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Biodiversity of Diatoms as Indicators of Water Quality and Landscape Sustainable Dynamics in the Zarafshan River, Uzbekistan

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Abstract: For the first time, we have compiled a general list of diatoms for the Zarafshan River consisting of 428 species based on our own research and the literature data. Indicator species for nine water parameters were identified, making up more than 90% of the list. Bioindicators and statistical methods revealed that sections of the river around the city of Samarkand and further in the middle reaches reflect the complexity of the impact of the environment on diatom communities. The surveyed sections of the middle reaches of the river are divided into branches and the dynamics of water parameters and diatom communities are shown from the border with Tajikistan to the confluence of the Zarafshan with the Amu Darya. The indices of organic pollution, S, and toxic impact, WESI, were calculated. They show that there is an increase in salinity and turbidity and a decrease in organic pollution downriver. At the same time, the Navoi section is a source of water acidification. Nutrients and heavy metals, as well as phenol pollution, enter the river from various sources, mainly in the middle reaches of the river. The Zarafshan Nature Reserve in the catchment area of the upper section of the river within Uzbekistan is important for maintaining water quality. Bioindicators show an increase in self-purification, with an increase in the species richness and abundance of diatoms in the middle section of the Zarafshan River. The integrated index of river pollution, RPI, shows that most pollution comes from the northern canal of the river in the middle reaches. A general look at the Zarafshan River catchment basin and the dynamics of the identified water parameters and bioindicator species of diatoms shows that the river ecosystem successfully copes with incoming pollution, including transboundary impacts from Tajikistan. Such a conclusion could not be made based on chemical analysis of the water alone. This allowed us to recommend expanding state monitoring points to the lower section of Karakul while including biological indicators in the observations.

Keywords: diatoms; bioindicators; water quality; landscape impact; pollution indices; transboundary effects; Zarafshan River; Uzbekistan

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1. Introduction

Of great importance in the life of aquatic organisms, including algae, is the nature of the trophic state, the altitude above sea level, the types of soil or rocks, and other factors that determine the degree of water transparency, its temperature, the quantity and qualitative composition of the salts dissolved in it, and some other ecological features that are vital for the aquatic ecosystems [1].

Much attention is paid in the world to monitoring the state of large aquatic ecosystems, assessing the level of transformation of biota under the influence of strong anthropogenic and technogenic influence. The main waterways of Central Asia are the Syr Darya, Amu Darya, Zarafshan, Chirchik, Talas, Chu, and Murgob, the waters of which have been used for irrigation of cultivated fields since time immemorial. For this purpose, various

irrigation and drainage canals, reservoirs, etc., were created [1]. Thus, water resources in the semi-desert and desert climate zone are vital, supporting the existence and economy of the countries of the region. It should be noted that almost all mountain water bodies (including the Zarafshan River), are basically fed by snow. Rain plays an insignificant role in this regard [2]. However, this resource replenishes the river mainly in its upper reaches, outside of Uzbekistan. In transboundary rivers, water flows from different geographic regions and the widespread use of water resources in agriculture and other economic sectors lead to changes in aquatic organism communities [3].

Water quality is a critical variable in conditions of limited water resources [4]. For Uzbekistan, such a main waterway is the Zarafshan River. This is the only river flowing through the entire territory of the country, supporting its economy, population, economy, and biodiversity. The upper part of the river's catchment area is located outside the country, so the river is transboundary [5].

In most cases, population growth in the areas of large rivers, an increase in the number of livestock, and wastewater discharge lead to radical changes in river algal flora and the formation of new species in the basin flora [6]. Excessive input of nutrients such as nitrogen and phosphorus into rivers can have significant impacts on benthic algal communities [7]. In mountain streams, diatoms are the most abundant and diverse taxonomic group in benthic algal communities [8].

