Journal of Life Sciences and Informatics

Volume 1, Issue 1, Fall 2025

Homepage: *https://journal.vu.edu.pk/JLSI*

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Citation: Zafar, A., Iqbal, K., Mughal, S. (2025). *A trophic status of freshwater phytoplankton diversity in wetlands of the Bahawalpur District, Pakistan*. *J Life Sci Inform, 1*(1), 83–95.

Conflict of Interest: Author (s) declared no conflict of interest

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A trophic status of freshwater phytoplankton diversity in wetlands of the Bahawalpur District, Pakistan

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Abstract

The study describes the diversity of phytoplankton communities that inhabit River Sutlej, Bahawalpur District, Pakistan. A total of 14 species identified, comprised classes Cyanophyceae, Chlorophyceae, Zygnematophyceae and Bacillariophyceae. The most common taxa were *Caloneis amphisbaena* (18%), then *Rhizoclonium* sp. (14%), and *Amphipleura pellucida* (12%), while *Gyrosigma* sp., *Pinnularia* sp. and *Entomoneis* sp. were found in less abundance. The presence of pollution-tolerant and sensitive species shows a moderately eutrophic state of freshwater environment. The dominance of *Caloneis* and *Rhizoclonium* shows nutrient enrichment possibly linked to mild salinity and agricultural runoff, whereas *Sirogonium* and *Euastrum* indicate microhabitats of moderately good water quality. While in comparison with studies from other areas of Pakistan, reveal a community structure shaped by semi-arid hydrology, fluctuating salinity, and nutrient dynamics. Overall, the phytoplankton community demonstrates the adaptive balance of freshwater organisms under environmental stress. These findings provide valuable baseline information for future ecological monitoring, biodiversity conservation and water quality management in the lower basin of Sutlej and other arid-zone river systems of Pakistan.

Keywords*: Phytoplankton diversity, River Sutlej, Bahawalpur, Bacillariophyceae, Chlorophyceae*

Introduction:

Phytoplankton are photosynthetic microscopic organisms that serve as the base of aquatic ecosystems. They are responsible for nearly 50% of the global primary productivity and play

an essential role in regulating nutrient and carbon cycling, and supporting aquatic food webs (Reynolds, 2006; Richardson, 1997). These organisms form a foundation of the trophic pyramid, sustaining zooplankton, fish, and other aquatic life, thus representing as the “green lungs” of the freshwater ecosystems. They often used as bioindicators of water quality due to their rapid response to environmental change (Harnström et al., 2009; Araujo et al., 2022).

Globally, the composition and diversity of phytoplankton are known to fluctuate in influence of various physicochemical factors such as light intensity, temperature, nutrient concentration, dissolved oxygen and pH (Chen & Durbin, 1994; Reynolds et al., 2002). The anthropogenic stressors that cause a change in productivity, including agricultural pollution, fertilizer runoff, and uncontrolled water use, and in some cases, harmful algal blooms (Paerl & Otten, 2013). These changes need to be understood not only to conduct ecological assessment but also in the management of freshwater resources in the area where that is relied on by the people to supply their domestic and agricultural needs.

In Pakistan, research on the ecology of freshwater phytoplankton has been growing over the last years but remains concentrated in the northern river systems and dams including the Indus Basin, Rawal Lake and Keenjhar Lake (Panhwar et al., 2022; Irfan et al., 2019; Zafar et al., 2021). These tests have recorded diversity make up, seasonal changes and pollution impact on phytoplankton community. Nevertheless, there is a significant gap in the literature concerning the structure and functioning of the plankton communities in the semi-arid freshwater ecosystems of the southern Punjab which is largely in the Bahawalpur District.

Bahawalpur is a city found in the southeastern region of Punjab and is typified by its dry to semi-arid climate, high temperatures, low level of rainfall, and mass production of irrigated crops. The native biodiversity has its habitats in water bodies in this region like in ponds, canals, and wetlands, which are also used to irrigate, support livestock, and household activities. These freshwater resources despite being under an ever-rising pressure due to farming intensification, use of fertilizers, seasonal water shortage and intrusion of saline. The effect of such conditions of the environment on water chemistry and nutrient availability may, in turn, affect the productivity and diversity of phytoplankton. In spite of these complications, scientific data on phytoplankton diversity and abundance in Bahawalpur district is very scanty.

