Teena Sharma, et. al. International Journal of Engineering Research and Applications
www.ijera.com
ISSN: 2248-9622, Vol. 13, Issue 1, January 2023, pp 190-199

RESEARCH ARTICLE OPEN ACCESS

Assessment of Gross and Net Primary Productivity in Relation to Planktonic Communities in Kagdi Pick-Up Weir, Southern Rajasthan

[1]Teena Sharma, [2]Lalit Choudhary* and [3]Seema Bharadwaj
[1,2]Department of Zoology, Leo College, Banswara (Rajasthan), India, 327001
[3]Department of Zoology, HDJ Govt. Girls College, Banswara (Rajasthan), India. 327001
GGTU UNIVERSITY, BANSWARA
**Corresponding author email: lalit540@gmail.com*

ABSTRACT:
This study examines gross primary production (GPP), net primary production (NPP), community respiration, and plankton diversity in Kagdi Pick-Up Weir, Banswara, from 2019 to 2021. GPP readings varied between 118.75 and 287.375 mgC/m²/hr at Station I, and between 96.875 and 284.375 mgC/m²/hr at Station II. NPP ranged from 53.125 to 206.375 mgC/m²/hr at Station I and from 37.5 to 209.875 mgC/m²/hr at Station II, demonstrating considerable seasonal and geographic variability in production. Community respiration reached a maximum of 178.125 mgC/m²/hr at Station I and 181.25 mgC/m²/hr at Station II, with the minimum values recorded in early 2019. Station I observed 24 phytoplankton species, while Station II recorded 26. Chlorophyceae emerged as the predominant phytoplankton group, accounting for 41.66% at Station I and 53.85% at Station II. Zooplankton diversity comprised 25 species at Station I and 26 species at Station II, with Rotifera predominating at both locations (52.00% and 50.00%, respectively). Protozoa, Cladocera, Copepoda, and Ostracoda were present in differing proportions. Various planktonic creatures, including insect larvae and arachnids, were also documented. This extensive analysis of primary productivity and plankton composition offers essential insights into the ecological dynamics and biodiversity condition of the Kagdi Pick-Up Weir aquatic ecosystem.
Keywords: Gross primary productivity, net primary productivity, plankton diversity, phytoplankton, zooplankton, respiration, Chlorophyceae, Rotifera, Kagdi Pick-Up Weir, Banswara.

I. INTRODUCTION

Aquatic ecosystems are dynamic environments in which primary production constitutes the foundation of the trophic structure, sustaining varied biological populations. Primary productivity, namely gross primary production (GPP) and net primary production (NPP) is essential for assessing the biological efficiency and ecological equilibrium of freshwater ecosystems (Wetzel, 2001). The efficacy of these systems is significantly affected by the availability and composition of phytoplankton, which serve as primary producers and bioindicators of water quality (Reynolds, 2006).

Multiple studies have shown the significance of comprehending primary productivity in connection with plankton diversity. Sharma and Mishra (2015) evaluated production patterns in Central India's freshwater ponds and noted significant seasonal variations driven by phytoplankton abundance. Kumar et al. (2014) also showed a positive association between phytoplankton density and gross primary productivity in tropical reservoirs of Bihar. Jain and Khan (2012) recorded the variety and productivity of phytoplankton in Ana Sagar Lake, emphasizing the predominance of Chlorophyceae in post-monsoon seasons in Rajasthan.

Phytoplankton communities are predominantly composed of Chlorophyceae, Bacillariophyceae, and Myxophyceae, and their composition may signify ecological stress or eutrophic conditions (Sarma et al., 2010). Zooplankton, encompassing taxa such as Rotifera, Cladocera, and Copepoda, are essential for nutrient cycling and energy transfer in aquatic ecosystems (Dodson et al., 2000). Zooplankton community structure and diversity can indicate the trophic condition of freshwater ecosystems (Sinha & Naik, 2002). In a study performed in the wetlands of Assam, Das and Bhattacharyya (2013) observed that rotifers predominated in nutrient-rich habitats and were closely linked to primary productivity levels.

In Southern Rajasthan, limited research has thoroughly examined the correlation between primary productivity and plankton dynamics. Jakher and Rawat (2003) examined the limnological attributes of Jaisamand Lake, revealing that productivity is substantially influenced by seasonal variations and phytoplankton density. Bhandari et al. (2017) investigated the physicochemical properties and corresponding planktonic diversity in the tribal areas of Rajasthan, highlighting the ecological significance of tiny reservoirs.

This study is to evaluate gross and net primary production of phytoplankton and zooplankton communities at two stations in Kagdi Pick-Up Weir, Banswara, from 2019 to 2021. This study enhances comprehension of the ecological condition of semi-arid freshwater systems and aids in the conservation of biodiversity in inland aquatic environments.

