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Diatom Flora and Seasonal Variation in Raja-Rani Lake, Letang, Morang, Nepal

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Abstract
Diatoms are the largest group of algae, consisting of microscopic, unicellular, diploid, and non-flagellated organisms that have a unique silica-based cell wall. In this study, diatom samples were collected by squeezing submerged macrophytes from the Raja-Rani Lake during the winter, summer, and rainy seasons. A total of 41 diatoms under 15 genera were reported including 16 species being new for Nepal. The most abundant genus was *Pinnularia* (24.39%), followed by *Eunotia* (12.19%) and then *Gomphonema*, *Neidium*, and *Stauroneis* (each 9.75%). The greatest diversity of diatoms was observed in winter (60.97%), followed by summer (56.09%), with the lowest recorded in the rainy season (43.9%). *Eunotia bilunaris* and *Navicula radiosa* were dominant across all seasons, while *E. bilunaris*, *Iconella linearis*, *N. radiosa*, and *Sellaphora capitata* were common throughout the year. Rare species included *Iconella curvula* in winter, *Craticula ambigua* in summer, and *Gomphonema pumilum* in the rainy season. The dominance of certain species, such as *Eunotia bilunaris* and *Navicula radiosa*, across all seasons, underscores their ecological adaptability. These findings contribute to the understanding of diatom diversity and offer insights for future studies on freshwater ecosystems in Nepal.

Keywords: Bacillariophyta, Freshwater ecosystems, Frustules, Seasonal variation.

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Introduction

Diatoms (Bacillariophyceae) are microscopic, unicellular, photosynthetic algae having siliceous cell walls. They inhabit almost every aquatic or moist environment, from oceans to ice, rivers, and wet rocks. Diatoms are among the most diverse groups of algae, with 16,427 living species worldwide (Guiry, 2024). Diatom reproduce typically through binary fission, with each daughter cell inheriting one of the parent cell's two frustules. Their siliceous frustules possess highly diverse and species-specific morphological characteristics, making them one of the best taxonomically resolved groups of algae.

They are essential for research on aquatic biodiversity, palaeolimnology, environmental monitoring, and ecosystem

functioning. They also play significant roles in ecology, paleontology, industry, forensics, nanotechnology, and biofuel production (Round et al., 1990; Smol & Stoermer, 2010; Wehr et al., 2015). They serve as primary food sources for zooplankton in freshwater and marine environments. They play vital roles in carbon sequestration, oxygen production, nutrient cycling, and the maintenance of aquatic food webs and contributed nearly 20% of global primary production (Bhat et al., 2025).

The varied geography of Nepal supports a wide range of diatom species. The freshwater diatoms of Nepal have been studied by various researchers, including Hirano (1955, 1963, 1969, 1984), Baral (1995), Jüttner et al. (1996, 2000, 2003, 2010, 2011), Dahal & Jüttner (2004), Rai (2006, 2011, 2013a, 2013b), Rai et al. (2008), and Ghimire et al. (2012). Raja-Rani Lake, is an ecologically important freshwater wetland supporting diverse aquatic biodiversity. Although the green algal flora of the lake has been documented (Godar & Rai, 2018; Rai et al., 2020), its diatom flora has not yet been systematically investigated. Similarly, the seasonal variation in whole algal diversity of various lakes and ponds of Nepal have been studied (Pokhrel et al., 2021; Dhakal et al., 2022; Roka et al., 2022; Poudel et al., 2024; Shrestha et al., 2025), but seasonal variation focusing on diatoms has not been studied yet. Therefore, this preliminary study aims to explore and document the diatoms of this wetland, providing the first baseline inventory for future biodiversity assessment, ecological monitoring, and conservation of this important wetland.

Materials and Methods

Study area

The Raja-Rani Lake, also known as Dhimal Pokhari, is located at 26°74'55.4"N, 87°48' 25.1"E in Letang Municipality, Morang, Nepal (Fig. 1), at an elevation of 462 meters. Situated within the 1,700 ha Raja-Rani Community Forest, the wetland basin spans 133 ha and comprises three lakes – Raja, Rani, and Rajkumari, covering about 20 ha. Rani Lake, the largest, lies to the east, while Raja Lake is in the west, each up to 7 meters deep in the rainy season. Two smaller Rajkumari lakes to the south are 2 meters deep. The wetland, fed by groundwater (locally "Jaruwa"), seasonal streams, and rainfall, lacks a consistent inflow. It holds cultural and historical significance for the Dhimal community and is managed by the Raja Rani Community Forest Users Group and the Raja Rani Pokhari Conservation Committee. The surrounding subtropical-to-temperate Churia region, dominated by *Shorea robusta*, experiences annual rainfall of 1,138–2,671 mm and temperatures ranging from 14–22°C (low) to 24–32°C (high) (FRA/DFRS, 2014).

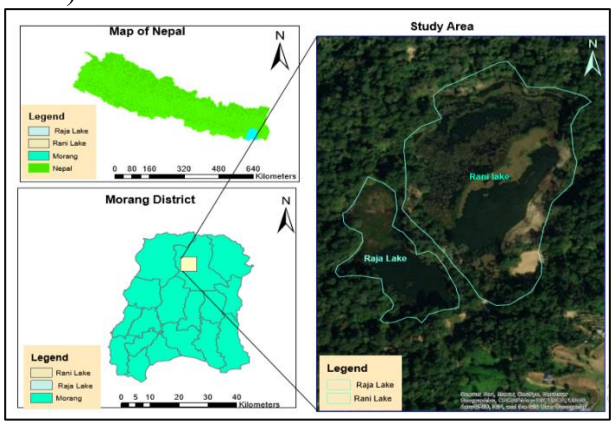

Figure 1. Study area, Raja-Rani Lake, Letang, Morang district, Nepal.

Diatom sampling and identification

A total of 36 samples were collected from six littoral sites in each of Raja and Rani Lakes during three seasons: winter (February), summer (May), and rainy (August). Submerged macrophytes were squeezed by hands, and extracted samples were preserved in 4% formaldehyde in airtight polythene bottles, and labeled properly. The samples were promptly transported to the Phycology Research Laboratory, Department of Botany, Degree Campus, Biratnagar. Preliminary observations were made using temporary slides under a light microscope. The final

investigation was conducted on permanent slides prepared by the improved nitric acid digestion method, using Olympus Chi20 microscope. Diatom dimensions were measured using calibrated ocular micrometers, and photomicrographs were taken at 40X and 100X magnifications using a Canon Ixus camera. Species were identified using literature (Krammer, 1997, 2000; Lange-Bertalot et al., 2011; Bey & Ector 2013; Karthick et al., 2013; Rybak et al., 2020) and the online database Algae Base (www.algaebase.org).

Water parameters

Water parameters such as temperature, pH, and conductivity of all 12 sites were measured on the spots using portable meter - Hanna HI9811-5. For dissolve oxygen (DO), water samples were collected and brought immediately to the laboratory and measure within 24 h following Winkler titration method (APHA et al., 2017).

Results

Water quality

The water analysis of Raja-Rani lake in three seasons revealed that the water temperature and DO were high in summer season and low in winter season (Table 1). Similarly, the pH and conductivity of water were high in winter season and low in summer season. Overall, the water of Raja-Rani Lake was slightly acidic, low in mineral content and dissolved ions, and well-oxygenated, indicating favourable conditions for aquatic life.

Table 1. The average water temperature, pH, conductivity, and DO of Raja-Rani lake in different seasons.

Seasons	Temperature (°C)	pH	Conductivity (µs/cm)	DO (mg/l)
Winter	21.08	6.9	83.3	6.35
Summer	26.25	5.86	57.6	7.45
Rainy	24.66	6.37	63.3	7.05

The largest order was Naviculales (23 sp.) followed by Cymbellales (5 sp). Among the families, Pinnulariaceae has the maximum number of diatoms (10 sp) followed by Eunotiaceae, and Stauroneidaceae (each 5 sp). Amphipleuraceae, Cymbellaceae, Fragilariaceae, Rhopalodiaceae, and Sellaphoraceae have single taxon only (Table 1). Similarly, among the genera, *Pinnularia* has maximum number of taxa, i.e., 10 (24.39%), followed by *Eunotia* with 5 (12.19%), and *Gomphonema*, *Neidium*, and *Sturoneis* each with 4 (9.75%) taxa (Fig. 2). Genera like *Craticula*, *Encyonema*, *Epithemia*, *Fragilaria*, *Frustulia*, *Sellaphora* and *Surirella* have only one (2.44%) taxon each.

Diatom flora

In the present study, a total of 41 fresh water diatoms belonging to 7 orders, 13 families and 15 genera under a single class bacillario-phyceae were recorded from 12 different sites of Raja-Rani Lake, Letang, Morang, Nepal (Table 2). Among them, 38 diatoms were identified up to species level whereas three were compared with the similar species. All these diatoms were new to the study area and 16 diatoms (marked by *) were new record for the country.

