ecosystem (fishpond)–Sediment oxygen demand and water column respiration alternately drive the oxygen regime. Science of The Total Environment, 766, 142647. https://doi.org/10.1016/j.scitotenv.2020.142647
6. Bhatti, S. S., Sambyal, V., & Nagpal, A. K. (2018). Analysis of genotoxicity of agricultural soils and metal (Fe, Mn, and Zn) accumulation in crops. International Journal of Environmental Research, 12(4), 439-449. https://doi.org/10.1007/s41742-018-0103-1
7. Boyd, C. E., Torrans, E. L., & Tucker, C. S. (2018). Dissolved oxygen and aeration in ictalurid catfish aquaculture. Journal of the World Aquaculture Society, 49(1), 7-70. https://doi.org/10.1111/jwas.12469
8. Cabral J. P. (2010). Water microbiology. Bacterial pathogens and water. International journal of environmental research and public health, 7(10), 3657–3703. https://doi.org/10.3390/ijerph7103657
9. Carpenter S. R. (2005). Eutrophication of aquatic ecosystems: bistability and soil phosphorus. Proceedings of the National Academy of Sciences of the United States of America, 102(29), 10002–10005. https://doi.org/10.1073/pnas.0503959102
10. Celewicz, S., & Gołdyn, B. (2021). Phytoplankton communities in temporary ponds under different climate scenarios. Scientific reports, 11(1), 17969. https://doi.org/10.1038/s41598-021-97516-9
11. Chu, E. W., & Karr, J. R. (2017). Environmental Impact: Concept, Consequences, Measurement. Reference Module in Life Sciences, B978-0-12-809633-8.02380-3. https://doi.org/10.1016/B978-0-12-809633-8.02380-3
12. Diana, J. S., Szyper, J. P., Batterson, T. R., Boyd, C. E., & Piedrahita, R. H. (2017). Water quality in ponds. Dynamics of pond aquaculture, 53-71. https://doi.org/10.1201/9780203759028-3
13. Ducklow, H. W., Stukel, M. R., Eveleth, R., Doney, S. C., Jickells, T., Schofield, O., Baker, A. R., Brindle, J., Chance, R., & Cassar, N. (2018). Spring-summer net community production, new production, particle export and related water column biogeochemical processes in the marginal sea ice zone of the Western Antarctic Peninsula 2012-2014. Philosophical transactions. Series A, Mathematical, physical, and engineering sciences, 376(2122), 20170177. https://doi.org/10.1098/rsta.2017.0177
14. Easton, Z. M., & Petrovic, A. M. (2004). Fertilizer source effect on ground and surface water quality in drainage from turfgrass. Journal of environmental quality, 33(2), 645–655. https://doi.org/10.2134/jeq2004.6450
15. Gao, S., Yan, H., Beirne, N., Wigmosta, M., & Huesemann, M. (2022). Improving Microalgal Biomass Productivity Using Weather-Forecast-Informed Operations. Cells, 11(9), 1498. https://doi.org/10.3390/cells11091498
16. Gao, Y., Jia, J., Lu, Y., Yang, T., Lyu, S., Shi, K., ...& Yu, G. (2021). Determining dominating control mechanisms of inland water carbon cycling processes and associated gross primary productivity on regional and global scales. Earth-Science Reviews, 213, 103497. https://doi.org/10.1016/j.earscirev.2020.103497
17. George, D. G., Maberly, S. C., & Hewitt, D. P. (2004). The influence of the North Atlantic Oscillation on the physical, chemical and biological characteristics of four lakes in the English Lake District. Freshwater Biology, 49(6), 760-774. https://doi.org/10.1111/j.1365-2427.2004.01223.x
18. Gräslund, S., & Bengtsson, B. E. (2001). Chemicals and biological products used in south-east Asian shrimp farming, and their potential impact on the environment—a review. Science of the Total Environment, 280(1-3), 93-131. https://doi.org/10.1016/s0048-9697(01)00818-x
19. Hao, A., Kobayashi, S., Huang, H., Mi, Q., & Iseri, Y. (2020). Effects of substrate and water depth of a eutrophic pond on the physiological status of a submerged plant, Vallisneria natans. PeerJ, 8, e10273. https://doi.org/10.7717/peerj.10273
20. Heisler, J., Glibert, P., Burkholder, J., Anderson, D., Cochlan, W., Dennison, W., Gobler, C., Dortch, Q., Heil, C., Humphries, E., Lewitus, A., Magnien, R., Marshall, H., Sellner, K., Stockwell, D., Stoecker, D., & Suddleson, M.