II. MATERIAL AND METHOD

Study Area

Kagdi Pick-Up Weir is located near Banswara city in the southern part of Rajasthan, India. Geographically positioned between **23°33′ N latitude and 74°27′ E longitude**, the weir is part of the Mahi River catchment and serves as a critical source of water for irrigation and local biodiversity. The region experiences a **semi-arid to sub-humid tropical climate** characterised by hot summers (March to June), monsoonal rainfall (July to September), and mild winters (October to February). The weir supports diverse aquatic flora and fauna and plays a significant role in sustaining regional water balance and ecological functions. Two distinct sampling stations—**Station I** and **Station II**—were selected based on their varying depths and levels of anthropogenic influence for detailed analysis during the study period from **February 2019 to January 2021**.

Sampling Design and Frequency

Field investigations were conducted **monthly** at both Station I and Station II for a continuous period of two years. Samples were collected in the **morning hours between 7:00 AM and 9:00 AM** to minimise diurnal variation.

Primary Productivity Measurement

Gross Primary Production (GPP), Net Primary Production (NPP), and Community Respiration (CR) were estimated using the **light and dark bottle oxygen method** (APHA, 2017). The procedure involved: Collection of surface water samples from both stations using **Van Dorn water samplers.** Samples were filled in **two BOD bottles** (300 mL each) for each station: one exposed to sunlight (**light bottle**) to estimate NPP and the other kept in darkness (**dark bottle**) to estimate CR. Initial dissolved oxygen (DO) was measured on-site using the **Winkler titration method;** after a 3-hour incubation period, final DO in both bottles was determined.

Formulas **NPP = DO in light bottle – DO in initial bottle**

CR = DO in initial bottle – DO in dark bottle

GPP = NPP + CR

The results were converted to carbon values (mgC/m²/hr) using the appropriate conversion factor.

Plankton Collection and Identification

Phytoplankton and zooplankton samples were collected simultaneously with productivity measurements.

- **Phytoplankton**: Collected from the surface using a **5L water sampler** and filtered through a **20 µm mesh plankton net**, preserved in **4% formalin** and Lugol's iodine solution, identified under a **compound light microscope** using standard taxonomic keys (Prescott, 1962; APHA, 2017). Quantitative estimation was done using a **Sedgwick-Rafter counting chamber** and expressed as **units/L**.
- **Zooplankton**: Collected by vertical and horizontal hauls using a **50 µm mesh plankton net**, concentrated to 100 mL and preserved in **4% formalin**, identified and enumerated under a microscope using standard references (Edmondson, 1959).

III. RESULTS AND DISCUSSION

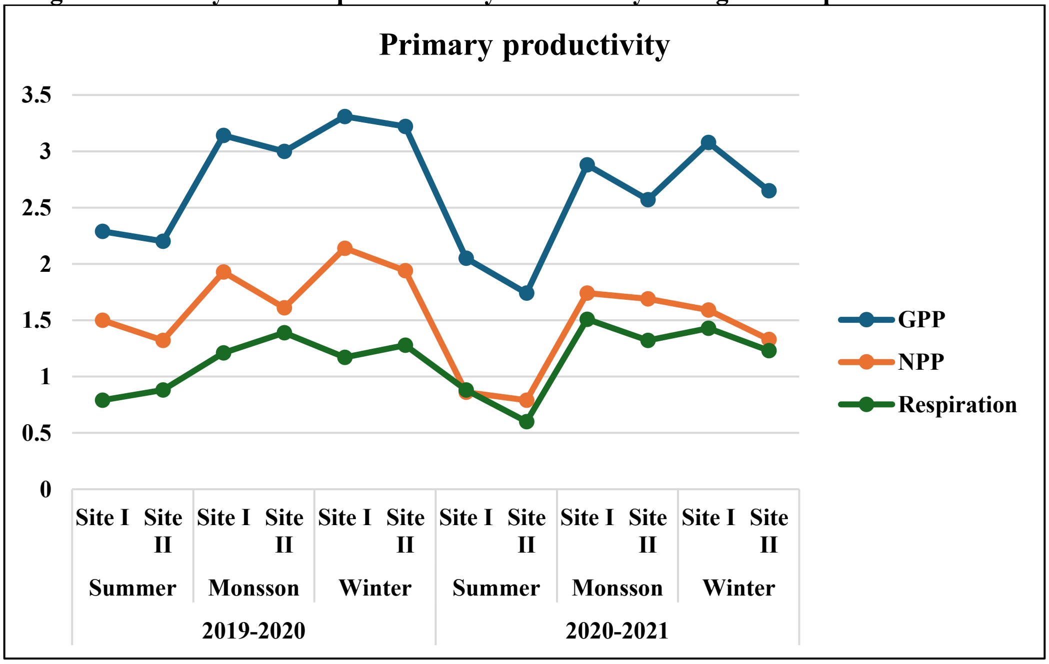
The gross primary production (GPP), net primary production (NPP), and community respiration were monitored seasonally from 2019 to 2021 at two stations (Site I and Site II) of Kagdi Pick-Up Weir in Banswara. According to the graphical representation, during the summer of 2019–2020, Site I showed moderate GPP (~2.3 mgC/m²/hr), which increased significantly to above 3.0 mgC/m²/hr during the monsoon and winter seasons. Similarly, Site II followed the same trend, reaching the peak GPP value (~3.3 mgC/m²/hr) during the monsoon. NPP values ranged from approximately 1.4 to 2.1 mgC/m²/hr in this year, peaking during winter at Site I. Community respiration also increased proportionally, with the highest respiration values observed in winter (~1.4 mgC/m²/hr).