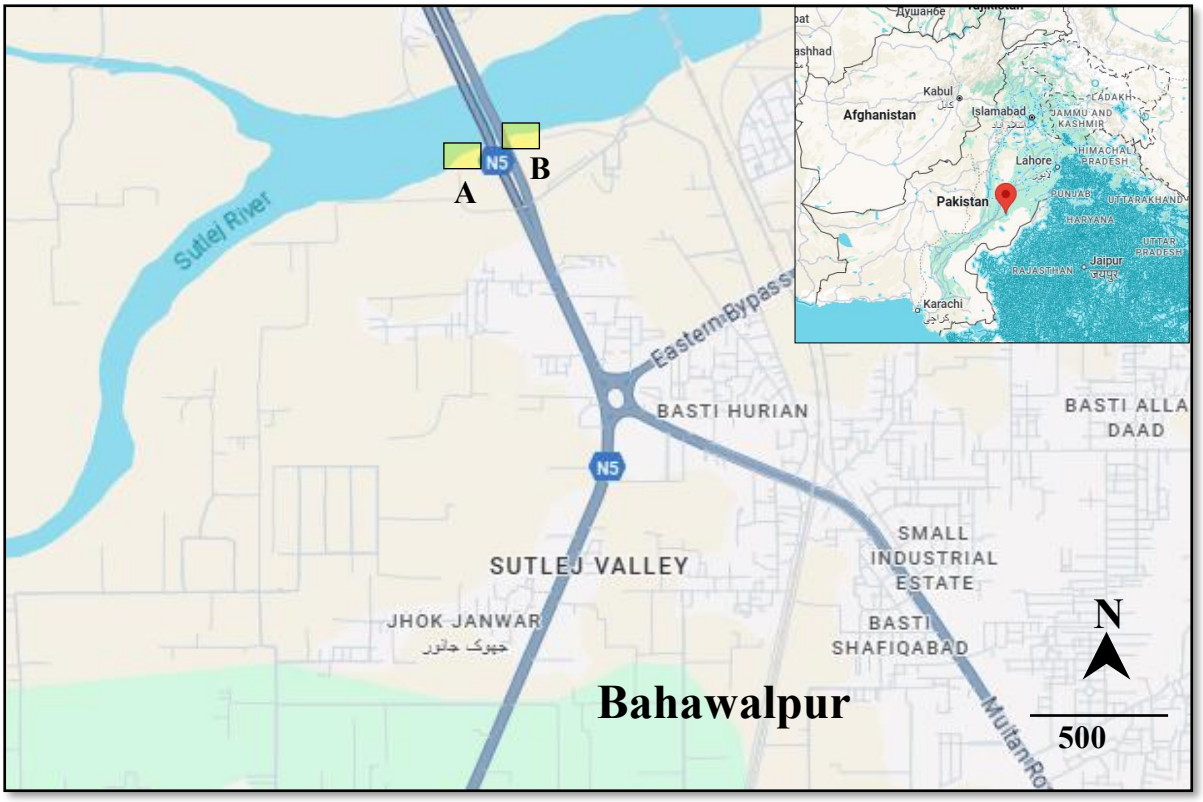

Figure 1. Map showing study sites A and B at the River Sutlej (29°26'30.4"N 71°38'43.6"E), District Bahawalpur, Pakistan.

Such lack of local ecological information is a grave limitation to the sustainable management of water resources. Without the background data on the dynamics of phytoplankton, one cannot estimate the ecology of freshwater systems and predict the extent to which the further change of the environment, e.g., climate warming or altered irrigation regimes will affect them. Moreover, since phytoplankton is the foundation of aquatic food webs, the composition and density of phytoplankton have a direct effect on the upper trophic levels, including the fisheries productivity and other waterfowl populations that utilize those habitats.

Some related literature available in other regions of Punjab dwell on the effect of nutrient enrichment and seasonal variation on diversity, distribution and abundance of phytoplankton (Irfan et al., 2019; Fatima et al., 2020). However, the environmental condition in Bahawalpur are different and unique due to high evaporation rates, saline soils, and fluctuating canal inflows that supports a specific phytoplankton community structure as compared to northern regions. These ecological differences remain unreported in the scientific literature.

