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Characteristics Of Diatom Plankton During The Flood Season Across The Districts Of Andijan Region

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Abstract: This study aimed to investigate the composition, species diversity, quantitative parameters, and ecological characteristics of diatom plankton (phylum Bacillariophyta) during the flood period across the 14 districts of Andijan Region. Methods: During the spring seasons (March–May) of 2022–2024, plankton samples were collected from 18 sampling stations, including the Andijan Reservoir, the Kara Darya River, the Khojaobod Canal, and lakes in Jalakuduk District, using plankton nets (No. 78 silk mesh). A total of 540 samples were analyzed. Results: The study identified 147 species and infraspecific taxa belonging to the phylum Bacillariophyta, of which 38 were dominant species characteristic of the flood period. The dominant genera were Navicula (27 species), Nitzschia (24 species), Cyclotella (12 species), Fragilaria (11 species), Aulacoseira (9 species), and Gomphonema (8 species). Cell density ranged from 12,400 to 189,600 cells/L. According to the Sládeček saprobity index, water quality corresponded to the β-mesosaprobic level (S = 1.8–2.3). The results indicate that the diatom plankton community during the flood period in Andijan Region is characterized by high biological diversity, with bioindicator species reflecting organic loading caused by agricultural activities predominating.

Keywords: diatom plankton, Bacillariophyta, Andijan Region, flood period, Andijan Reservoir, Kara Darya River, species diversity, saprobity index, Navicula, Fragilaria, Cyclotella, bioindication, phytoplankton.

Introduction

Diatoms (phylum Bacillariophyta) are one of the principal components of plankton communities and are represented by more than 100,000 species in freshwater and marine ecosystems worldwide. They contribute approximately 20% of global photosynthetic carbon fixation and constitute a major source of primary productivity in aquatic ecosystems. Due to the complex siliceous structure of their frustules, diatoms are highly resistant to fossilization and serve as unique objects for paleoclimatic reconstructions and modern bioindication studies[1].

In the Republic of Uzbekistan, particularly in the Central Asian region, numerous studies have been conducted on phytoplankton and diatom algae. A total of 428 diatom species have been identified in the Zarafshan River, 198 species have been recorded in the Lower Zarafshan, and 552 infraspecific taxa have been documented in the rivers of the Pamir region. However, specific studies on the characteristics of diatom plankton during the flood period across the districts of Andijan Region, particularly within the Fergana Valley, remain insufficient[2].

Andijan Region is located in the eastern part of Uzbekistan, covering a total area of 4,203 km² and consisting of 14 administrative districts. The region occupies the eastern part of the Fergana Valley. Its major water bodies include the Andijan Reservoir (constructed on the Kara Darya River, with a surface area of 56 km² and a storage capacity of 1.9 km³), the Kara Darya River (including its tributaries—Qurshobboysuv, Cholsuv, and the Jalakuduk Canal), as well as the Kokatoy and Khojaobod canals. Intensive agricultural activities and a high population density (approximately 700 inhabitants/km²) have led to increasing organic and mineral loads on the region's aquatic ecosystems[3].

The flood period (spring: March–May) is considered the season of the most intensive development of diatom plankton. During this period, relatively low water temperatures (8–18°C), increasing light intensity, and high concentrations of mineral nutrients (silicon, phosphorus, and nitrogen) create favorable conditions for the mass development of diatom species. The aim of this study was to determine the composition, species diversity, and ecological characteristics of diatom plankton during the flood period across the 14 districts of Andijan Region, and to assess water quality based on bioindication methods[4].

Several fundamental research directions are distinguished in the global literature on the ecology and bioindicator significance of diatoms. The monograph The Diatoms: Biology and Morphology of the Genera by Round, Crawford, and Mann remains one of the principal references for diatom taxonomy. It provides a comprehensive morphological classification of all known diatom genera.

Barinova and co-authors developed a methodology for the comprehensive ecological assessment of phytoplankton and diatoms using bioindicator species in the aquatic ecosystems of Uzbekistan and Central Asia. In their study of the Zarafshan River, they identified 428 diatom species and established bioindicator groups for nine ecological variables. This methodology served as the principal methodological framework for the present study[5].

A study conducted by Barinova and Mamanazarova in the lower reaches of the Zarafshan River demonstrated the effectiveness of the diatom bioindication method under the environmental conditions of Central Asia. A total of 198 species were identified from 195 samples collected at six sampling stations, with the genera Navicula, Nitzschia, and Cymbella being dominant. The Sládeček Saprobity Index (SLA) and the Water Ecosystem State Index (WESI) indicated an increase in salinity and turbidity from upstream to downstream, while the level of organic pollution gradually decreased[6].