In the subsequent year (2020–2021), a marked dip in all three parameters was noted during the summer season. GPP dropped below 2.0 mgC/m²/hr at both stations, and NPP fell below 1.0 mgC/m²/hr, particularly at Site II. Community respiration recorded its lowest level (~0.6 mgC/m²/hr) during the same period. However, with the onset of the monsoon, all values rebounded—GPP climbed again above 2.5 mgC/m²/hr, NPP reached ~1.8 mgC/m²/hr, and respiration increased above 1.4 mgC/m²/hr. During the winter of 2020–2021, the productivity values slightly declined compared to the monsoon but still remained higher than the summer low (Fig. 1).

Overall, the graphical data illustrates clear seasonal variations in primary productivity, with peak values during monsoon and winter and significant reductions during summer. These trends highlight the influence of hydrological and climatic changes on primary productivity and plankton metabolism in the Kagdi Pick-Up Weir ecosystem.

Similar seasonal productivity trends were observed by **Verma and Saksena (2010)** in tropical lakes, where monsoonal nutrient influx significantly enhanced GPP and NPP levels, supporting robust planktonic growth. **Saha and Pal (2019)** also emphasized that seasonal hydrological dynamics, especially during monsoons, result in increased organic matter and nutrient availability, thereby increasing biological productivity. The dominance of chlorophyceae in the phytoplankton community supports the findings of **Pandey and Verma (2004)**, who reported that members of Chlorophyceae thrive under high light and nutrient-rich conditions, particularly during the monsoon and post-monsoon periods. The observed decrease in community respiration during summer months at both stations can be related to lower biological activity, as also documented by **Mishra and Saksena (1991)**, who highlighted that high summer temperatures often lead to thermal stress on aquatic biota, reducing respiration rates and overall metabolic activity. Thus, the observed seasonal fluctuations in productivity and plankton structure in the Kagdi Pick-Up Weir affirm the role of abiotic factors such as temperature, nutrient availability, and hydrological input in shaping the aquatic ecosystem.

Fig. 1: Seasonally Line Graph of Primary Productivity of Kagdi Pickup Weir 2019-2021.



Observations of Plankton in Kagdi Pick-Up Weir

(I) Observations on phytoplanktonic groups and their species: At station-I

In the present study total 24 species of phytoplankton were recorded during February 2019 to January 2021 (Table 1) out of which 10 species belongs to Chlorophyceae, 2 species of Xanthophyceae, 6 species of Myxophyceae, 2 species of Dinophyceae and 4 species of Bacillariophyceae. **Chlorophyceae** was represented by its 10 species viz. *Spirogyra sp. Oedogonium sp., Ulothrix sp., Chlorella sp., Zygnemopsis sp., Microspora sp., Spaerocystis sp., Volvox sp., Pediastrum sp., Oocystis sp.*Among the Chlorophyceae group *Spirogyra sp., Ulothrix sp. and Volvox sp.* Occurred throughout the study period.

Xanthophyceae group was represented by its 2 species viz. *Botrydiopsis sp. and Chlorobotrys sp.*. **Myxophyceae** group was represented by its 6 species viz. *Coccochlaris sp., Oscillatoria sp., Anabaena sp., Nostoc sp., Microcystis sp. and Spirulina sp. Among the myxophyceae group Anabaena sp. was present throughout* the study period and represents most dominant species. **Dinophyceae** group was represented by its 2 species named *Ceratium sp. and Peridinium sp.*

This group was not observed during the rainy months.
Bacillariophyceae *consisted by 4 species viz. Fragillaria sp., Cyclotella sp., Bacillaria sp., Cymbella sp*.
On the basis of density, the percentage composition of phytoplankton indicated the following ranking Chlorophyceae (41.66%) > Myxophyceae (25.00 %) > Bacillariophyceae (16.33%) > Xanthophyceae (8.33%) = Dinophyceae (8.33%)

At station-II

In the present study total 26 species of phytoplankton were recorded during February 2019 to January 2021 (Table 1) out of which 14 species belongs to Chlorophyceae, 1 species of Xanthophyceae, 4 species of Myxophyceae, 1 species of Dinophyceae and 6 species of Bacillariophyceae.
Chlorophyceae consisted as most dominant group of phytopoanktinic population in Kagdi pick-up weir and its represented by 14 species viz. *Coelastrum sp., Spirogyra sp. Oedogonium sp., Ulothrix sp., Scenedesmus sp., Chlorella sp., Zygnemopsis sp., Pleodorina sp., Microspora sp., Spaerocystis sp., Volvox sp., Eudorina sp. Pediastrum sp. and Oocystis sp.* Among the Chlorophyceae group *Spirogyra sp., Ulothrix sp. and Volvox sp.* Occurred throughout the study period.
Xanthophyceae group was represented by only 1 species viz. *Chlorobotrys sp.*
Myxophyceae group was represented by its 4 species viz. *Oscillatoria sp., Nostoc sp., Microcystis sp. and Spirulina sp. Among the Myxophyceae group Nostoc sp. and Microcystis sp., were present throughout* the study period.