The present study aims to provide a baseline data and investigate the diversity and trophic status of freshwater phytoplankton in the Bahawalpur District, Punjab, Pakistan.

Materials and methods:

Sampling was conducted from four stations of two waterlogged wetland sites close to River Sutlej (29°26'30.4"N 71°38'43.6"E), District Bahawalpur Pakistan (Figure 1). Water samples were collected from water surface, preserved in 4% formalin.

In the laboratory, the preserved water samples were microscopically observed for identification and morphological analysis of plankton. The primary identification of plankton was executed by the manual catalogue by Needham & Needham (1927) and AlgaeBase (Guiry & Guiry, 2025).

Results:

A total of 14 phytoplankton species were identified belonged to classes Cyanophyceae, Chlorophyceae, Zygnematophyceae and Bacillariophyceae.

1. *Oscillatoria* sp. (Figure 2A)

Class: Cyanophyceae
Family: Oscillatoriaceae

Description: Filamentous, unbranched cyanobacterium with cylindrical trichomes showing gliding motility. Cells are uniform in size with no heterocysts or akinetes. The apical cell is rounded or conical.

2. *Rhizoclonium* sp. (Figure 2B)

Class: Chlorophyceae
Family: Cladophoraceae

Description: Filamentous green alga with long, unbranched threads and cylindrical cells. Cell walls are thick, with distinct cross-septa and conspicuous chloroplasts.

3. *Chaetomorpha minima* (Figure 2C)

Class: Chlorophyceae
Family: Cladophoraceae

Description: Filamentous and unbranched with firm, spirally arranged cells; each cell has a single parietal chloroplast.

4. *Neochloris* sp. (Figure 2D)

Class: Chlorophyceae
Family: Neochloridaceae

Description: Unicellular, spherical or ovoid with a distinct chloroplast and no flagella.

5. *Euastrum* sp. (Figure 2E)

Class: Zygnematophyceae
Family: Desmidiaceae

Description: Unicellular, deeply constricted at the isthmus, forming two symmetrical semicells with smooth or ornamented walls.

6. *Sirogonium* sp. (Figure 2F)

Class: Zygnematophyceae
Family: Zygnemataceae

Description: Filamentous and unbranched; cells contain spiral chloroplasts without pyrenoids.

7. *Gyrosigma* sp. (Figure 3A)

Class: Bacillariophyceae
Family: Naviculaceae

Description: Elongated sigmoid frustules with distinct transverse and longitudinal striae visible under high magnification.

8. *Caloneis amphisbaena* (Figure 3B)

Family: Naviculaceae

Description: Linear-lanceolate valves with slightly constricted central areas; raphe straight with expanded central pores.

9. *Rhopalodia* sp. (Figure 3C)

Family: Rhopalodiaceae

Morphology: Elliptic valves with a central canal and internal symbiotic cyanobacteria (endosymbionts).

10. *Rhopalodia gibba* (Figure 3D)

Family: Rhopalodiaceae

Description: Lanceolate valves with curved ends; central canal houses symbiotic cyanobacteria.

11. *Cymbella* sp. (Figure 3E)

Family: Cymbellaceae

Description: Asymmetric valves with dorsal convexity and ventral concavity; raphe lies on ventral side.

12. *Pinnularia* sp. (Figure 3F)

Family: Pinnulariaceae

Description: Linear-lanceolate valves with pronounced striae; central area broad and rectangular.

13. *Amphipleura pellucida* (Figure 3G)

Family: Amphipleuraceae

Description: Extremely elongated frustules with fine striation; high optical resolution species.

14. *Entomoneis* sp. (Figure 3H)

Family: Entomoneidaceae

Description: Elongated, sigmoid valves with central constriction; raphe curves around the central nodule.