The largest order was Naviculales (23 sp.) followed by Cymbellales (5 sp). Among the families, Pinnulariaceae has the maximum number of diatoms (10 sp) followed by Eunotiaceae, and Stauroneidaceae (each 5 sp). Amphipleuraceae, Cymbellaceae, Fragilaria-ceae, Rhopalodiaceae, and Sellaphoraceae have single taxon only (Table 2). Similarly, among the genera, *Pinnularia* has maximum number of taxa, i.e., 10 (24.39%), followed by *Eunotia* with 5 (12.19%), and *Gomphonema*, *Neidium*, and *Sturoneis* each with 4 (9.75%) taxa (Fig. 2). Genera like *Craticula*, *Encyonema*, *Epithemia*, *Fragilaria*, *Frustulia*, *Sellaphora* and *Surirella* have only one (2.44%) taxon each.

Table 2. Diatom flora of Raja-Rani lake, Letang with seasonal occurrence.

Class: Bacillariophyceae

Order	Family	Genus	Species	Occurrence		
				W	S	R
Bacillariales	Bacillariaceae	*Nitzschia*	*N. palea*	+	-	+
			N. subtilis[*]	+	-	-
Cymbellales	Cymbellaceae	*Encyonema*	*E. silesiacum*	+	-	-
	Gomphonemataceae	*Gomphonema*	*G. acidoclinatum*	+	+	-
			G. exilissimum	-	-	+
			G. pantropicum[*]	+	+	-
			G. pumilum	+	-	+
Eunotiales	Eunotiaceae	*Eunotia*	*E. bilunaris*	+	+	+
			E. flexuosa	+	-	-
			E. juga	-	-	+
			E. metamonodon[*]	+	-	-
			E. sedina[*]	-	+	-
Fragilariales	Fragilariaceae	*Fragilaria*	*F. tenera*	+	-	+
Naviculales	Amphipleuraceae	*Frustulia*	*F. crassinervia*	-	+	-
	Naviculaceae	*Navicula*	*N. radiosa*	+	+	+
			N. rostellata	-	+	-
	Neidiaceae	*Neidium*	*N. gracile*[*]	+	+	-
			N. gracile cf. var. *aequalis*[*]	-	-	+
			N. iridis	+	+	-
			N. productum[*]	+	+	-
	Pinnulariaceae	*Pinnularia*	*P. borealis*	+	+	-
			P. brauniana	-	+	-
			P. cf. *cardinaliculus*[*]	-	-	+
			P. divergens var. *mesoleptiformis*	+	-	-
			P. mesolepta	-	+	-
			P. microstauron	+	-	+
			P. neomajor var. *inflata*[*]	-	+	-
			P. cf. *stidolphii*	+	-	+
			P. cf. *transversa*[*]	-	+	-
			P. viridis	+	-	+
	Sellaphoraceae	*Sellaphora*	*S. capitata*	+	+	+
	Stauroneidaceae	*Craticula*	*C. ambigua*	-	+	-
		Stauroneis	*S. ancepsfallax*[*]	-	+	-
			S. gracilis	+	-	+
			S. neohyalina[*]	-	+	-
			S. phoenicenteron	-	+	+
Rhopalodiales	Rhopalodiaceae	*Epithemia*	*E. saxonica*[*]	-	+	-
Surirellales	Surirellaceae	*Iconella*	*I. capronii*[*]	+	-	+
			I. curvula[*]	+	-	+
			I. linearis	+	+	+
		Surirella	*S. capronioides*[*]	+	+	-
Total species				25	23	18

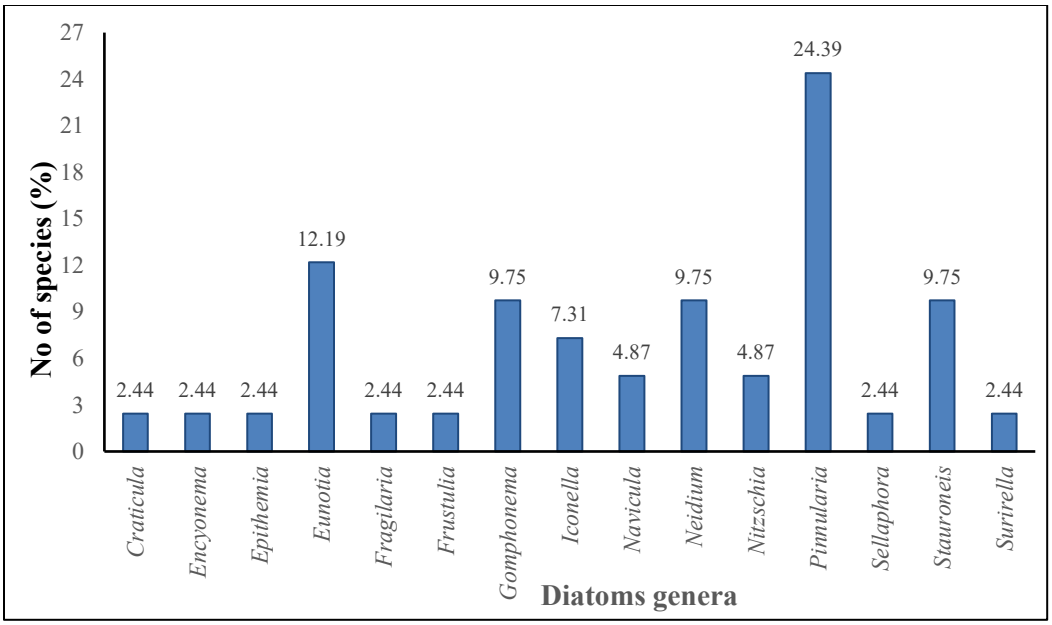

Figure 2. Genera-wise representation of diatoms of Raja-Rani Lake, Letang, Morang.

Seasonal and site-wise distribution of diatoms

Study revealed that the maximum diatoms were reported in winter season (25 taxa, 60.97%), followed by summer (23 taxa, 56.09%), and least in rainy season (18 taxa, 43.90%) (Fig. 3).

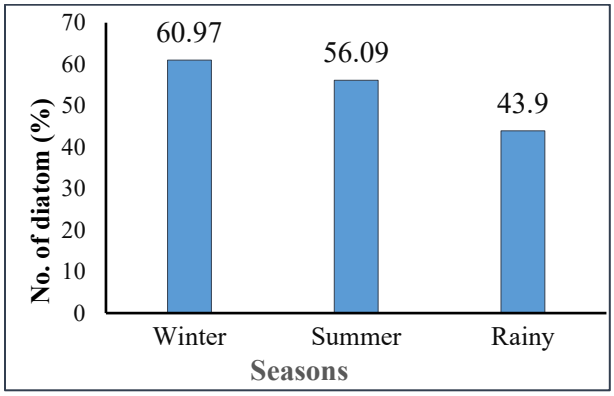

Figure 3. Diatoms found in three different seasons in Raja-Rani Lake.

Similarly, the maximum number (6 sp, 85.71%) of orders were reported in winter and rainy seasons while (5 sp, 71.42%) of orders were present in summer season. In the winter season, 10 diatom taxa (40%) were dominant from order Naviculales while least diatom taxa (4%) were from order Fragilariales (Fig. 4). In summer season, 16 diatom taxa (69.56%) were dominant from order Naviculales while least diatom taxa (4.34%) were from order Rhopalodiales. Similarly, in rainy season, 9 diatom taxa (50%) were dominant from order Naviculales while least diatom taxa (1.11%) were from order Cymbellales. Order Rhopalodiales was absent in winter and rainy season while order Bacillariales and Fragilariales were absent in summer season.

Four diatoms, viz., *Eunotia bilunaris, Navicula radiosa*, *Sellaphora capitata* and *Iconella linearis* were found in all three seasons (Table 2). Diatoms reported only in winter were *Encyonema silesiacum*, *Eunotia flexosa*, *Eunotia metamonodon*, *Nitzschia subtilis* and *Pinnularia divergens* var. *mesoleptiformis*; reported only in summer were *Craticula ambigua*, *Epithemia saxonica*, *Eunotia sedina*, *Frustulia crassinervia*, *Navicula rostellata*, *Pinnularia brauniana*, *Pinnularia mesolepta*, *Pinnularia neomajor* var. *inflata*, *Pinnularia* cf. *transversa*, *Stauroneis ancepsfallax* and *Stauroneis neohyalina*; and reported only in rainy were *Eunotia juga*, *Gomphonema exilissimum*, *Neidium gracile* cf. var. *aequalis* and *Pinnularia* cf. *cardinaliculus*.

Out of 12 localities, maximum number of diatoms (31 taxa, 75.6%) was reported from

site I and least number of diatoms (20 taxa, 48.78%) was reported from site VIII (Fig. 5).

Diatoms reported from all 12 sites were *Eunotia bilunaris*, *Navicula radiosa*, *Gomphonema acidoclinatum*, *Nitzschia palea*, *Pinnularia viridis* and *Stauroneis gracilis*. *Craticula ambigua* and *Eunotia metamonodon* were the diatoms which were listed from only 3 sites within the study area. Similarly, maximum number (17 sp, 73.91%) of diatoms were found from site V in summer season whereas the least number (7 sp, 38.88%) of diatoms were reported from site III in rainy season (Fig. 6).