Dinophyceae group was represented by its 1 species *Ceratium sp. This group was not observed during the rainy months.*
Bacillariophyceae was *represented by 6 species viz. Fragillaria sp., Pinnularia sp., Cyclotella sp., Bacillaria sp., Cymbella sp. and Amphora sp*. On the basis of density, the percentage composition of phytoplankton indicated the following ranking:Chlorophyceae (53.85%) > Bacillariophyceae (23.07%) > Myxophyceae (15.38 %) > Xanthophyceae (3.58%) = Dinophyceae (3.58%)"

Observations on zooplanktonic groups and their species: At station-I

In the present study total 25 species of zooplankton were observed which belongs to different families (Table 2). Out of which 4 species belong to *Protozoa*, 13 to *Rotifera*, 3 to *Cladocera*, 3 to *Copepoda* and 2 to *Ostracoda*. The bulk of zooplanktoinic assemblages of this dam was contributed primarily by *Rotifers* followed by *Protozoans, Cladocerans, Copepods and Ostracods*. The group **protozoa** was represented by its 4 species viz. *Volvox sp., Euglena sp., Amoeba sp. and Paramecium sp.*
Rotifera was represented as most dominant zooplanktonic group of the Kagdi pick-up weir and represented by its 13 species viz. *Brachionus forficula, Brachionus angularis, Keratella cochleris, Trichotria similis, Mytilina ventralis, Lecane luna, Cephalodella exigua, Tricocerca cylindrico, Lepadella ovalis, Polyarthra vulgaris, Horella mira Filinia longiseta and Philodina*. *The* group **Cladocera** was represented by its 3 species viz. *Ceriodaphnia laticaudata, Daphnia dubia and Daphnia lumholtzi*. In this group *Daphinia dubia* was most dominant.
Copepoda was represented by its 3 species viz. *Heliodiaptomus viddus, Cyclops leuckarti and Nauplii*. *Nauplii* represents the most dominant species among the copepods.The group **Ostracoda** represents by its 2 species viz. *Eucypris and Heterocypris*. This group was not observed in rainy months at Kagdi pick-up weir. The observed scenario of zooplankton dominance at station I of Kagdi Pick-up weir (Banswara) studied is as under:

Rotifera (52.00%) > Protozoa (16.00%) > Cladocera (12.00%) = Copepoda (12.00%)> Ostracoda (08.00%)"

At station-II

In the present study a total of 26 species of zooplankton were observed which belongs to different families. Out of which 5 species belong to protozoa, 13 to rotifera, 3 to Cladocera, 3 to copepoda and 2 to ostracoda. The bulk of zooplanktoinic assemblages of this dam was contributed primarily by rotifers followed by protozoans, cladocerans, copepods and ostracods.

The group **Protozoa** was represented by its 5 species viz. *volvox sp., Euglena sp., Amoeba sp., Arcella discoida and paramecium sp.*

Rotifera was represented as most dominant zooplanktonic group of the Kagdi pick-up weir and represented by its 13 species viz. *Brachionus forficula, Keratella vulga, Trichotria similis, Mytilina ventralis, Lecane luna, Monostyla bulla, Cephalodella exigua, Tricocerca cylindrico, Lepadella ovalis, Asplanchna herricki, Polyarthra vulgaris, Filinia longiseta and Philodina.*

The group **Cladocera** was represented by its 3 species viz. *Ceriodaphnia laticaudata, Daphnia dubia and Daphnia lumholtzi*. In this group *Daphinia dubia* was most dominant.

Copepoda was represented by its 3 species viz. *Heliodiaptomus viddus, Cyclops leuckarti and Nauplii. Nauplii* represents the most dominant species among the copepods.

The group **Ostracoda** represents by its 2 species viz. *Eucypris and Heterocypris*. This group was not observed in rainy months at Kagdi pick-up weir.

The observed scenario of zooplankton dominance at station II of Kagdi Pick-up weir, studied is as under:

Rotifera (50.00%) > Protozoa (19.23%) > Cladocera (11.54%) = Copepoda (11.54%)> Ostracoda (07.69%)

MISCELLANEOUS PLANKTONIC FORMS

Besides the found phytoplankton and zooplanktonic forms, we found some miscellaneous plantonic forms like Arachnids, Insects and Insect larvae. These were observed at all the stations of both study sites during the whole study period 2019-21.

Chlorophyceae dominated both stations, with Spirogyra sp., Ulothrix sp., and Volvox sp. found consistently, aligning with findings by Verma and Mohanty (1995), who reported Chlorophyceae dominance in tropical freshwater bodies due to their tolerance to variable nutrient levels and light conditions.