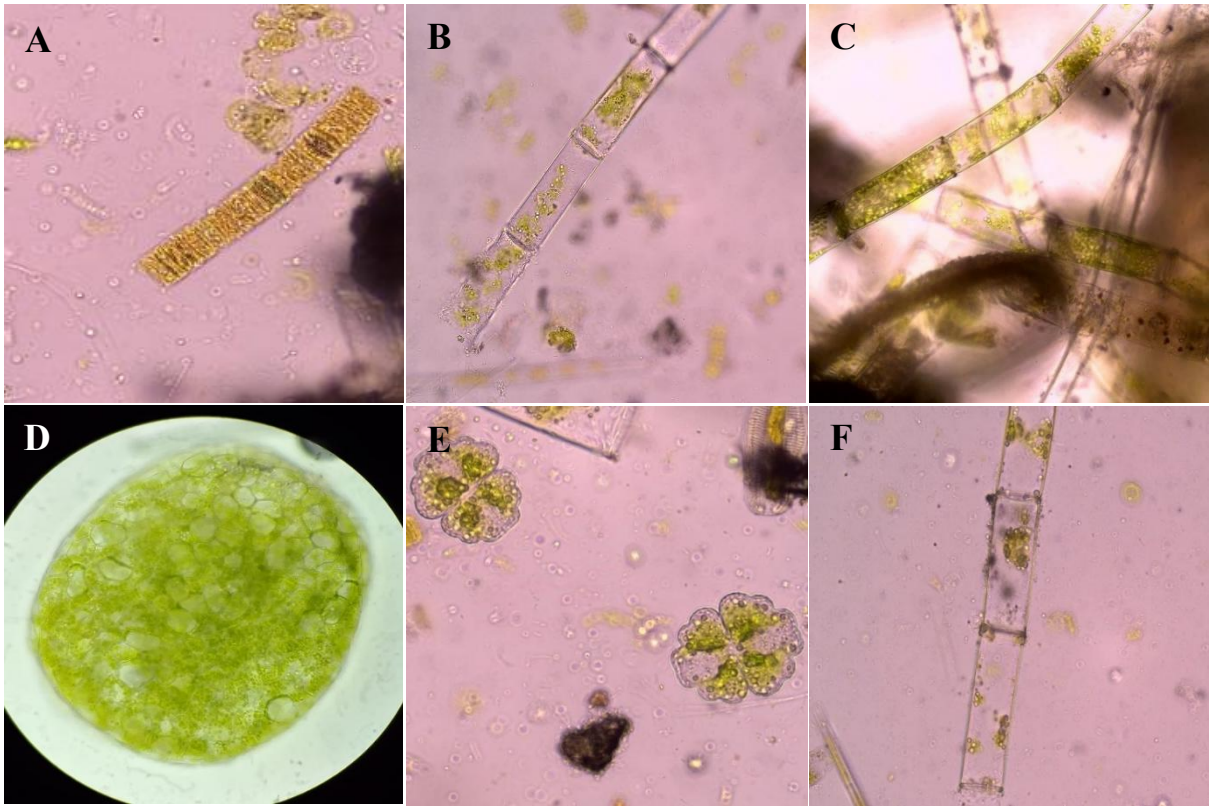

Figure 2. Phytoplankton species. A. *Oscillitoria* sp. B. *Rhizoclonium* sp. C. *Chaetomorpha minima* D. *Neochloris* sp. E. *Euastrum* sp. and F. *Sirogonium* sp.

Discussion:

The phytoplankton community recorded from the River Sutlej at Bahawalpur revealed a diverse mix of Cyanophyceae, Chlorophyceae, Zygnematophyceae, and Bacillariophyceae, reflecting an ecosystem under moderate nutrient enrichment but still maintaining zones of good water quality.

The presence of *Oscillatoria sp.* indicates nutrient-rich and slightly polluted conditions, consistent with findings from freshwater bodies in Malakand and Khyber Pakhtunkhwa (Hussain et al., 2016; Hanif et al., 2024). Globally, similar trends have been noted in China's Lake Taihu (Wu et al., 2019) and the Nile Delta (El-Sheekh et al., 2020), where *Oscillatoria* thrives in eutrophic waters. Its restricted quantities here indicate moderate and not severe eutrophication.