Diatoms are increasingly used to assess short-term and long-term environmental changes because they are informative, versatile, flexible, and powerful environmental indicators, as they respond rapidly to changes in many environmental factors [9,10]. Thus, through having data on the diversity of diatoms in a river, one can discuss changes in water quality and sources of its pollution. Moreover, the experience of ecological mapping of chemical pollution parameters and toxicity indices, as was performed for the Arys River basin in the nearby region of Kazakhstan [11], opens up opportunities for linking data to the landscape and allows for the identification of critical areas in the river catchment basin.

An analysis of the literature data on the diversity of diatoms in the Zarafshan River showed that a generalized assessment of its ecological state in terms of algal diversity has not yet been carried out. However, some fragmentary data are known. In previous years, the hydrochemical indicators and composition of periphyton algae in the Zarafshan River were given separately for the upper, middle, and lower parts of the river [12]. Several other publications are devoted to the study of the diversity of algae, including diatoms, in the rivers and reservoirs of Uzbekistan located in the catchment area of the Zarafshan River. While some references do not provide a link to a specific collection site [13,14] and were published about a hundred years ago in Russian, they may have only historical value. Others, published in Russian and in the form of abstracts [15–17], were included in the general reference [18] that was used by us as one of the sources of the biodiversity data within the following published paper [19]. A short analysis of the middle part of the river diatom flora was presented in [20]. The hydrochemical data on the section of the Zarafshan River that interests us are discussed separately in the work of Kulmatov et al. [21].

The aim of our study was a comprehensive assessment of the ecological state of the Zarafshan River, which is an environment-forming river for Uzbekistan, based on the species composition of diatoms and environmental indicators using statistical methods and bioindication in the conditions of a transboundary river in a semi-desert climate. Ecological mapping of the quality of river waters for organic and toxic pollution will link the chemical and biological data of the study to the landscape of the transboundary river.

2. Materials and Methods

2.1. Description of Study Site

The Zarafshan River originates at the junction of three mountain systems—the Turkestan, Zarafshan, and Gissar (Alai) ranges from the Zarafshan glacier at an altitude of about 5000 m outside of Uzbekistan. Zarafshan Valley is the largest intermountain depression in Central Asia. Its length is about 877 km [22].

The initial section of the current, about 300 km long, runs in a narrow and deep valley between the Turkestan (in the north) and Zarafshan (in the south) ranges (Figure 1). From the left southern side, it receives significant tributaries—the Fandarya, Kshtutdarya, and Magiandarya. The average annual water flow in this section fluctuates between 58–108 m^3/s. The water level is high in July and August, and low in April [22].

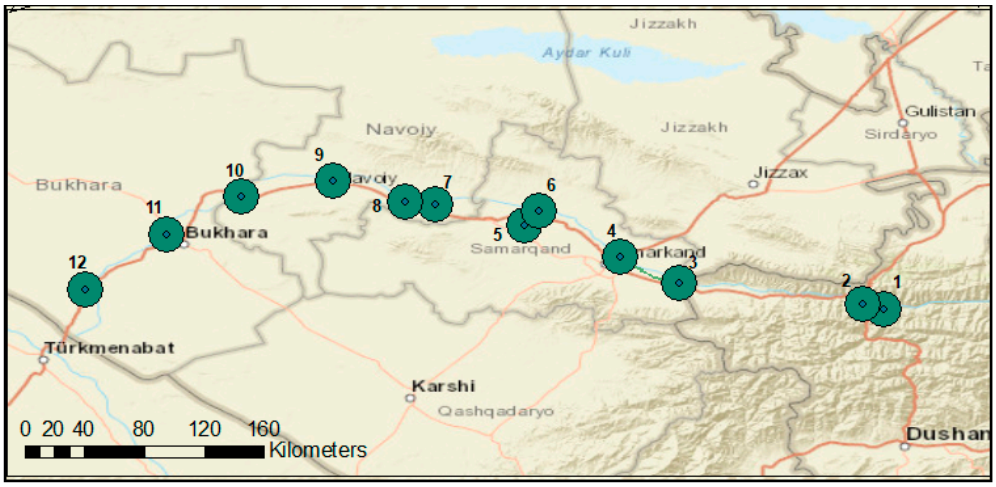


Figure 1. Sampling stations over the Zarafshan River; numbers are described in Table 1.