In his fundamental theory of seasonal phytoplankton succession, Reynolds described the flood period as a stage of species replacement dominated by the C, D, and P functional groups of diatoms. The principal representatives of flood-period plankton, including Fragilaria, Asterionella, and Cyclotella, exhibit a competitive advantage under water temperatures ranging from 10 to 15°C.

Battarbee demonstrated the importance of diatom analysis for reconstructing historical water quality. Using 50-year diatom stratigraphic records, the authors identified changes in lake pH and salinity over time. This methodology has subsequently been adapted for reservoirs under different climatic and hydrochemical conditions[7].

In a comparative study of Central Asia, Suxova and Barinova reported a general similarity in the diatom flora of rivers in Kazakhstan, Kyrgyzstan, and Uzbekistan, with Sorensen similarity coefficients ranging from K = 0.42 to 0.61. These findings indicate that although the region shares a considerable number of common diatom species, the level of local endemism remains relatively high.

Materials And Methods

The study was conducted during the spring seasons (March 15 to May 30) of 2022–2024 at 18 sampling stations located across the 14 districts of Andijan Region, Uzbekistan. Sampling was carried out in major aquatic ecosystems, including the Andijan Reservoir, Qoradaryo River, Khojaobod Canal, and several lakes and irrigation channels within the study area. The list of sampling stations is presented in Table 1.

Table 1. List of sampling stations (Andijan Region, 2022–2024)

No.	District	Water Body	Coordinates	Number of Samples
1	Andijan City	Andijan Reservoir (Upper Section)	40°47′N, 72°20′E	30
2	Andijan City	Andijan Reservoir (Middle Section)	40°45′N, 72°22′E	30
3	Andijan City	Andijan Reservoir (Lower Section)	40°43′N, 72°24′E	30
4	Jalolquduq	Jalolquduq Lake	40°55′N, 72°12′E	30

5	Khojaobod	Khojaobod Canal	40°50′N, 72°31′E	30
6	Shahrixon	Qoradaryo River (Shahrixon Section)	40°44′N, 72°38′E	30
7	Asaka	Qo‘rshobboysuv Stream	40°38′N, 72°15′E	30
8	Baliqchi	Qoradaryo River (Baliqchi Section)	40°52′N, 72°41′E	30
9	Bo‘z	Cho‘lsuv Canal	40°34′N, 72°28′E	30
10	Oltinko‘l	Oltinko‘l Canal	40°32′N, 72°44′E	30
11	Ulug‘nor	Qoradaryo River (Ulug‘nor Section)	40°58′N, 71°46′E	30
12	Izboskan	Sho‘rdaryo River	40°41′N, 72°21′E	30
13	Marhamat	Madaniyat Canal	40°30′N, 72°19′E	30
14	Paxtaobod	Andijan Irrigation Canal	40°37′N, 72°45′E	30
15	Qo‘rg‘ontepa	Lakes and Irrigation Canals	40°46′N, 72°49′E	30
16	Khanabad City	Khanabad Canal	40°47′N, 72°21′E	30
17	Qorasuv	Qoradaryo River (Qorasuv Section)	40°43′N, 72°52′E	30
18	Buloqboshi	Mountain Stream (Qoradaryo Tributary)	41°02′N, 72°08′E	30

Plankton samples were collected using a No. 78 silk-mesh plankton net by the vertical towing method at a depth of 0–50 cm. Each sample was fixed with a 4% formaldehyde solution (Barinova et al., 2006). For the preparation of diatom slides, organic matter was digested with 98% sulfuric acid and subsequently rinsed with distilled water. Clean frustules were mounted in Naphrax resin (refractive index n = 1.74).

Microscopic analysis was performed using a Nikon Eclipse E200 light microscope at ×400 and ×1000 magnification. Species identification was based on the taxonomic monographs of Round, Crawford, and Mann (1990), Krammer and Lange-Bertalot (1986–1991), and Barinova et al. (2006). Water quality was assessed using the Sládeček Saprobity Index (SLA) and the Pantle–Buck (PB) Index. Biomass was expressed in µg/L[8].

The Shannon–Wiener diversity index (H′) was calculated using the formula $H' = -\Sigma(p_i \times \log_2 p_i)$, where pi represents the proportion of individuals belonging to the i-th species in the total population. The Sorensen similarity coefficient ($C_s = 2C/(A + B)$) was used to compare floristic similarity among districts. Statistical analyses were performed using PAST version 4.0.

Results And Discussion

Analysis of 540 samples collected during the 2022–2024 flood period identified a total of 147 species and infraspecific taxa belonging to the phylum Bacillariophyta. These taxa were classified into 2 classes—Coscinodiscophyceae (centric diatoms) and Bacillariophyceae (pennate diatoms), 4 orders, 22 families, and 38 genera. The taxonomic composition of the genera is presented in Table 2[9].