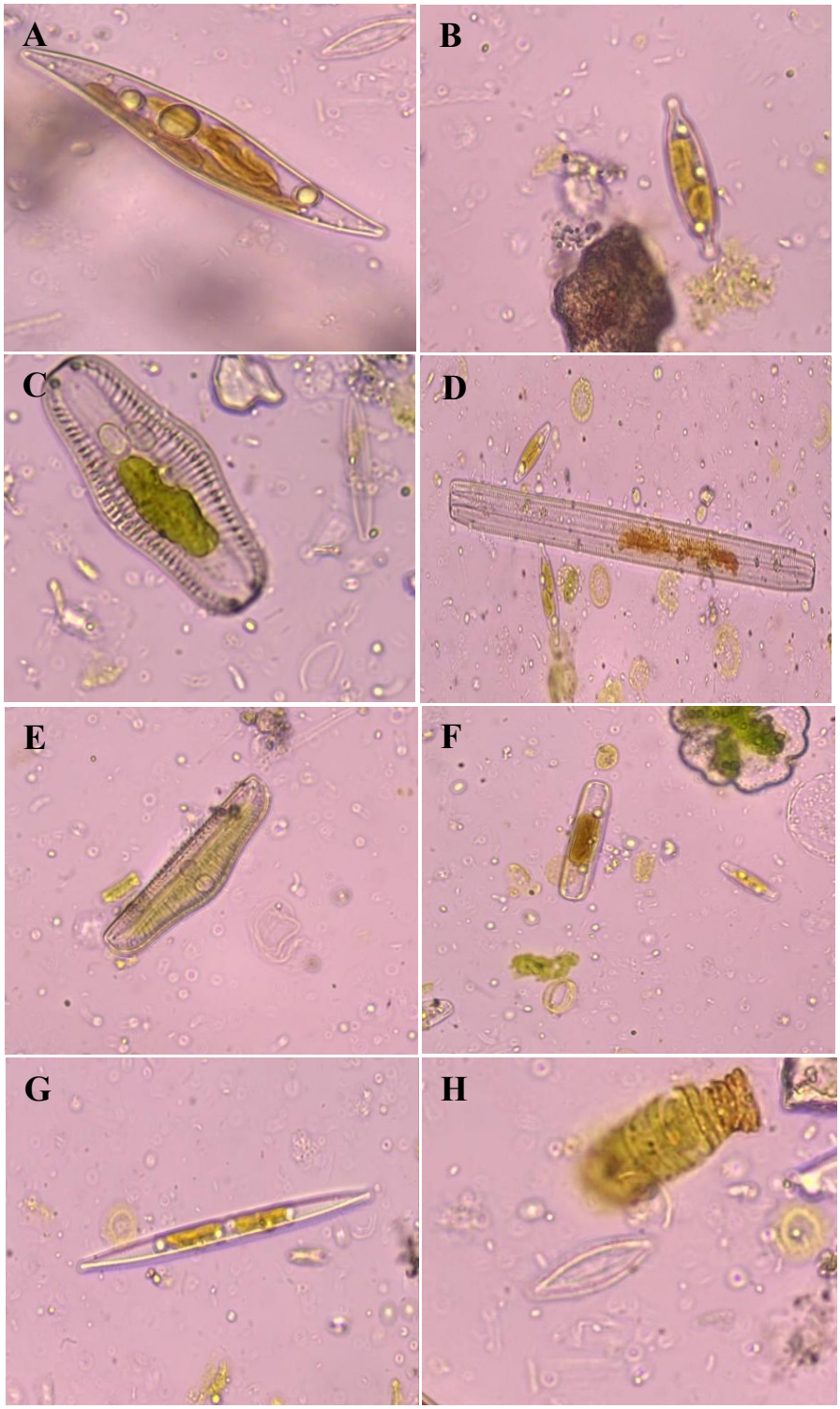

Figure 3. Bacillariophyceae species. A. *Gyrosigma* sp. B. *Caloneis amphisbaena* C. *Rhopalodia* sp. D. *R. gibba* E. *Cymbella* sp. F. *Pinnularia* sp. G. *Amphipleura pellucida* and H. *Entomoneis* sp.