Table 1. Sampling sites, river part, code, coordinates, altitude, and distance from the Tajikistan border of the Zarafshan River.

Site	No.	River Part	Code	North	East	Altitude, m a.s.l.	Distance, km
Fandarya	1	Upper	Fan	39°23′2.91″	68°38′32.02″	1455	0
Upper Zeravschan	2	Upper	Up-Zer	39°25′1.48″	68°30′56.40″	1403	21
Pervomayskaya plotina	3	Middle	P-mays	39°32′16.87″	67°24′36.43″	880	188
Upper Choponata	4	Middle	Up-Chop	39°41′40.29″	67° 3′14.25″	702	38
Akdarya	5	Middle	Akda	39°53′20.18″	66°28′30.56″	522	62
Karadarya	6	Middle	Kara	39°58′26.02″	66°33′46.88″	523	55.5
Khatirchi	7	Lower	Khat	40°0′47.40″	65°56′34.06″	427	52.3
Pakhtakor	8	Lower	Pakh	40°1′59.89″	65°45′42.50″	396	32.11
Navoi	9	Lower	Navo	40°9′32.56″	65°19′47.08″	330	34.35
Gizhduvon	10	Lower	Gizh	40°3′48.40″	64°46′26.15″	277	54.74
Bukhara	11	Lower	Bukh	39°49′57.97″	64°19′38.60″	214	48.47
Karakul	12	Lower	Kara	39°29′53.98″	63°49′58.58″	197	63.12

The Zarafshan River, after merging with Magiandarya, passes through the territory of Tajikistan to the west to Penjikent and turns to the northwest into the territory of Uzbekistan (Figure 1). Below Penjikent, on the territory of Uzbekistan, a flat section of the course begins, where not one single significant tributary flows into the Zarafshan until the end of the river [22].

In Uzbekistan, the upper part of the riverbed has a high biodiversity, which is protected by the IUCN reserve. The Zarafshan State Reserve (Figure 1) was established in 1975 in the Samarkand region on the right bank of the Zarafshan River, 15 km from the city of Samarkand, at an altitude of 600 to 900 m above sea level. Its area is 2352 hectares, including a small area covered by forest of 868 hectares. The territory of the reserve extends for 35 km along the riverbank with a width of 150 m to 1400 m. Its main objective is to preserve, study, and restore the natural environment of forest plants and animals as well as the gene pool of rare and endangered plants and animals. The climatic conditions of the reserve are typical of the continental subtropics. The air temperature in summer reaches +4 °C, and in winter it drops to −27 °C. The average annual precipitation is 100–400 mm. The

flora consists of trees, shrubs, and herbs such as poplar, willow, cypress, and chakanda. The reserve is home to 266 plant species, 172 bird species, and 8 fish species. The reserve protects the golden pheasant, and cage breeding has been studied. Since 2016, work has been underway in the reserve to acclimatize six Bukhara deer, and the work to breed this unique animal is being continued [23].

Further downstream, the riverbed is flat, has virtually no catchment area, and is constantly changing and anastomosing. Sampling points cover all three parts of the river on the territory of Uzbekistan (Table 1). As can be seen from the table, the altitude of sampling points in the upper part of the river is significantly higher and refers to its mountainous section. The other points are much lower, and the drop in altitude occurs smoothly, starting from the city of Samarkand to the confluence of the river with the Amu Darya River. In the middle part of the riverbed, the Zarafshan River divides into two approximately equal streams at stations 5 and 6, then reuniting into one river at station 7.

2.2. Material

For a full-scale analysis of the dynamics of diversity and assessment of water quality in the Zarafshan River, hydrochemical data from 7 of the 12 stations from UzHYDROMET (Hydrometeorological Service Center (Uzgidromet) under the Cabinet of Ministers of the Republic of Uzbekistan) [24] were used, as well as data from previously conducted studies of algae diversity by the authors and other researchers.