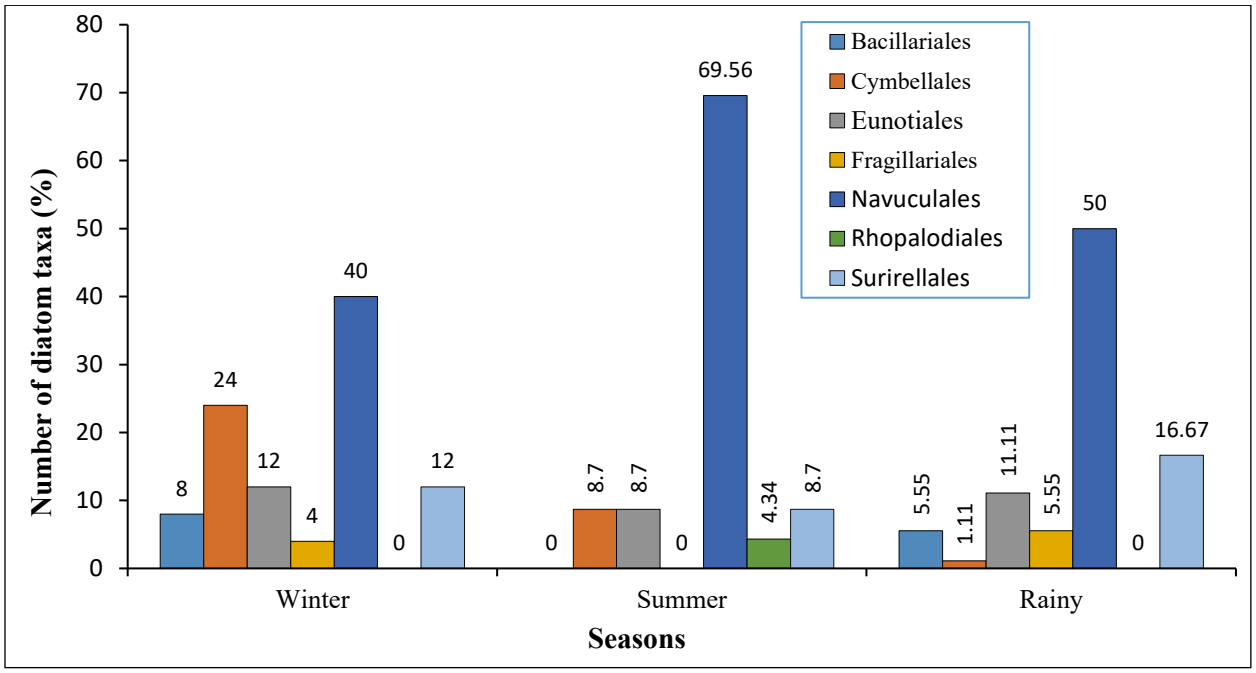

Figure 4. Season-wise occurrence of diatom orders in Raja-Rani Lake.

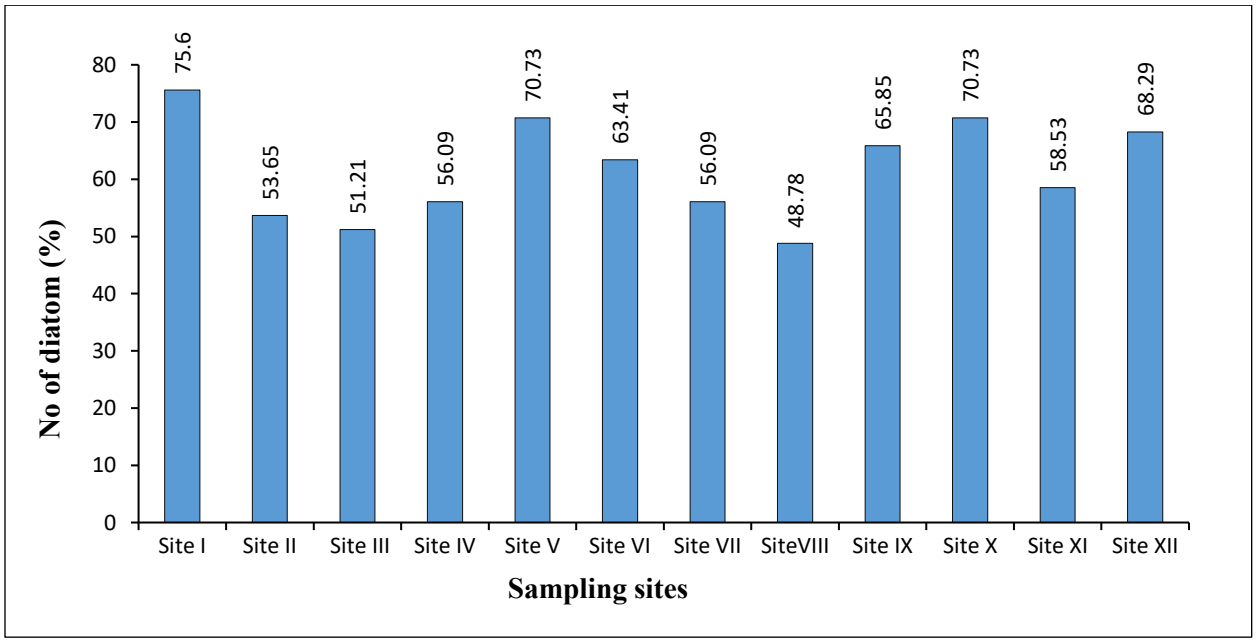

Figure 5. Diatoms reported from different sites of Raja-Rani Lake.

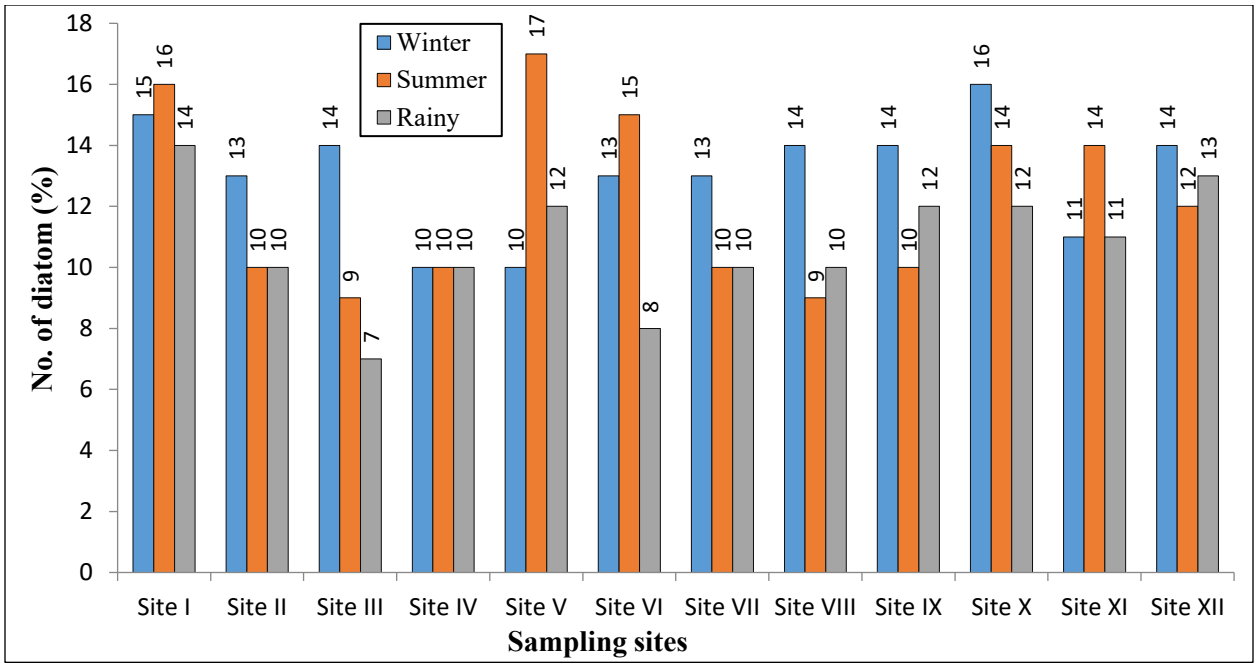

Figure 6. Seasonal occurrence of diatoms from different sites in Raja-Rani lake.