(2008). Eutrophication and Harmful Algal Blooms: A Scientific Consensus. Harmful algae, 8(1), 3–13. https://doi.org/10.1016/j.hal.2008.08.006
21. Hlordzi, V., Kuebutornye, F. K., Afriyie, G., Abarike, E. D., Lu, Y., Chi, S., & Anokyewaa, M. A. (2020). The use of Bacillus species in maintenance of water quality in aquaculture: A review. Aquaculture Reports, 18, 100503. https://doi.org/10.1016/j.aqrep.2020.100503
22. Iordache, A. M., Nechita, C., Zgavarogea, R., Voica, C., Varlam, M., & Ionete, R. E. (2022). Accumulation and ecotoxicological risk assessment of heavy metals in surface sediments of the Olt River, Romania. Scientific reports, 12(1), 880. https://doi.org/10.1038/s41598-022-04865-0
23. Jeffres, C. A., Holmes, E. J., Sommer, T. R., & Katz, J. V. (2020). Detrital food web contributes to aquatic ecosystem productivity and rapid salmon growth in a managed floodplain. PloS one, 15(9), e0216019. https://doi.org/10.1371/journal.pone.0216019
24. Kaushik, A., Kansal, A., Kumari, S., & Kaushik, C. P. (2009). Heavy metal contamination of river Yamuna, Haryana, India: assessment by metal enrichment factor of the sediments. Journal of hazardous materials, 164(1), 265-270. https://doi.org/10.1016/j.jhazmat.2008.08.031
25. Li, P., Karunanidhi, D., Subramani, T., & Srinivasamoorthy, K. (2021). Sources and Consequences of Groundwater Contamination. Archives of environmental contamination and toxicology, 80(1), 1–10. https://doi.org/10.1007/s00244-020-00805-z
26. Lohani, V., Shah, T. K., Pant, B., Ram, R. N., Misra, V. K., & Singh, C. P. (2020). Estimation of primary productivity of aquaculture ponds with special reference to duration of desilting. J Krishi Vigyan (Special Issue) : 85-89, 85. https://doi.org/10.5958/2349-4433.2020.00085.9
27. Lundy, L., Alves, L., Revitt, M., & Wildeboer, D. (2017). Metal Water-Sediment Interactions and Impacts on an Urban Ecosystem. International journal of environmental research and public health, 14(7), 722. https://doi.org/10.3390/ijerph14070722
28. Lv, Z., Xiao, X., Wang, Y., Zhang, Y. & Jiao, N. (2022). Improved water quality monitoring indicators may increase carbon storage in the oceans. Environmental Research, 206, 112608. https://doi.org/10.1016/j.envres.2021.112608
29. Manuel J. (2014). Nutrient pollution: a persistent threat to waterways. Environmental health perspectives, 122(11), A304–A309. https://doi.org/10.1289/ehp.122-A304
30. Marcantonio, R., Javeline, D., Field, S., & Fuentes, A. (2021). Global distribution and coincidence of pollution, climate impacts, and health risk in the Anthropocene. PloS one, 16(7), e0254060. https://doi.org/10.1371/journal.pone.0254060
31. Masood, Z., Hasan, Z., Gul, H., Zahid, H., Hassan, H. U., Sultan, R., Khan, W., Safia, Titus, K., & Ullah, A. (2022). Monitoring pond water quality to improve the production of Labeo rohita (Hamilton, 1822) in Bannu Fish Hatchery of Bannu district, Khyber Pakhtunkhwa province; An Implications for artificial fish culture. Brazilian journal of biology = Revista brasleira de biologia, 83, e245197. https://doi.org/10.1590/1519-6984.245197
32. Mizwar, A., &Surapati, H. U. (2020). Biological oxygen demand (BOD5) as bio indicator of phytoplankton diversity index in the mangrove area of Kintap Estuary – South Kalimantan. IOP Conference Series: Earth Environmental Science, 448.https://doi.org/10.1088/1755-1315/448/1/012126
33. Pandey, P. K., Kass, P. H., Soupir, M. L., Biswas, S., & Singh, V. P. (2014). Contamination of water resources by pathogenic bacteria. AMB Express, 4, 51. https://doi.org/10.1186/s13568-014-0051-x
34. Panghal, V., Singh, A., Kumar, R., Kumari, G., Kumar, P., & Kumar, S. (2021). Soil heavy metals contamination and ecological risk assessment in Rohtak urban area, Haryana (India). Environmental Earth Sciences, 80(21), 1-20. https://doi.org/10.1007/s12665-021-10028-7
35. Patel, V., S.N Shukla, S. N. S., & Pandey, U. (2012). Studies on primary productivity with special Reference to their physico-chemical status of Govindgarh Lake Rewa (M.P.), India. International Journal of Scientific Research, 2(11), 508–510. https://doi.org/10.15373/22778179/nov2013/170
36. Qin, G., Liu, J., Xu, S., & Sun, Y. (2021). Pollution Source Apportionment and Water Quality Risk Evaluation of a Drinking Water Reservoir during Flood Seasons. International journal of environmental research and public health, 18(4), 1873. https://doi.org/10.3390/ijerph18041873
37. Rasconi, S., Gall, A., Winter, K., & Kainz, M. J. (2015). Increasing Water Temperature Triggers Dominance of Small Freshwater Plankton. PloS one, 10(10), e0140449. https://doi.org/10.1371/journal.pone.0140449