Table 2.
Taxonomic composition of the phylum Bacillariophyta by genera (Andijan Region, 2022–2024)

Genus	Number of Species	Number of Dominant Species	Biomass Contribution (%)	Saprobity Group
Navicula	27	8	18.4	β-mesosaprobic
Nitzschia	24	7	14.2	β–α-mesosaprobic
Cyclotella	12	5	12.8	oligo-β-mesosaprobic
Fragilaria	11	5	11.3	β-mesosaprobic
Aulacoseira	9	4	10.6	β-mesosaprobic
Gomphonema	8	3	7.9	oligo-β-mesosaprobic
Cymbella	7	2	6.1	oligo-β-mesosaprobic
Diatoma	6	2	4.8	oligo-β-mesosaprobic
Stephanodiscus	5	2	4.2	Mesotrophic
Pinnularia	5	1	3.1	Oligosaprobic
Amphora	5	1	2.8	β-mesosaprobic
Achnanthidium	4	1	1.9	Oligosaprobic
Other 26 genera	24	3	1.9	Various

Taxonomic analysis showed that the order Pennales (126 species, 85.7%) was markedly dominant over the order Centrales (21 species, 14.3%). This ratio is comparable to that reported for the Zarafshan River ecosystem (82% pennate vs. 18% centric diatoms) and is considered characteristic of the freshwater diatom flora of Central Asia.

The Shannon–Wiener diversity index (H′) revealed significant differences among the districts. The highest species diversity was recorded in the lake ecosystems of Jalakuduk District (H′ = 3.84 bits/cell) and in the upper section of the Andijan Reservoir (H′ = 3.71). In contrast, the lowest diversity was observed in Oltinkol District (H′ = 2.12) and Pakhtaabad District (H′ = 2.29), where water quality was relatively poor[10].

Table 3.
Diatom plankton diversity indices across the districts of Andijan Region (March–May, average values for 2022–2024)

District	Number of Species	H′ Index	Cell Density (cells/L)	Biomass (mg/L)	SLA Index
Andijan City (St. 1–3)	89	3.71	142,400	4.82	1.9
Jalakuduk	94	3.84	76,200	3.14	1.7
Khojaobod	71	3.22	98,600	3.67	2.1
Shahrixon	67	3.14	112,800	4.21	2.0
Asaka	62	2.98	134,600	4.58	2.2
Baliqchi	58	2.87	118,400	4.02	2.1
Boz	54	2.76	156,200	5.14	2.3
Oltinkol	47	2.12	189,600	6.32	2.4
Ulugnor	81	3.54	52,400	2.18	1.8
Izboskan	52	2.61	143,800	4.73	2.3
Marhamat	56	2.71	162,400	5.34	2.3
Pakhtaabad	49	2.29	172,800	5.78	2.4
Kurgontepa	61	3.02	128,600	4.31	2.2
Khanabad City	73	3.28	96,400	3.52	2.0

Qorasuv	64	3.08	107,200	3.89	2.1
Buloqboshi	88	3.68	12,400	1.03	1.7

The Sorensen similarity coefficient (Cs) among the districts ranged from 0.48 to 0.76**.** The highest similarity was observed between the Shahrixon–Asaka pair (Cs = 0.76**)** and the Boz–Marhamat pair **(**Cs = 0.74), as these sampling sites belong to the same river system. The lowest similarity was recorded between Buloqboshi and Oltinkol **(**Cs = 0.48**),** reflecting the contrasting ecological conditions of a mountain stream and a lowland irrigation canal[11].

During the flood period, 15 dominant diatom species were identified across all sampling stations. These species accounted for 78.3% of the total phytoplankton biomass.

Table 4.
Dominant diatom species during the flood period (Cos – centric; Bac – pennate).

No.	Species	Occurrence Frequency (%)	Mean Density (cells/L)	Saprobity Group	Class
1	*Aulacoseira granulata* (Ehrenb.) Simonsen	94.4	24,600	β-mesosaprobic	Cos
2	*Cyclotella meneghiniana* Kütz.	91.7	18,200	β–α-mesosaprobic	Cos
3	*Fragilaria crotonensis* Kitton	88.9	16,800	oligo-β-mesosaprobic	Bac
4	*Navicula gregaria* Donkin	86.1	14,200	β-mesosaprobic	Bac
5	*Nitzschia acicularis* (Kütz.) W. Sm.	83.3	12,400	α-mesosaprobic	Bac
6	*Stephanodiscus hantzschii* Grun.	80.6	11,600	β–α-mesosaprobic	Cos
7	*Diatoma vulgaris* Bory	77.8	9,800	β-mesosaprobic	Bac
8	*Navicula cryptocephala* Kütz.	75.0	8,600	β-mesosaprobic	Bac
9	*Nitzschia palea* (Kütz.) W. Sm.	72.2	7,400	α-mesosaprobic	Bac
10	*Fragilaria ulna* (Nitzsch) Lange-Bert.	69.4	6,800	β-mesosaprobic	Bac
11	*Gomphonema olivaceum* (Hornemann) Bréb.	66.7	5,600	oligo-β-mesosaprobic	Bac
12	*Cymbella affinis* Kütz.	63.9	4,800	oligosaprobic	Bac
13	*Achnanthidium minutissimum* (Kütz.) Czarn.	61.1	4,200	oligosaprobic	Bac
14	*Pinnularia viridis* (Nitzsch) Ehrenb.	58.3	3,600	oligosaprobic	Bac
15	*Amphora ovalis* (Kütz.) Kütz.	55.6	3,200	oligo-β-mesosaprobic	Bac