Taxonomic descriptions

1. *Craticula ambigua* (Ehrenberg) Mann (1990)
   Levkov et al. 2016, P. 133, Fig. 8.
   Valve 53.32 µm long, 14.3 µm wide.
   Collection No. and Date: Raja Lake, A3; 2021.03.08 (winter season)
   Distribution: Bagjhora wetland 137 m, Sundar Haraicha, Sunsari district (Shrestha et al., 2013).
2. *Encyonema silesiacum* (Bleisch) Mann (1990)
   Krammer K. 1997, P. 171, Pl. 117, Figs. 19-24.
   Valve 27 µm long, 8.77 µm wide; 5 striae in 5 µm.
   Collection No. and Date: Rani Lake, B4; 2021.07.13 (summer season)
   Distribution: Panch Pokhari lake, 4100 m, Sindhulpalchowk district (Krstić et al., 2012); Gokyo Valley at Everest National Park, 4750 m, Solukhumbu district (Van de Vijver et al., 2011); Jagadishpur Tal, 197 m, Kapilvastu district (Rai & Paudel, 2019).
3. **Epithemia saxonica* Kützing (1844)
   Rybak et al. 2020, P. 168, Fig.3.
   Valve 49.95 µm long, 8.65 µm wide.
   Collection No. and Date: Raja Lake, A4; 2021.07.13 (summer season)
4. *Eunotia bilunaris* (Ehrenberg) Schaarschmidt (1880)
   Patrick and Reimer 1966, P. 20, Fig. 7.
   Valve 89.1 µm long, 3.91 µm wide.
   Collection No. and Date: Rani Lake, B3; 2021.9.29 (rainy season)
   Distribution: Raja-Rani Lake, 1574 m, Dhankuta district (Shrestha & Rai, 2017).
5. *Eunotia flexuosa* (Brébisson ex Kützing) Kützing (1849)
   Tremarin et al. 2008, P. 852, Fig 22.
   Valve 115.02 µm long, 5.4 µm middle valve wide; 4.7 µm tip valve wide.
   Collection No. and Date: Raja Lake, A3; 2021.07.13 (summer season)
   Distribution: Jagadishpur Tal, 197 m, Kapilvastu district (Rai & Paudel, 2019).
6. *Eunotia juga* (Frenguelli) Vouilloud et Kociolek (2023)
   Glushchenko and Kulikovskiy 2017, P. 130-139, Figs. 5-8.
   Valve 50.22 µmlong, 8.1µm wide.
   Collection No. and Date: Raja Lake, A6;

2021.03.08 (winter season)
Distribution: Jagadishpur Tal, 197 m, Kapilvastu district (Rai & Paudel, 2019).

7. **Eunotia metamonodon* Lange-Bertalot (2011)
Lange-Bertalot et al. 2011, P. 218, Figs. 21-23; de Garcia Souza et al. 2015, Figs. 21-23.
Valve 39.42 µm long, 8.1 µm wide; 11 striae in 10 µm.
Collection No. and Date: Rani Lake, B6; 2021.07.13 (summer season)
8. **Eunotia sedina* Lange-Bertalot et al. (2011)
Lange-Bertalot et al. 2011, P.215, Figs. 36-39.
Valve 27.94 µmlong, 5.4 µm wide; 8 striae in 10 µm.
Collection No. and Date: Rani Lake, B4; 2021.9.29 (rainy season)
9. *Fragilaria tenera* (W. Smith) Lange-Bertalot (1980)
Karthick et al. 2013, Pl.15.
Valve 141.75 µmlong, 6.21 µm wide.
Collection No. and Date: Raja Lake, A6; 2021.07.13 (summer season)
Distribution: Raja-Rani Lake, 1574 m, Dhankuta district (Shrestha & Rai, 2017).
10. *Frustulia crassinervia* (Brébisson ex W. Smith) Lange-Bertalot et Krammer (1996)
Lange-Bertalot et al. 2011,P.127, Figs 7-15.
Valve 43.2 µmlong, 10.8 µm wide.
Collection No. and Date: Raja Lake, A5; 2021.03.08 (winter season)
Distribution: Bhalukhop 2850 m, Tehrathum district (Mainali, 2020).
11. *Gomphonema acidoclinatum* Lange-Bertalot et Reichardt (2004)
Werum and Lange-Bertalot 2004, P. 160, Pl. 92, Figs. 1-3.
Valve 45.9 µm long, 7.83 µm wide.
Collection No. and Date: Raja Lake, A5; 2021.07.13 (summer season)
Distribution: Sundarijal 1350 m, Bagmati river, Kathmandu district (Rai & Khadka, 2017).
12. *Gomphonema exilissimum* (Grunow) Lange-Bertalot et Reichardt (1996)
Medeiros et al. 2018, P. 11, Pl. 62, Figs. 31-33. Valve 25.65 µm long, 4.05 µm wide; 14 striae in 10 µm.
Collection No. and Date: Raja Lake, A4; 2021.9.29 (rainy season)
Distribution: A pond at Biratnagar, 72 m, Morang district (Rai & Rai, 2005).
13. **Gomphonema pantropicum* Reichardt (2015)
da Silva-Lehmkuhl 2019, P. 13, Fig. 3 N-0.
35.7 µm long, 6.5 µm wide; 11 striae in 10 µm.
Collection No. and Date: Raja Lake, A5; 2021.03.18 (winter season)
14. *Gomphonema pumilum* (Grunow) Reichardt et Lange-Bertalot (1991)
Reichardt and Lange-Bertalot 1991, P. 528, Pl. 6, Figs. 4-11.
Valve 27µm long, 6.75 µm wide.
Collection No. and Date: Raja Lake, A6; 2021.03.18 (winter season)
Distribution: Tamor river 365 m, Mulghat, Dhankuta (Rai & Rai, 2021).
15. **Iconella capronii* (Brébisson et Kitton) Ruck et Nakov (2016)
Ruck et al. 2016, P. 2.
Valve 78.3 µm long, 30.3 µm wide.
Collection No. and Date: Rani Lake, B5; 2021.03.08 (winter season)
16. **Iconella curvula* (W.Smith) Ruck et Nakov (2016)
Morais et al. 2018, Figs. 3-5.
Valve 142 µm long, 7 µm wide.
Collection No. and Date: Rani Lake, B6; 2021.07.13 (summer season)
17. *Iconella linearis* (W.Smith) Ruck and Nakov (2016)
Smith and West 1853, P. 31, Pl. 8, Fig. 58; Hirano 1972, Pl. 13, Fig. 1.
Valve 70 µm long, 18 µm wide; 3 costaein 10 µm.
Collection No. and Date: Rani Lake, B4; 2021.9.29 (rainy season)

Distribution: Ponds at Luitel Bhajyang, 770 m, Gorkha district; and Phewa Tal, 967 m, Kaski district (Hirano, 1955; 1984); Streams of Gajurmukhi, 2210 m, Ilam district (Rai et al., 2008); Sundarijal, 1350 m, Bagmati river, Kathmandu district (Rai & Khadka, 2017).

18. *Navicula radiosa* Kützing (1844)
Prasad and Srivastava 1992, P. 212, Pl. 28, Fig. 4;
Valve 60.75 µm long, 7 µm wide; 9 striae in 10 µm.
Collection No. and Date: Raja Lake, A1; 2021.9.29 (rainy season)
Distribution: A stream at Tukucha moor, 2600m, Mustang district (Hirano, 1955); Sundarijal, 1350 m, Bagmati river, Kathmandu district (Rai & Khadka, 2017); Raja-Rani Lake 1574 m, Dhankuta district (Shrestha & Rai, 2017); Jagadishpur Tal, 197 m, Kapilvastu district (Rai & Paudel, 2019).

19. *Navicula rostellata* Kützing (1844)
Foged 1980, P. 654, Pl. 6, Fig. 7.
Valve 45.5 µm long, 9.5 µm wide; 11 striae in 10 µm.
Collection No. and Date: Raja Lake, A6; 2021.03.18 (winter season)
Distribution: Gokarna, 1335 m, Bagmati river, Kathmandu district (Rai & Khadka, 2017).

20. **Neidium gracile* Hustedt (1938)
Simonsen 1987, P. 233, Pl. 340, Fig. 1; Siver et al. 2003: P. 140. Fig. 7.
Valve 57 µm long, 11.5 µm wide; 17 striae in 10 µm.
Collection No. and Date: Raja Lake, A6; 2021.03.18 (winter season)

21. **Neidium gracile* cf. var. *aequalis* Hustedt (1938)
Patrick and Reimer 1966, P. 394, Pl. 35, Fig. 10; Siver et al. 2003, P. 140, Fig. 8.
Valve 53.5 µm long, 10 µm wide; 23 striae in 10 µm.
Collection No. and Date: Raja Lake, A3; 2021.07.13 (summer season)

22. *Neidium iridis* (Ehrenberg) Cleve 1894
Hustedt 1930, P. 245, Fig.37; Patrick and Reimer 1966, P. 386, Pl.34, Fig.1.
Valve 53 µm long, 14.5 µm wide; 14 striae in 10 µm.
Collection No. and Date: Rani Lake, B6; 2021.03.08 (winter season)
Distribution: A stream at Tukucha moor, 2600m, Mustang district; and Ponds at Pisang, 3100 m, Manang district (Hirano, 1955).