The Myxophyceae group, especially *Anabaena sp.* and *Microcystis sp.*, were persistent across seasons, indicating potential eutrophication, as cyanophycean blooms are often associated with high nutrient loads (Singh & Swarup, 1980). Similarly, Dinophyceae were observed only in non-rainy months, likely due to their sensitivity to turbulence and dilution, as reported by Rajashekhar et al. (2007), who found Dinoflagellates declining during monsoons in similar reservoir ecosystems.

Bacillariophyceae, especially *Cyclotella sp.* and *Fragillaria sp.*, were more prominent at Station II. Their relative abundance suggests stable substrate availability and cooler conditions during winter, supporting earlier work by Kumar and Singh (2010), who associated diatom proliferation with low water temperatures and moderate silica levels.

Zooplankton composition was similarly diverse, with 25 species at Station I and 26 species at Station II. Rotifera was the most dominant group at both stations, contributing over 50% to total zooplankton density. This dominance reflects nutrient-rich conditions and aligns with studies by Sharma (2005), who emphasized rotifers as indicators of eutrophication in Indian freshwater lakes. The abundance of *Brachionus forficula* and *Keratella* spp. reinforces this trophic characterization.

Protozoa, particularly *Volvox* and *Paramecium*, were the next major contributors, indicating moderately productive waters. According to Rao and Durve (1989), such protozoan presence is linked with organic matter availability and moderate pollution. Interestingly, Ostracods were absent during monsoons, which can be attributed to sediment disturbances and increased water flow, similar to observations by Sugunan (1995) in man-made lakes.

Table 1 Phytoplankton diversity of Kagdi Pickup Weir 2019-2021

No.	Name of Phytoplankton	2019-20		2020-21	
		Station -I	Station-II	Station -I	Station-II
	A) CHLOROPHYCEAE				
1	*Coelastrum sp.*	-	+	-	-
2	*Spirogyra sp.*	+	+	+	-
3	*Oedogonium sp.*	+	+	-	+
4	*Ulothrix sp.*	+	-	+	+
5	*Scenedesmus sp.*	-	+	-	+
6	*Chlorella sp.*	+	+	-	+
7	*Zygnemopsis sp.*	+	+	-	+
8	*Pleodorina sp.*	-	+	-	-
9	*Microspora sp.*	+	+	+	-
10	*Spaerocystis sp.*	+	-	-	+
11	*Volvox sp.*	+	+	+	+
12	*Eudorina sp.*	-	+	-	+

No.	**Name of Phytoplankton**	**2019-20**		**2020-21**	
		Station -I	**Station-II**	**Station -I**	**Station-II**
13	*Pediastrum sp.*	+	+	+	+
14	*Oocystis sp.*	+	+	+	-
	B) XANTHOPHYCEAE				
15	*Botrydiopsis sp.*	+	-	-	-
16	*Botryococcus sp.*	-	-	-	
17	*Chlorobotrys so.*	-	+	+	-
	C) MYXOPHYCEAE				
18	*Coccochlaris sp.*	+	-	+	-
19	*Oscillatoria sp.*	-	+	+	+
20	*Anabaena sp.*	+	-	+	-
21	*Nostoc sp.*	+	+	-	+
22	*Microcystis sp.*	+	+	-	+
23	*Spirulina sp.*	-	+	+	-
	D) DINOPHYCEAE				
24	*Ceratium sp.*	+	-	-	+
25	*Peridinium sp.*	+	-	-	-
	E) BACILLARIOPHYCEAE				
26	*Fragillaria sp.*	-	+	+	-
27	*Pinnularia sp.*	-	+	-	+
28	*Cyclotella sp.*	+	-	+	+
29	*Bacillaria sp.*	+	+	-	+
30	*Cymbella sp.*	+	-	+	+
31	*Amphora sp.*	-	+	-	-

Table 2 Zooplankton diversity of Kagdi Pickup Weir 2019-2021

		2019-20		2020-21	
		Station -I	Station-II	Station-I	Station-II
	Protozoa				
	Sub phylum –				
	Sarcomastigophora,				
	Super class – Mastigophora				
	Class – Phytomastigophora,				
	Order – Volvocida				
	Family – Volvocacae				
1	*Volvox**	+	+	+	+
	Family – Nebelidae				
2	*Euglena sp.*	+	-	+	+
	Class – Rhizopodea,				
	Order – Amoebida				
3	*Amoeba sp.*	+	+	-	+
	Order – Arcellinida,				
	Family – Arcellidae				
4	*Arcella discoida*	-	+	-	+