Among the chlorophyceae, *Chaetomorpha minima* and *Rhizoclonium* sp. were dominated. *Rhizoclonium* grows in slightly alkaline and nutrient-enriched habitat (Ahmad et al., 2013;

Wali et al., 2017), which similar to conditions found in riverine waters of India (Nath et al., 2019). *Chaetomorpha minima*, a salinity-tolerant alga, indicates marginal salinity and conductivity, perhaps from return irrigation flows, consistent with Indus delta along Karachi coastline (Qari et al., 2018). Meanwhile, *Sirogonium* sp. and *Euastrum* sp., known for preferring clean waters (Saber et al., 2018; Yasar et al., 2016), indicate that parts of the Sutlej still retain good-quality freshwater pockets.

Table I. Phytoplanktonic community reported from waterlogged bodies at River Sutlej, Bahawalpur, Pakistan.

Group	Species	Abundance (%)	Location	Reference
Cyanophyceae	*Oscillitoria* sp.	2	Malakand, Karak, Pakistan	Hussain *et al*., 2016; Hanif *et al*., 2024
Chlorophyceae	*Rhizoclonium* sp.	14	Lahore (GC university), River Naguman, Khyber Pakhtunkhwa	Ahmad *et al*., 2013; Wali *et al*.,2017
	Chaetomorpha minima	12	Karachi coast, Pakistan	Qari *et al*., 2018
	Neochlroris sp.	9	-	-
Zygnematophyceae	*Euastrum* sp.	6	Western Desert of Egypt	Saber *et al*., 2018
	Sirogonium sp.	5	Lahore, Pakistan	Yasar *et al*., 2016
Bacillariophyceae	*Gyrosigma* sp.	0.5	Karachi, Pakistan	Naz et al., 2012; Shoaib *et al*., 2017
	Caloneis amphisbaena	18	Costa Rica, Central America	Bursey *et al*., 2006
	Rhopalodia sp.	7	Karachi and Kabul River, Pakistan	Aliya *et al*., 2009; Barinova *et al*., 2016
	Rhopalodia gibba	10	Xinjiang Uygur, China	You *et al*., 2009
	Cymbella sp.	4	Khyber Pakhtunkhwa, Pakistan	Badshah, *et al*., 2013
	Pinnularia sp.	0.5	Karachi coast, Pakistan	Naz *et al*., 2012
	Amphipleura pellucida	12	Argentine Islands, Antarctic Regions	Kuz'menko *et al*., 2008
	Entomoneis sp.	1	West Coast of Sweden	Al-Handal *et al*., 2020

Diatoms were also well represented. *Rhopalodia sp.*, *Cymbella sp.*, and *Pinnularia sp.* suggest stable and oxygenated habitats, in line with studies from the Kabul River and northern Pakistan (Aliya et al., 2009; Barinova et al., 2016). The occurrence of *Rhopalodia gibba*, which hosts nitrogen-fixing endosymbionts, reflects adaptation to fluctuating nutrient levels—a trait also noted in Chinese rivers (You et al., 2009). Similarly, *Gyrosigma sp.* and *Caloneis amphisbaena* were associated with moderate organic content, comparable to reports from the Costa Rican and European freshwater systems (Bursey et al., 2006; Kelly et al., 2018).

Overall, the coexistence of pollution-tolerant (*Oscillatoria*, *Rhizoclonium*) and sensitive (*Euastrum*, *Cymbella*) species highlights a transitional ecological state, neither pristine nor heavily degraded. This equilibrium indicates that the River Sutlej in Bahawalpur has moderately stressed but stable aquatic environments, which are determined by seasonal flow, agricultural impacts, and semi-arid hydrology. This biodiversity and ecological integrity will need continued monitoring in order to maintain its biodiversity.

Conclusion:

The present study gives a baseline information about the phytoplankton community in River Sutlej near Bahawalpur and shows that the community consists of a rich combination of cyanobacteria, green algae, desmids, and diatoms. The presence of both tolerant species (*Oscillatoria*, *Rhizoclonium*) and sensitive taxa (*Euastrum*, *Cymbella*) indicates a moderately stressful ecologically active freshwater system. The results provide a valuable point of reference in terms of ecological health monitoring and act as a guide in the future in limnological and conservation studies in semi-arid environments.

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