23. **Neidium productum* (W. Smith) Cleve (1894)
Patrick and Reimer 1966, P. 389. Pl. 35. Fig.1; Krammer and Lange-Bertalot 1986, P. 281. Pl. 107. Fig.4.
Valve 55.5 µm long, 12 µm wide; 17 rows in 10 µm.
Collection No. and Date: Rani Lake, B5; 2021.07.13 (summer season)

24. *Nitzschia palea* (Kützing) W. Smith (1856)
Hirano 1974, Pl. 5, Fig. 17; Prasad and Srivastava 1992, P. 288, Pl. 35, Fig. 5.
Valve 15.5 µm long, 3 µm wide.
Collection No. and Date: Rani Lake, B5; 2021.03.18 (winter season)
Distribution: Sundarijal 1350 m, Bagmati river, Kathmandu district (Rai & Khadka, 2017).

25. **Nitzschia subtilis* (Kützing) Grunow (1880)
Hamsher et al. 2016, P. 83, Figs. 37-59.
Valve 88 µm long, 5.5 µm wide; 18 striae in 10 µm.
Collection No. and Date: Rani Lake, B5; 2021.03.18 (winter season)

26. *Pinnularia borealis* Ehrenberg (1843)
Hustedt 1938, P. 393, Pl. 21, Fig. 7; Foged 1986, P. 567, Pl. 5, Fig. 20.
Valve 43 µm long, 7.5 µm wide; 4 striae in 10 µm.
Collection No. and Date: Raja Lake, A3; 2021.9.29 (rainy season)
Distribution: Mai Pokhari 2100 m, Ilam district (Rai, 2005).

27. *Pinnularia brauniana* (Grunow) Studnicka (1888)
Rocha and Bicudo 2008, P. 603, Figs. 21–25.
Valve 47 µm long, 8.5 µm wide.
Collection No. and Date: Rani Lake, B5; 2021.03.08 (winter season)
Distribution: Mewa Valley, 3900 m, Taplejung district (Hirano, 1984).
28. **Pinnularia* cf. *cardinaliculus* Cleve (1895)
Krammer 2000, P. 78. Figs. 31-35.
Valve 51 µm long, 11 µm wide; 11 striae in 10 µm.
Collection No. and Date: Raja Lake, A6; 2021.03.18 (winter season)
29. *Pinnularia divergens* var. *mesoleptiformis* Krammer et Metzeltin (1998)
Alfinito and Lange-Bertalot 2013, P. 144, Fig. 137.
Valve 88 µm long, 14µm wide; 11 striae in 10 µm.
Collection No. and Date: Raja Lake, A4; 2021.9.29 (rainy season)
Distribution: Sundarijal, 1350 m, Bagmati river, Kathmandu district (Rai & Khadka, 2017).
30. *Pinnularia mesolepta* (Ehrenberg) W. Smith (1853)
Smith and West 1853, P. 58, Pl. 19, Fig. 182.
Valve 49 µm long, 11 µm wide.
Collection No. and Date: Rani Lake, B6; 2021.07.13 (summer season)
Distribution: Mewa Valley, 3900 m, Taplejung district (Hirano, 1984).
31. *Pinnularia microstauron* (Ehrenberg) Cleve (1891)
Foged 1982, P. 351, Pl. 8, Fig. 5; Wojtal 2009, P. 169, Pl. 26.
Valve 76 µm long, 11 µm wide; 9 striae in 10 µm.
Collection No. and Date: Raja Lake, A6; 2021.03.18 (winter season)
Distribution: Sundarijal, 1350 m, Bagmati river, Kathmandu district (Rai & Khadka, 2017).
32. **Pinnularia neomajor* var. *inflata* Krammer (2000)
Krammer 2000, P. 166, Pl. 171, Fig. 1.
Valve 101 µm long, 12.5 µm wide; 6 striae in 10 µm.
Collection No. and Date: Raja Lake, A6; 2021.03.08 (winter season)
33. *Pinnularia* cf. *stidolphii* Krammer (2000)
Bey and Ector 2013, P. 668, Figs. 1-5.
Valve 111 µm long, 18 µm wide; 11 striae in 10 µm.
Collection No. and Date: Raja Lake, A4; 2021.09.29 (rainy season)
Distribution: Hasina wetland 126 m, Sundar Haraicha, Morang district (Rai & Adhikari, 2019).
34. **Pinnularia* cf. *transversa* (Cleve) Mayer (1939)
Patrick and Reimer 1966, P. 630. Pl. 61. Fig. 6; Krammer 2000, P. 171, Pl. 177, Fig. 1.
Valve 87 µm long, 13 µm wide; 8 striae in 10 µm.
Collection No. and Date: Raja Lake, A1; 2021.9.29 (rainy season)
35. *Pinnularia viridis* (Nitzsch) Ehrenberg (1843)
Hirano 1972, P. 27, Pl. 8, Figs. 1-4; Karthick et al., 2013, Pl. 72.
Valve 149 µm long, 20 µm wide; 9 striae in 10 µm.
Collection No. and Date: Rani Lake, B5; 2021.07.13 (summer season)
Distribution: Gokarna, 1335 m, Bagmati river, Kathmandu district (Rai & Khadka, 2017); Godawari 1439 m, Lalitpur district (Dhakal et al., 2021).
36. *Sellaphora capitata* Mann et McDonald (2004)
Mann et al. 2004, P. 477, Figs. 4 j-l.
Valve 23 µm long, 7.5 µm wide; 13 striae in 10 µm.

Collection No. and Date: Raja Lake, A3; 2021.09.29 (rainy season)

Distribution: Pashupati, 1320 m, Bagmati river, Kathmandu district (Rai & Khadka, 2017).

37. **Stauroneis ancepsfallax* Bahls (2010)

Werum and Lange-Bertalot 2004, P. 172. Pl. 50, Fig. 4.

Valve 79 µm long, 15 µm wide.

Collection No. and Date: Raja Lake, A3; 2021.03.08 (winter season)

38. *Stauroneis gracilis* Ehrenberg (1843)

Reichardt 1995, P. 27, Pl. 19, Figs. 1-6; Pl. 20, Figs. 1-6.

Valve 55.5 µm long, 12 µm wide; 14 striae in 10 µm.

Collection No. and Date: Rani Lake, B4; 2021.9.29 (rainy season)

Distribution: Sundarijal 1350 m, Bagmati river, Kathmandu district (Rai & Khadka, 2017).

39. **Stauroneis neohyalina* Lange-Bertalot et Krammer (1996)

Lange-Bertalot and Metzeltin 1996, P. 104, Pl. 35, Figs. 7-10.

Valve 44 µm long, 10 µm wide; 20 striae in 10 µm.

Collection No. and Date: Rani Lake, B3; 2021.09.29 (rainy season)

40. *Stauroneis phoenicenteron* (Nitzsch) Ehrenberg (1843)

Van de Vijver et al. 2004, P. 114, Pl. 14, Figs. 1-4.

Valve 143 µm long, 29 µm wide; 15 striae in 10 µm.

Collection No. and Date: Rani Lake, B4; 2021.09.29 (rainy season)

Distribution: A stream at Tukucha moor, 2600m, Mustang district (Hirano, 1955).

41. **Surirella capronioides* Gandhi (1959)

Gandhi 1999, P. 328, Fig. 52, Figs. 19-32.

Valve 105 µm long, 34 µm wide.

Collection No. and Date: Rani Lake, B6; 2021.03.08 (winter season)

These findings mark an important contribution to diatom research in Nepal and provide a basis for further ecological and taxonomical studies in the region.

Discussion

In the present study, the maximum record of diatoms in winter followed by summer indicates that these are the most favorable seasons for algal growth, possibly due to the transition from cold to warm weather, which may promote rapid growth and reproduction. The focus of this study was on Bacillariophyceae (diatoms) in the Raja-Rani lake, Letang, expanding upon earlier research by Godar and Rai (2018), which primarily investigated Chlorophyceae (green algae), documenting 72 species. The current study fills the gap in understanding the diversity of Bacillariophyceae in this location, identifying species like *Pinnularia borealis* and *Pinnularia brauniana*, previously reported in nearby freshwater ecosystems such as Mai Pokhari Lake (Rai, 2005) and Betana Wetland, Morang (Rai, 2011). These findings suggest a regional distribution of these diatom species across freshwater habitats. Additionally, *Pinnularia viridis* was confirmed in the Raja-Rani lake, a species commonly found in freshwater environments and previously documented in Gokyo Lake-III in Sagarmatha National Park (Rai et al., 2012), highlighting its adaptability to diverse ecological conditions.

Rai and Rai (2021) also contributed valuable insights into seasonal variations in diatom communities along the Tamor River, where genera such as *Cocconeis*, *Encyonema*, *Gomphonema*, *Navicula*, and *Ulnaria* consistently dominated throughout late summer, winter, and late winter. This suggests that these genera are well-adapted to the river's environmental conditions, displaying resilience and stability. Similar studies have identified dominant diatom genera across various regions: Everest and Aslan (2016) in the Mersin River, Turkey; Tiwari et al. (2023)

along the west coast of India; and Simkhada and Jüttner (2006) in the Kathmandu Valley ponds and lakes. Additionally, *Gomphonema* and *Navicula* were reported as dominant genera in lentic bodies in Mexico (Segura-García et al., 2012), freshwater ponds in Tamil Nadu (Arumugham et al., 2023), and various freshwater habitats in Patna, Bihar (Bharati et al., 2019). Wojtal (2003) reported *Gomphonema* as dominant in Koblyanka streamin Poland, while Hamilton et al. (2023) listed it as the second most dominant genus in the Tanana River, Alaska.