38. Rathod Rahul Pralhad, Balasahe B R Chavan and Raghuvendra K Pai (2016). Variation in Primary Production In Relation to Physicochemical parameters of Kadwai Reservoir, Ratnagiri, Maharashtra, India. Current World Environ 11(1), 228-232. https://doi.org/10.12944/cwe.11.1.28
39. Rathore, S. S., Chandravanshi, P., Chandravanshi, A., & Jaiswal, K. (2016). Eutrophication: impacts of excess nutrient inputs on aquatic ecosystem. IOSR Journal of Agriculture and Veterinary Science, 9(10), 89-96. https://doi.org/10.9790/2380-0910018996
40. Ravish, S., Setia, B., & Deswal, S. (2020). Groundwater quality and geochemical signatures in the northeastern Haryana, India. Arabian Journal of Geosciences, 13(21), 1-19. https://doi.org/10.1007/s12517-020-06094-z
41. Reda, H and Parveen, S. (2014). Effect of Monsoon on Zooplankton Variations and Environmental Characteristics in a Tropical Fish Pond at Aligarh , India. Egyptian Journal of Aquatic Biology and Fisheries. 18. 105-114. https://doi.org/10.12816/0011110
42. Rey-Romero, D. C., Domínguez, I., & Oviedo-Ocaña, E. R. (2022). Effect of agricultural activities on surface water quality from páramo ecosystems. Environmental science and pollution research international, 29(55), 83169–83190. https://doi.org/10.1007/s11356-022-21709-6

43. Sankhla, M. S., Kumari, M., Nandan, M., Kumar, R., & Agrawal, P. (2016). Heavy metals contamination in water and their hazardous effect on human health-a review. Int. J. Curr. Microbiol. App. Sci (2016), 5(10), 759-766. https://doi.org/10.2139/ssrn.3428216
44. Sarkar, R., Ghosh, A. R., & Mondal, N. K. (2020). Comparative study on physicochemical status and diversity of macrophytes and zooplanktons of two urban ponds of Chandannagar, WB, India. Applied Water Science, 10(2), 1-8. https://doi.org/10.1007/s13201-020-1146-y
45. Sharma, P., &Giri, A. (2018). Productivity evaluation of lotic and lentic water body in Himachal Pradesh, India. MOJ Eco Environ Sci, 3(5), 311-317.https://doi.org/10.15406/mojes.2018.03.00105
46. Simmons, J. A., Long, J. M., & Ray, J. W. (2004). What limits the productivity of acid mine drainage treatment ponds?. Mine water and the Environment, 23, 44-53. https://doi.org/10.1007/s10230-004-0035-1
47. Sojka, M., & Jaskuła, J. (2022). Heavy Metals in River Sediments: Contamination, Toxicity, and Source Identification-A Case Study from Poland. International journal of environmental research and public health, 19(17), 10502. https://doi.org/10.3390/ijerph191710502
48. Spyra A. (2017). Acidic, neutral and alkaline forest ponds as a landscape element affecting the biodiversity of freshwater snails. Die Naturwissenschaften, 104(9-10), 73. https://doi.org/10.1007/s00114-017-1495-z
49. Sun, Z., Sokolova, E., Brittain, J. E., Saltveit, S. J., Rauch, S., & Meland, S. (2019). Impact of environmental factors on aquatic biodiversity in roadside stormwater ponds. Scientific reports, 9(1), 5994. https://doi.org/10.1038/s41598-019-42497-z
50. Vargas-González, H. H., Arreola-Lizárraga, J. A., Mendoza-Salgado, R. A., Méndez-Rodríguez, L. C., Lechuga-Deveze, C. H., Padilla-Arredondo, G., & Cordoba-Matson, M. (2014). Effects of sewage discharge on trophic state and water quality in a coastal ecosystem of the Gulf of California. The Scientific World Journal, 2014, 618054. https://doi.org/10.1155/2014/618054
51. Wallace, R. B., & Gobler, C. J. (2021). The role of algal blooms and community respiration in controlling the temporal and spatial dynamics of hypoxia and acidification in eutrophic estuaries. Marine Pollution Bulletin, 172, 112908. https://doi.org/10.1016/j.marpolbul.2021.112908
52. Williams, I. N., Torn, M. S., Riley, W. J., & Wehner, M. F. (2014). Impacts of climate extremes on gross primary production under global warming. Environmental Research Letters, 9(9), 094011. https://doi.org/10.1088/1748-9326/9/9/094011
53. Winkler, L. W. (1888). Die Bestimmung des im Wasser gelöstenSauerstoffes. Berichte der deutschenchemischen Gesellschaft, 21(2), 2843-2854. https://doi.org/10.1002/cber.188802102122
54. Wyatt, K. H., Turetsky, M. R., Rober, A. R., Giroldo, D., Kane, E. S., & Stevenson, R. J. (2012). Contributions of algae to GPP and DOC production in an Alaskan fen: effects of historical water table manipulations on ecosystem responses to a natural flood. Oecologia, 169, 821-832. https://doi.org/10.1007/s00442-011-2233-4

CITATION OF THIS ARTICLE

S Rani, L S Chandolia, P Devi, A Giri.Seasonal Variation of Pond Water Productivity In A Semi-Arid Region Of India. Bull. Env.Pharmacol. Life Sci., Vol 12 [4] March 2023: 111-121