	Sub-phylum Ciliophora,				
	Class – Ciliata				
	Family – Paramecidae				
5	*Paramecium sp.*	+	+	+	+
	Rotifera				
	Family – Brachionidae				
6	*Brachionus forficula*	+	-	+	+
7	*Brachionus angularis*	+	-	+	-
8	*Keratella cochleris*	+	-	+	-
9	*Keratella vulga*	-	+	-	+
10	*Trichotria similis*	+	-	-	+
11	*Mytilina ventralis*	+	+	-	-
	Family – Lecanidae				
12	*Lecane luna*	-	+	+	+
13	*Monostyla bulla*	-	+	-	-
14	*Cephalodella exigua*	+	-	+	+
	Family – Calurinae				
15	*Tricocerca cylindrico*	-	-	+	+
16	*Lepadella ovalis*	+	-	+	+
	Family – Asplanchnidae				
17	*Asplanchna herricki*	-	+	-	-
	Family – Synchaetidae				
18	*Polyarthra vulgaris*	+	+	-	-
	Family – Testudinellidae				
19	*Horella mira*	+	-	+	-
20	*Filinia longiseta*	+	-	-	+
	Family – Hexarthridae				
21	*Philodina*	-	-	+	+
	Cladocerans				
	Family – Daphnidae				
22	*Ceriodaphnia laticaudata*	+	-	+	+
23	*Daphnia dubia*	+	+	+	-
24	*Daphnia lumholtzi*	-	-	+	+
	Sub-class – Copepoda				
	Order – Calanoida				
	Family – Diaptomidae				
25	*Heliodiaptomus viddus*	+	+	-	-
	Order – Cyclopoida				
	Family – Cyclopidae				
26	*Cyclops leuckarti*	-	+	+	+
	Family-Canthocamptidae				
27	*Nauplii*	+	+	+	+
	Ostracoda				
28	*Eucypris*	+	-	-	+

29	*Heterocypris*	-	+	+	-
	Miscellaneous planktonic forms				
30	*Arachnides*	+	-	+	-
31	*Insects*	+	+	+	+
32	*Insect larvae*	+	+	+	+

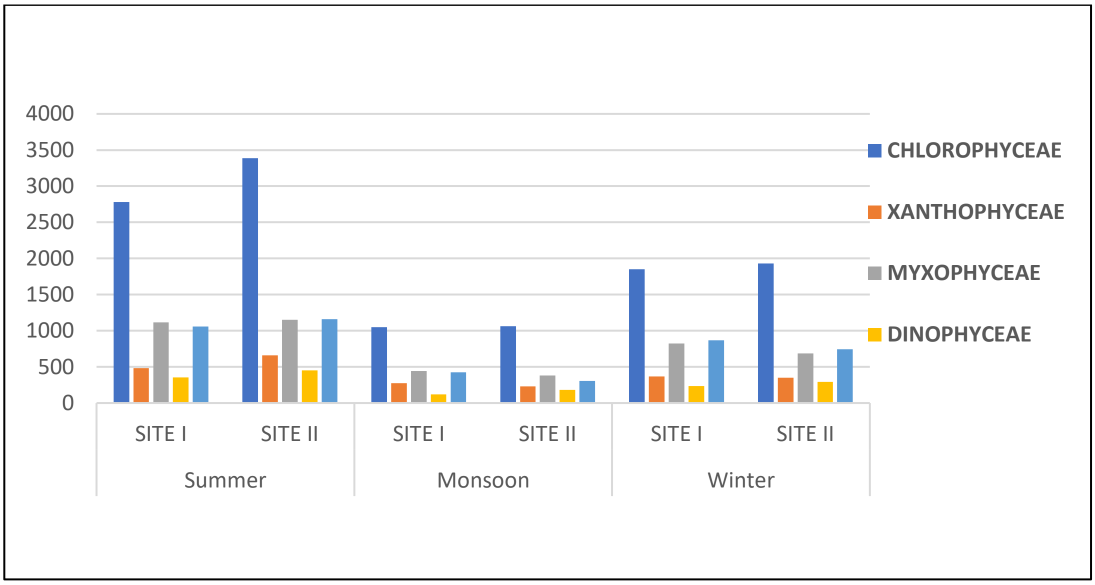


Fig 2 Phyto-plankton diversity of Kagdi Pickup Weir 2019-2020.