In comparison to other studies, this research revealed a unique seasonal pattern in diatom abundance, with the highest abundance recorded in winter (60.97%), followed by summer (56.09%), and the lowest during the rainy season (43.9%). This finding suggests that the diatom communities in the study area thrive most during winter, likely due to stable water flow, reduced competition from other algal groups, and favorable nutrient conditions. This contrasts with Patil et al. (2013), who found that diatom density and species richness peaked during summer in Lotus Lake, with the lowest values recorded in winter and post-monsoon. In Rai and Rai (2021) study, the highest species richness occurred in late winter, while the lowest was observed in winter.

The decline in diatom abundance during the rainy season may be attributed to factors such as increased turbidity, changes in water chemistry, and physical disturbances caused by higher water flow, which can dislodge diatom colonies from their substrates. This aligns with findings from Borgohain and Tanti (2014), who observed a similar decline in diatom diversity during monsoon conditions in Assam's silica-rich soils.

Conclusion

The study showed that the diatom flora of Raja-Rani lake is rich and interesting. A total of 16 diatom taxa were reported for the first time in Nepal. Out of 41 diatoms reported from this wetland, largest order was Naviculales, largest family was Pinnulariaceae, and largest genus was *Pinnularia*. Altogether only four diatom taxa, i.e., *Eunotia bilunaris, Navicula radiosa*, *Sellaphora capitata,* and *Iconella linearis* were found in all three seasons. *Craticula*, *Encyonema, Epithemia*, *Fragilaria*, *Frustulia*, *Sellaphora* and *Surirella* were the 7 genera having single diatom taxa.

The rare but interesting species reported here were *Craticula ambigua*, *Fragilaria tenera*, *Gomphonema pumilum, Iconella curvula*. It was observed that the number and types of diatom species in the lake have changed according to the seasons. Further extensive explorations are essential to explore more interesting and new algae for their proper documentation and conservation. The discussion reflects the importance of comprehensive studies that include all major algal groups to fully understand the biodiversity and ecological dynamics of aquatic systems. It also underscores the continuity and overlaps of species across different aquatic habitats in Nepal, suggesting potential common environmental factors or dispersal mechanisms influencing the distribution of diatom species. Furthermore, these findings contribute valuable data to the broader scientific understanding of freshwater biodiversity in Nepal, highlighting the need for continued exploration and documentation of algae across different ecosystems.

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References

Alfinito, S., & Lange-Bertalot, H. (2013). Contribution to the knowledge of the freshwater algae of Sierra Leone (Tropical West Africa): diatoms from Loma Mountains and Bumbuna Falls, the Northern

Province. *Biodiversity Journal*, *4*(1), 135-178. https://doi.org/10.11646/phytotaxa.161.2.5

APHA. (2017). *Standard methods for the examination of water and wastewater* (23rd ed.). American Public Health Association.

Arumugham, S., Joseph, S. J. P., Gopinath, P. M., Nooruddin, T., & Subramani, N. (2023). Diversity and ecology of freshwater diatoms as pollution indicators from the freshwater Ponds of Kanyakumari district, Tamilnadu. *Energy Nexus*, *9*, 100164. https://doi.org/10.1016/j.nexus.2022.100164

Baral, S. R. (1995) *Enumeration of the algae of Nepal*. Biodiversity Profiles Project Publication No. 11. Department of National Parks and Wildlife Conservation, Govt. of Nepal/Directorate General International Cooperation, Govt. of the Netherlands, Euroconsult, Arnhem, The Netherlands.

Bey, M. Y., & Ector, L. (2013). Atlas of river diatoms the Rhone Alpes region. *Agence Française pour la Biodiversité, Vincennes (in French)*. https://doi.org/10.1007/s10661-019-7290-x

Bharati, R., Verma, D., & Lavania, S. (2019). Study on fresh water diatoms from different habitats of Patna, Bihar, India. *The Journal of Indian Botanical Society*, *98*(3 and 4), 157-165. 10.5958/2455-7218.2019.00017.2

Bhat, K., Ajees, M. A., Kumar, P., Vibha, Bhat, V. G., Nayak, R., & Mazumder, N. (2025). Diatoms: Harnessing nature's microscopic marvels for biosensing and multifaceted applications. *Biophysical Reviews*, *17*, 203-125. https://doi.org/10.1007/s12551-024-01249-8

Borgohain, D., & Tanti, B. (2014). Seasonal variations of freshwater diatoms in the silica rich soils of Assam. *J. Res. Plant Sci*, *3*(1), 242-248.

da Silva-Lehmkuhl, A. M., Tremarin, P. I., Vercellino, I. S., & Ludwig, T. A. V. (2019). Periphytic diatoms from an oligotrophic lentic system, Piraquara I Reservoir, Paraná State, Brazil. *Biota Neotropica, 19*(2), e20180568. https://doi.org/10.1590/1676-0611-BN-2018-0568

Dahal, B. M., & Jüttner, I. (2004). *Monitoring water quality in springs of the Nepalese middle hills using diatoms* (Report No. 2235-2003). Report to the British Ecological Society, Small Ecological Project Grants (SEPG).

De Garcia Souza, D. R., Bueno, N. C., Nardelli, M. S., Tremarin, P. I., Ludwig, T. A. V., & Baumgartner, G. (2015). *Eunotia* Ehrenberg (Bacillariophyceae) in the Hercílio River, Santa Catarina, southern Brazil. *Brazilian Journal of Botany, 38*(3), 623–637. https://doi.org/10.1007/s40415-015-0159-5

Dhakal, S., Ghimire, N. P., Rai, S. K., & Dhakal, S. (2022). Seasonal variations of algae in relation to the water quality at Kingfisher lake, Central Nepal. *Journal of Plant Resources*, Special Issue, *20*(2), 1-11. https://doi.org/10.3126/bdpr.v20i2.56773

Dhakal, S., Rai, S. K., & Pathak, M. L. (2021). Enumeration of freshwater algae in Godawari area, Lalitpur district, central Nepal. *Banko Janakari, 31*(1), 41–50. https://doi.org/10.3126/banko.v31i1.37344

Everest, A., & Aslan, D. C. (2016). Seasonal diatom density investigation of the Mersin rivers. *World J. Res. Rev*, *2*(5), 21-30.

Foged, N. (1980). Diatoms in Egypt. *Nova Hedwigia*, *33*(1-4), 629-675-707.

Foged, N. (1982). Diatoms in Asklepieion, Pergamen, Turkey. *Nova Hedwigia*, *36*(2-4), 87-620.

Foged, N. (1986). Diatoms in Anholt, a Danish Island in the Cattegat. *Nova Hedwigia*, *42*(2-4), 53-589.

FRA/DFRS. (2014). *Churia forests of Nepal* (2011-2013). Forest Resource Assessment Nepal Project, Department of Forest Research and Survey, Kathmandu, Nepal. https://frtc.gov.np

Gandhi, H. P. (1999). *Fresh-water diatoms of central Gujarat: with a review and some others*. Bishen Singh Mahendra Pal Singh.

Ghimire, N. P., Rai, S. K., Jha, P. K., & Caravello, G. U. (2012). Some Bacillariophyceae from Nepal, including a new record. *Indian Hydrobiology*, *15*(2), 189-193.

Glushchenko, A. M., & Kulikovskiy, M. S. (2017). Taxonomy and distribution of *Eunotia camelus* Ehrenberg (Bacillariophyta) infraspecific taxa from South-East Asia. *Botanicheskij Journal*, *102*(2), 329-339.

Godar, K., & Rai, S. K. (2018). Freshwater green algae from Raja-Rani wetland, Bhogateni-

Letang, Morang, Nepal. *Journal of Plant Resources*, *16*(1), 1-17.

Guiry, M. D. (2024). How many species of algae are there? A reprise. Four kingdoms, 14 phyla, 63 classes and still growing. *Journal of Phycology*, *60*, 214-228. https://doi.org/10.1111/jpy.13431

Hamilton, V. A., Lee, S. S., Rober, A. R., Furey, P. C., Manoylov, K. M., & Wyatt, K. H. (2023). A Voucher Flora of Diatoms from Fens in the Tanana River Floodplain, Alaska. *Water*, *15*(15), 2803. https://doi.org/10.3390/w15152803

Hamsher, S., Kopalova, K., Kociolek, J. P., Zidarova, R., & Van De Vijver, B. (2016). The genus *Nitzschia* on the South Shetland Islands and James Ross Island. *Fottea*, *16*(1), 79-102. https://doi.org/10.5507/fot.2015.023

Hirano, M. (1955). Fresh water algae. In H. Kihara (Ed.), *Fauna and flora of Nepal Himalaya* (pp. 5-42). Kyoto University.

Hirano, M. (1963). Freshwater algae from the Nepal Himalaya, collected by a member of the Japanese climbing expedition. *Contr. Biol. Lab.,* Kyoto University, *16*, 1-23.