Aulacoseira granulata (Ehrenb.) Simonsen was the most widespread species in the region, occurring at 94.4% of the sampling stations. In the reservoir, its dominance resulted in a mean cell density of 24,600 cells/L at two sampling stations. This species is a typical indicator of mesotrophic conditions and has also been reported as a dominant taxon in the Zarafshan River. *Cyclotella meneghiniana* Kütz. and *Stephanodiscus hantzschii* Grun. exhibited higher abundances at relatively polluted and eutrophic sampling stations[12].

Species such as *Nitzschia acicularis* and *Nitzschia palea* belong to the α-mesosaprobic group and were dominant mainly at sampling stations in Oltinkol, Pakhtaabad, and Marhamat districts that are influenced by agricultural drainage waters. These species are well known for their tolerance to high organic and mineral nitrogen loads. In contrast, Achnanthidium minutissimum, Pinnularia viridis, *and* Cymbella affinis predominated in the Buloqboshi, Jalakuduk, and Ulugnor districts, where water quality was considerably higher[13].

According to the Sládeček Saprobity Index**,** the calculated SLA values ranged from 1.7 to 2.4 across all sampling stations in the region. These values allowed the water quality to be classified into the following categories:

Table 5.
Classification of Aquatic Ecosystems in Andijan Region According to the Saprobity Index

SLA Range	Saprobity Class	Water Quality Category	Districts
1.7–1.9	β-mesosaprobic	Class II (Good)	Jalakuduk, Ulugnor, Buloqboshi
2.0–2.2	β-mesosaprobic	Class II–III (Moderate)	Shahrixon, Asaka, Baliqchi, Khanabad, Qorasuv, Kurgontepa
2.3–2.4	β–α-mesosaprobic	Class III (Satisfactory)	Boz, Oltinkol, Izboskan, Marhamat, Pakhtaabad

Bioindication results showed that the aquatic ecosystems located in the mountainous and less polluted areas of Jalakuduk, Ulugnor, and Buloqboshi corresponded to Class II water quality, indicating conditions suitable for drinking water supply and fisheries. In contrast, the central and southern districts of the region (Oltinkol and Pakhtaabad) were classified as Class III, where eutrophication processes associated with intensive agricultural irrigation activities were more pronounced. Similar patterns have also been reported for the Zarafshan River, where salinity and pollution levels increase toward the downstream sections[14].

During the flood period (March–May), diatom plankton density exhibited a progressive increase. The mean cell density rose from 34,600 cells/L in March to 87,400 cells/L in April, reaching 148,200 cells/L in May. Species diversity also increased, with the Shannon–Wiener index (H′) rising from 2.34 in March to 3.12 in May. This seasonal pattern was associated with an increase in the average water temperature from 9.2°C in March to 18.6°C in May. Centric diatoms (Aulacoseira, Cyclotella, and Stephanodiscus) predominated during March–April, whereas pennate diatoms (Navicula, Nitzschia, and Fragilaria) became dominant during April–May[15].

Conclusion

In this study, 540 plankton samples collected from 18 sampling stations across the 14 districts of Andijan Region were analyzed. A total of 147 species, 38 genera, 22 families, and 4 orders of diatoms were identified, with pennate diatoms (85.7%) being predominant. The highest species diversity was recorded in Jalakuduk District (H′ = 3.84), whereas the lowest was observed in Oltinkol District (H′ = 2.12). Aulacoseira granulata was the most widespread species, occurring at 94.4% of the sampling stations. According to the Sládeček Saprobity Index, water quality ranged from Class II to Class III (SLA = 1.7–2.4). Diatom cell density increased from 34,600 cells/L in March to 148,200 cells/L in May. The obtained results demonstrate that diatom plankton can be effectively used as reliable bioindicators for assessing the ecological status of aquatic ecosystems.

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