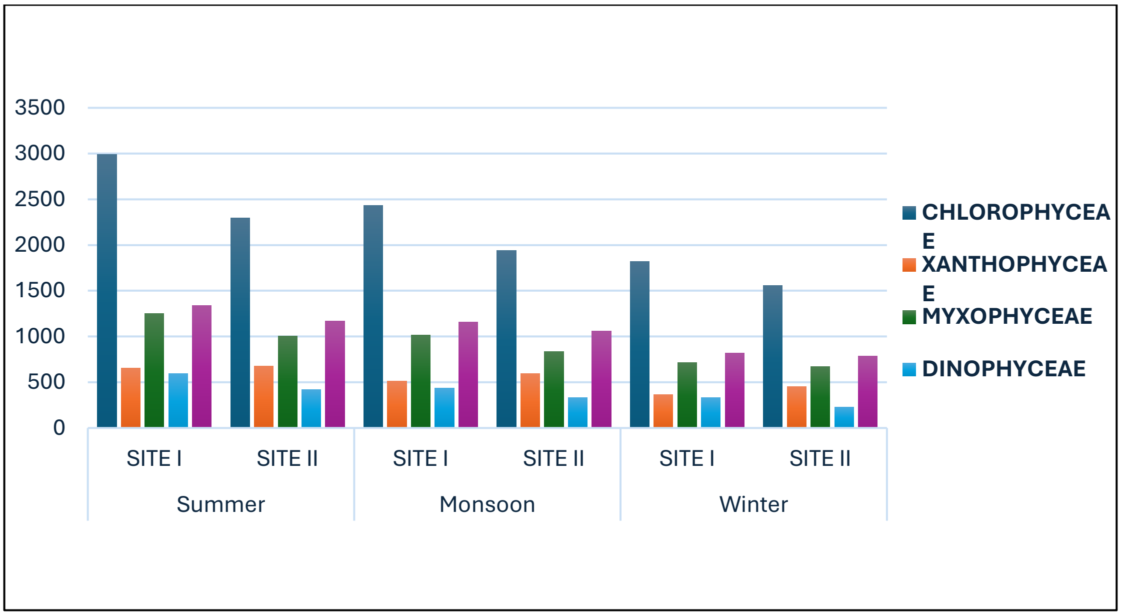


Fig. 3 Phyto-plankton diversity of Kagdi Pickup Weir 2020-2021.

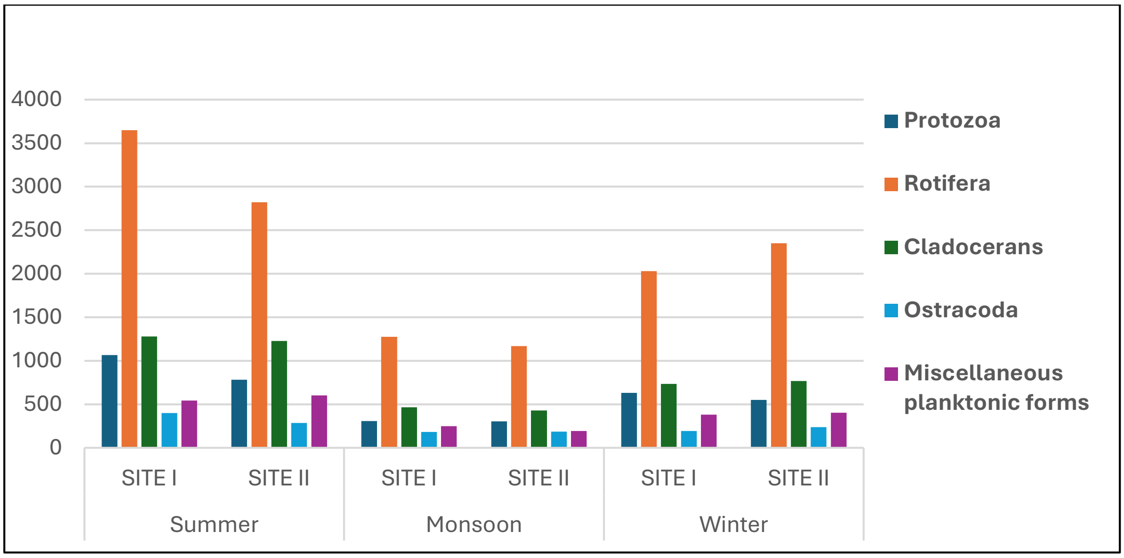


Fig. 4 Zoo-plankton diversity of Kagdi Pickup Weir 2019-20.

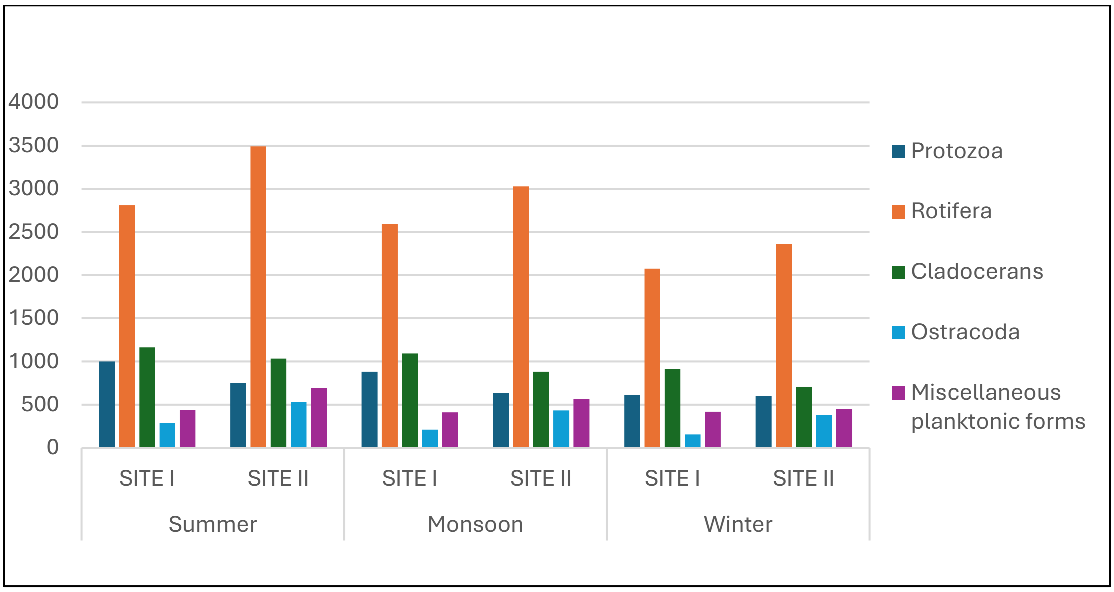


Fig. 5 Zoo-plankton diversity of Kagdi Pickup Weir 2020-21.