Hirano, M. (1969). Freshwater algae from Rangtang Himal, Nepal Himalaya. *Contr. Biol. Lab.,* Kyoto University, *22*, 1-42.

Hirano, M. (1972). Diatoms from the Hida mountain range in the Japan Alps. *Contr. Biol. Lab.,* Kyoto University, *24*(1), 10-30.

Hirano, M. (1974). Freshwater algae from north Borneo. *Contr. Biol. Lab.,* Kyoto University, *24*(3), 121-144. http://hdl.handle.net/2433/155995.

Hirano, M. (1984). Fresh water algae from East Nepal. *Study reported of Baika Junior College*, *32*, 197-215.

Hustedt, F. (1930). *Bacillariophyta (diatomeae)* (Heft 10). In A. Pascher (Ed.), *Die Susswasser-Flora Mitteleuropas* (pp. 1-466). Gustav Fischer.

Hustedt, F. (1938). Systematische und okologische Untersuchungen uber die Diatomeen-Flora von Java, Bali und Sumatra nach dem Material der Deutschen limnologischen Sunda-Expedition. Teil 1. Systematischer Teil. *Archiv fur Hydrobiologie, Supplment-Bund*, *15*, 131-506.

Jüttner, I., Chimonides, J., & Cox, E. J. (2011). Morphology, ecology and biogeography of diatom species related to *Achnanthidium pyrenaicum* (Hustedt) Kobayasi (Bacillariophyceae) in streams of the Indian and Nepalese Himalaya. *Algological studies: International Journal of Phycological Research*, *136*/*137*, 45-76. https://doi.org/10.1127/1864-1318/2011/0136-0045

Jüttner, I., Chimonides, P. D. J., Ormerod, S. J., & Cox, E. J. (2010). Ecology and biogeography of Himalayan diatoms: distribution along gradients of altitude, stream habitat and water chemistry. *Fundamental and Applied Limnology / Archiv für Hydrobiologie*, *177*(4), 293-311. https://doi.org/10.1127/18639135/2010/0177-0293

Jüttner, I., Cox, E. J., & Ormerod, S. J. (2000). New or poorly known diatoms from Himalayan streams. *Diatom research*, *15*(2), 237-262. https://doi.org/10.1080/0269249X.2000.9705498

Jüttner, I., Rothfritz, H., & Ormerod, S. J. (1996). Diatoms as indicators of river quality in the Nepalese Middle Hills with consideration of the effects of habitat-specific sampling. *Freshwater Biology*, *36*(2), 475-486. https://doi.org/10.1046/j.1365-2427.1996.00101.x

Jüttner, I., Sharma, S., Dahal, B.M., Ormerod, S.J., Chimonides, P.J., & Cox, E.J. (2003). Diatoms as indicators of stream quality in the Kathmandu valley and Middle hills of Nepal and India. *Freshwater Biology*, *48*(11), 2065-2084. https://doi.org/10.1046/j.1365-2427.2003.01138.x

Karthick, B., Hamilton, P. B., & Kociolek, J. P. (2013). *An illustrated guide to common diatoms of Peninsular India*. Gubbi labs.

Krammer, K. (1997). Die cymbelloiden diatomeen. Ein monographie der Weltweit bekannten Taxa. Teil 1. Allgemeines und Encyonema part. *Bibliotheca diatomologica*, *36*, 1-382.

Krammer, K. (2000). The genus *Pinnularia*. In H. Lange-Bertalot (Ed.), *The Diatoms of Europe: Diatoms of inland waters and comparable habitats* (Vol. 1). A.R.G. Gantner Verlag K.G.

Krammer, K., & Lange-Bertalot, H. (1986). *Bacillariophyceae*: *1 Teil, Naviculaceae*. In H. Ettl, J. Gerloff, H. Heynig, & D. Mollenhauer (Eds.), *Süsswasserflora von Mitteleuropa* (Band 2/1), Gustav Fisher.

Krstić, S. S., Zech, W., Obreht, I., Svirčev, Z., & Marković, S. B. (2012). Late quaternary

environmental changes in Helambu Himal, Central Nepal, recorded in the diatom flora assemblage composition and geochemistry of Lake Panch Pokhari. *Journal of Paleolimnology*, *47*, 113-124. https://doi.org/10.1007/s10933-011-9563-4

Lange-Bertalot, H. & Metzeltin, D. (1996). *Indicators of oligotrophy: 800 taxa representative of three ecologically distinct lake types: Carbonate buffered, oligodystrophic, weakly buffered soft water*. In H. Lange-Bertalot (Ed.), *Iconographia Diatomologica: Annotated diatom micrographs* (Vol. 2, *Ecology, diversity, taxonomy*). Koeltz Scientific Books.

Lange-Bertalot, H., Bak, M., Witkowski, A., & Tagliaventi, N. (2011). *Eunotia and some related genera* (Vol. 6). In H. Lange-Bertalot (Ed.), *Diatoms of Europe: Diatoms of the European inland waters and comparable habitats*. ARG Gantner Verlag K.G.

Levkov, Z., Tofilovska, S., & Mitic-Kopanja, D. (2016). Species of the diatom genus *Craticula* Grunow (bacillariophyceae) from Macedonia. *Contributions, Section of Natural, Mathematical and Biotechnical Sciences*, *37*(2), 129-165.

Mainali, A. (2020). Studies on algae of Gupha Pokhari and Lam Pokhari, Sankhuwasabha and qualitative analysis of Compsopogon caeruleus and Sheathia indonepalensis for secondary compounds. [Unpublished M.Sc. thesis] Department of Botany, Degree Campus, Tribhuvan University, Biratnagar, Nepal.

Mann, D. G., McDonald, S. M., Bayer, M. M., Droop, S. J., Chepurnov, V. A., Loke, R. E., ... & Du Buf, J. H. (2004). The *Sellaphora pupula* species complex (Bacillariophyceae): morphometric analysis, ultrastructure and mating data provide evidence for five new species. *Phycologia*, *43*(4), 459-482. https://doi.org/10.2216/i0031-8884-43-4-459.1

Medeiros, G., Amaral, M. W. W., Ferreira, P. C., Ludwig, T. V., & Bueno, N. C. (2018). *Gomphonema* Ehrenberg (Bacillariophyceae, Gomphonemataceae) of the São Francisco Falso River, Paraná, Brazil. *Biota Neotropica*, *18*(3), e20170495. http://doi.org/10.1590/1676-0611-bn-2017-0495

Morais, K. S. D., Bartozek, E. R., Zorzal-Almeida, S., Bicudo, D. C., & Bicudo, C. E. D. M. (2018). Taxonomy and ecology of order Surirellales (Bacillariophyceae) in tropical reservoirs in Southeastern of Brazil. *Acta Limnologica Brasiliensia*, *30*, e204. https://doi.org/10.1590/S2179-975X9817

Patil, J. V., Ekhande, A. P., & Padate, G. S. (2013). Water quality monitoring- Study of seasonal variation of diatoms and their correlation with physicochemical parameters of Lotus Lake, Toranmal (M.S.) India. *Archives of Applied Science Research, 5*(1), 172-176.

Patrick, R. M. & Reimer, C. W. (1966). *The diatoms of the United States (exclusive of Alaska and Hawaii)* (Vol. 1). *Monographs of the Academy of Natural Sciences of Philadelphia* (No. 13). Academy of Natural Sciences of Philadelphia.

Pokhrel, S., Ghimire, N.P., & Rai S.K. (2021). Seasonal variation of algal diversity with reference to water quality in Jagadishpur Reservoir, Nepal. *Limnological Review* (Poland), *21*(4), 189-199. https://doi.org/10.2478/limre-2021-0018

Poudel, P., Ghimire, N. P., & Rai, S. K. (2024). Algal diversity and its relationship with seasonal variation of water quality in Gajedi Lake, Rupandehi District, Nepal. *International Journal on Algae*, *26*(4), 375-392. https://doi.org/10.1615/InterJAlgae.v26.i4.60

Prasad, B. N., & Srivastava, M. N. (1992). *Freshwater algal flora of Andaman and Nicobar Islands* (Vol. 1). B. Singh & M. P. Singh Publishers.

Rai, S. K. (2005). Preliminary report of diatoms from Maipokhari lake, Ilam, Nepal. *Our Nature*, *3*(1), 26-30. https://doi.org/10.3126/on.v3i1.331

Rai, S. K. (2006). Taxonomic studies on some freshwater diatoms from the eastern Terai region, Nepal. *Our Nature*, *4*(1), 10-19. http://doi.org/10.3126/on.v4i1.498

Rai, S. K. (2011). Algal flora of Betana wetland, Morang, Nepal. *Nepalese Journal of Biosciences*, *1*, 104-113. https://doi.org/10.3126/njbs.v1i0.7477

Rai, S. K. (2013a). Algal flora of Koshi Tappu Wildlife Reserve including some new species to Nepal. *Nepalese Journal of Integrated Sciences*, *3*, 26-32.

Rai, S. K. (2013b). Taxonomic account on algal flora (exclusive to desmids) of Bees Hazari

Tal, Chitwan, Nepal. In D. Adhikari, S. K. Rai, & K. P. Limbu (Eds.), *Modern Trends in Science and Technology* (pp. 33–50). Nepal Biological Society; Nepal Physical Society, Eastern Chapter; & Research Council of Science and Technology.

Rai, S. K., & Adhikari, K. (2019). Diatom flora of Hasina pond, Morang, Nepal. *Nepalese Journal of Biosciences*, *9*(1), 1-27. https://doi.org/10.3126/njbs.v9i1.51726

Rai, S. K., & Adhikari, K. (2019). Diatom flora of Hasina pond, Morang, Nepal. *Nepalese Journal of Biosciences*, *9*(1): 1-27. https://doi.org/10.3126/njbs.v9i1.51726

Rai, S. K., & Khadka, S. (2017). Diatoms of Bagmati River, Kathmandu, Nepal. *Nepalese Journal of Biosciences*, *7*(1), 1-25. https://doi.org/10.3126/njbs.v7i1.41754

Rai, S. K., & Paudel, S. (2019). Algal flora of Jagadishpur Tal, Kapilvastu, Nepal. *Journal of Plant Resources*, *17*(1), 6-20.

Rai, S. K., & Rai, R. K. (2005). Some bacillario-phycean algae from Biratnagar, Nepal. *Ecoprint*, *12*, 71-76. https://doi.org/10.3126/eco.v12i0.3202

Rai, S. K., Godar, K., & Dhakal, S. (2020). Some freshwater green algae of Raja-Rani Wetland, Letang, Morang: New for Nepal. *Journal of Plant Resources*, *18*(1), 6-26.

Rai, S. K., Mishra, P. K., & Madan, K. (2012). On some diatoms from high altitude Gokyo lake-III, Sagarmatha National Park, Nepal. *Journal of Natural History Museum*, *26*, 93-110. http://doi.org/10.3126/jnhm.v26i0.14134

Rai, S. K., Subba, B. R., & Limbu, K. P. (2008). Fresh Water Algae from Running Streams of Gajurmukhi VDC, Ilam, Nepal. *Our Nature*, *6*(1), 80-81. https://doi.org/10.3126/on.v6i1.1659

Rai, S., & Rai, S. K. (2021). Algal diversity and water quality of Tamor River at Mulghat, Dhankuta District. In M. Siwakoti, T. N. Mandal, S. K. Rai, S. K. Rai, T. P. Gautam, H. P. Aryal, & K. P. Limbu (Eds.), *Integrating Biological Resources for Prosperity* (pp. 292-300). Botanical Society of Nepal, Nepal Biological Society, & Department of Plant Resources.

Reichardt, E. (1995). *Die Diatomeen (Bacillariophyceae) in Ehrenbergs material von Cayenne, Guyana Gallica (1843)*. In H. Lange-Bertalot (Ed.), *Iconographia diatomologica*: *Annotated diatom micrographs* (Vol. 1). Koeltz Scientific Books.

Reichardt, E., & Lange-Bertalot, H. (1991). Taxonomische Revision des Artenkomplexes um *Gomphonoma angustum* - *G. dichotomum* - *G. intricatum* - *G. vibrio* und ähnliche Taxa (Bacillariophyceae). *Nova Hedwigia*, *53*(3-4), 519-544.

Rocha, A. C. R. D., & Bicudo, C. E. D. M. (2008). Criptógamos do Parque Estadual das Fontes do Ipiranga, São Paulo, SP: algas, 25: Bacillariophyceae (Naviculales: Pinnularia-ceae). *Hoehnea*, *35*, 597-618. http://hdl.handle.net/11449/27190

Roka, D., Rai, S. K., & Ghimire, N. P. (2022). Seasonal variations of algal diversity in response to water quality at Beeshazari Lake, tropical lowland, Nepal. *Pakistan Journal of Botany*, *54*(4), 1445-1452. http://dx.doi.org/10.30848/PJB2022-4(19)

Round, F. E., Crawford, R. M., & Mann, D. G. (1990). *Diatoms: Biology and morphology of the genera*. Cambridge University Press.

Ruck, E. C., Nakov, T., Alverson, A. J., & Theriot, E. C. (2016). Nomenclatural transfers associated with the phylogenetic reclassification of the Surirellales and Rhopalodiales. *Notulae algarum*, *10*, 1-4.

Rybak, M., Kochman-Kędziora, N., & Pęczuła, W. (2020). Diversity of the Rhopalodiaceae diatoms (Bacillariophyta) on macrophytes of different architecture in small and shallow oxbow lakes (SE Poland). *Journal of Ecological Engineering*, *21*(5), 164-173. https://doi.org/10.12911/22998993/122486

Segura-García, V., Cantoral-Uriza, E. A., Israde, I., & Maidana, N. (2012). Epilithic diatoms (Bacillariophyceae) as indicators of water quality in the Upper Lerma River, Mexico. *Hidrobiológica*, *22*(1), 16-27.

Shrestha, G. & Rai, S. K. (2017). Algal flora of Rajarani lake, Dhankuta and their seasonal distribution. *Our Nature*, *15*(1-2), 44-54. http://dx.doi.org/10.3126/on.v15i1-2.18793

Shrestha, R., Ghimire, N. P., & Rai, S. K. (2025). Seasonal microalgal diversity and water quality trends in Mai Pokhari Lake, a Ramsar site, Eastern Nepal. *Philippine Journal of Science*, *154*(5), 1199-1214.

Shrestha, S., Rai, S. K., & Dhakal, M. R. (2013). Algae of Itahari Municipality and its adjoining area, Eastern Nepal. *Int. J. Appl. Sci. Biotechnol*, *1*(1), 5-10. http://doi.org/ 10.3126/ ijasbt.v1i1.7920

Simkhada, B., & Jüttner, I. (2006). Diatoms in ponds and small lakes of the Kathmandu Valley, Nepal - relationships with chemical and habitat characteristics. *Arch. Hydrobiol., 166*(1), 41-65. https://doi.org/10.1127/0003-9136/2006/0166-0041

Simonsen, R. (1987). *Atlas and catalogue of the diatom types of Friedrich Hustedt* (Vol. 1). J. Cramer.

Siver, P. A., Hamilton, P. B., Stachura-Suchoples, K., & Kociolek, J. P. (2003). Morphological observations of *Neidium* species with sagittate apices, including the description of *N. capecodii* sp. nov. *Diatom Research*, *18*(1), 131-148. https://doi.org/10.1080/0269249X.2003.9705578

Smith, W. (1856). *A synopsis of the British Diatomaceae: With remarks on their structure, functions and distribution; and instructions for collecting and preserving specimens* (Vol. 2). J. Van Voorst.

Smith, W., & West, T. (1853). *A synopsis of the British Diatomaceae: With remarks on their structure, functions and distribution; and instructions for collecting and preserving specimens* (Vol. 1). J. Van Voorst. https://doi.org/10.5962/bhl.title.10706

Smol, J. P., & Stoermer, E. F. (Eds.). (2010). *The diatoms: applications for the environmental and earth sciences*. Cambridge University Press.

Tiwari, P., Srivastava, P., & Thakur, B. (2023). Diatom response in different climatic zones from west coast of India. *Journal of the Palaeontological Society of India*, *68*(1), 84-98. https://doi.org/10.1177/05529360231182261

Tremarin, P. I., Ludwig, T. A. V., & Moreira Filho, H. (2008). *Eunotia* Ehrenberg (Bacillariophyceae) do rio Guaraguaçu, litoral do Paraná, Brasil. *Acta Botanica Brasilica*, *22*(3), 845-862.

Van de Vijver, B., Beyens, L., & Lange-Bertalot, H. (2004). *The genus Stauroneis in Arctic and Antarctic regions. Bibliotheca Diatomologica* (Vol. 50). J. Cramer.

Van de Vijver, B., Jüttner, I., Gurung, S., Sharma, C., Sharma, S., de Haan, M., & Cox, E. J. (2011). The genus Cymbopleura (Cymbellales, Bacillariophyta) from high altitude freshwater habitats, Everest National Park, Nepal, with the description of two new species. *Fottea*, *11*(2), 245-269. https://doi.org/ 10.5507/fot.2011.025

Wehr, J. D., Sheath, R. G., & Kociolek, J. P. (Eds.). (2015). *Freshwater algae of North America: Ecology and classification*. Elsevier.

Werum, M. & Lange-Bertalot, H. (2004). *Diatoms in springs from central Europe and elsewhere under the influence of hydrogeology and anthropogenic impacts*. *Iconographia diatomologica* (Vol. 13), A.R.G. Gantner Verlag K.G.

Wojtal, A. (2003). Diatoms of the genus *Gomphonema* Ehr. (Bacillariophyceae) from a karstic stream in the Krakowsko-Czestochowska Upland. *Acta Societatis Botanicorum Poloniae*, *72*(3), 213-220. https://doi.org/10.5586/asbp.2003.028