References

[1]. American Public Health Association. (2017). *Standard methods for the examination of water and wastewater* (23rd ed.). Washington, D.C.: APHA, AWWA, WEF.

[2]. Bhandari, M., Sharma, L. L., & Meena, L. R. (2017). Limnological study of tribal ponds in Banswara district of Rajasthan. *Journal of Fisheries and Life Sciences*, 2(1), 45–50.

[3]. Das, B. K., & Bhattacharyya, S. B. (2013). Seasonal variation in zooplankton diversity and its relation to primary productivity in floodplain wetlands of Assam. *Indian Journal of Fisheries*, 60(4), 55–60.

[4]. Dodson, S. I., Arnott, S. E., & Cottingham, K. L. (2000). The relationship in lake communities between primary productivity and species richness. *Ecology*, 81(10), 2662–2679.

[5]. Edmondson, W. T. (1959). *Fresh-water biology* (2nd ed.). New York: John Wiley and Sons.

[6]. Jain, D., & Khan, A. A. (2012). Phytoplankton dynamics and productivity in relation to physicochemical factors in Ana Sagar Lake, Rajasthan. *Research Journal of Recent Sciences*, 1(5), 56–60.

[7]. Jakher, G. R., & Rawat, M. S. (2003). Limnology of Jaisamand Lake, Rajasthan. *Ecology, Environment and Conservation*, 9(1), 11–18.

[8]. Kumar, A., & Singh, D. (2010). Seasonal variation in phytoplankton diversity and its relationship with physico-chemical parameters of Rani Lake, Bihar. *Journal of Environmental Biology*, *31*(6), 995–1000.

[9]. Kumar, P., Sinha, A., & Kumar, R. (2014). Seasonal variation in primary productivity of a tropical reservoir in Bihar. *Journal of Applied and Natural Science*, 6(2), 537–542.

[10]. Mishra, S. R., & Saksena, D. N. (1991). Seasonal variations in primary productivity of a sewage-fed lake at Gwalior (M.P.), India. *Journal of Environmental Biology, 12*(4), 355–361.

[11]. Pandey, B. D., & Verma, S. R. (2004). Limnological study of eutrophication in a pond at Faizabad. *Environment and Ecology, 22S*, 112–115.

[12]. Prescott, G. W. (1962). *Algae of the Western Great Lakes area* (2nd ed.). Dubuque, Iowa: W.C. Brown Co.

[13]. Rajashekhar, M., Vijaykumar, K., & Vaishali, K. (2007). Seasonal variations of phytoplankton in two freshwater lakes of Gulbarga District, Karnataka. *Journal of Ecobiology*, *20*(3), 209–214.

[14]. Rao, K. S., & Durve, V. S. (1989). Protozoan zooplankton as indicators of water quality. *Indian Journal of Environmental Health*, *31*(1), 40–44.

[15]. Reynolds, C. S. (2006). *The ecology of phytoplankton*. Cambridge University Press.

[16]. Saha, M., & Pal, R. (2019). Temporal variation of phytoplankton community structure and primary productivity in a tropical freshwater wetland. *Environmental Monitoring and Assessment, 191*(11), 682. https://doi.org/10.1007/s10661-019-7845-9

[17]. Sarma, S. S. S., Nandini, S., & Gulati, R. D. (2010). Life history strategies of cladocerans: comparisons of tropical and temperate taxa. *Hydrobiologia*, 653(1), 317–333.

[18]. Sharma, B. K. (2005). Rotifer diversity in floodplain lakes of the Brahmaputra River basin, Assam (N.E. India): Biodiversity and conservation perspectives. *International Review of Hydrobiology*, *90*(5-6), 491–505. https://doi.org/10.1002/iroh.200510792

[19]. Sharma, B. K., & Mishra, S. (2015). Seasonal distribution of phytoplankton and productivity in a pond of Central India. *International Journal of Aquatic Biology*, 3(5), 320–328.

[20]. Singh, S. R., & Swarup, K. (1980). Seasonal variation in phytoplankton population in relation to physico-chemical factors in a freshwater pond. *Ecology*, *2*(1), 61–72.

[21]. Sinha, A., & Naik, S. (2002). Zooplankton as indicators of trophic status in a tropical lake. *Pollution Research*, 21(3), 327–331.

[22]. Verma, H. G., & Saksena, D. N. (2010). Seasonal variations in primary productivity of a tropical lake. *Asian Journal of Experimental Biological Sciences, 1*(1), 151–158.

[23]. Verma, S. R., & Mohanty, R. C. (1995). Limnological studies of a tropical freshwater lake with reference to plankton productivity. *Indian Journal of Environmental Protection*, *15*(6), 413–419.

[24]. Wetzel, R. G. (2001). *Limnology: Lake and river ecosystems* (3rd ed.). Academic Press.