For stations 1 and 2 of the upper reaches of the Zarafshan River, the data on diatoms published by A.M. Muzafarov [1] were used, and only 233 taxa identified in the riverbed were selected from the list, excluding lakes and other water bodies.

In the middle reaches of the Zarafshan River basin at stations 3–6, the diversity of diatoms was studied by J. Toshpulatov together with K. Alimjanova in 2005–2011 and amounted to 218 species from 81 samples [15,18]. Diatoms in the lower reaches of the Zarafshan River were studied at stations 7–12 [19] during 2009–2015 in relation to pollutant influx and water quality, and 198 species were identified from 195 samples. Both series of sampling in the four seasons and species definition were performed under the supervision of K. Alimjanova in 2005–2019 and published in detail in [15,18,19]. Diatom samples were collected throughout the river within the borders of Uzbekistan at 12 sampling stations. Periphyton was collected by scraping with a scalpel or knife from underwater substrates, aquatic vegetation, or dead plant substrate at a depth of 0 to 50 cm along the riverbanks from an area of 10 cm^2. Benthos samples were collected from the river bottom using improvised means. Samples were fixed in 4% neutral formaldehyde and transported to the lab in an icebox.

All these data on water chemistry and diatom diversity were combined by us into a database for this work. A list of species was compiled for each of the 12 stations. As a result, we have a set of hydrochemical data from state monitoring stations (2–7, 9) for analysis, as well as a set of biological data from stations 1–12, which we collected not only at state monitoring stations, but also in the upper reaches of the river near the border with Tajikistan, in the intervals between hydrochemical stations, and in the lower reaches of the river. Thus, biological data cover the river with a denser and more continuous network of monitoring stations.

The modern taxonomic names were updated with the help of algaebase.org [25]. The abundance of cells of each revealed species in each station community was assessed as scores from 1 to 6 according to a semi-quantitative method [26]. Index saprobity, S, was calculated according to each indicator species abundance and its species-specific value [27,28].

2.3. Methods

Bioindication properties of each identified species are taken from our collected database [28,29]. Bioindicator analysis was performed with species-specific ecological preferences of revealed taxa classified according to indicator systems [29,30]. Hydrochemi-

cal variables were classified from an ecological point of view [31]. Both hydrochemical and biological data were analyzed with the following statistical programs. Similarity trees were performed using the BioDiversity Pro 2.0 program [32]. The correlation network analyses were performed in JASP (Jeffreys's Amazing Statistics Program) on the botnet package in R Statistica [33]. The heat map was constructed in the ExStartR program [34].

Calculation of the Water Ecosystem State Index (WESI) was performed for definition of the environmental impact to the diatom communities on each sampling station [31] as a function of the classification rank of Index S and rank N-NO_3.

$$\text{Index WESI} = \text{rank of Index S}/\text{rank N-}NO_3$$

where Rank S is the rank of water quality according to the range of Sládeček's saprobity indices [27] calculated for the sampling site; Rank N-NO_3 is the rank of water quality according to the range of nitric nitrogen concentration [28,31].

The index values vary from 0 to 9. If WESI is more than one, the aquatic ecosystem stayed in good condition, whereas for affected communities exposed to toxic pollution inhibiting photosynthesis, WESI is below one.

The integral River Pollution Index (RPI), according to Sumita [35], was calculated for chemical and biological data in the sampling sites and the distance between them (Table 1) according to equation:

$$RPId = \frac{\sum_1^n (Di + Dj) \times l}{2L}$$

where Di, Dj are the variable values of entire format units for the adjacent sites i, j; l is the distance between two adjacent sites (km); and L is the total river length.

3. Results

3.1. Physicochemical Properties of the Zarafshan River Water

Averaged chemical variables over stations 2–7 and 9, defined by [24] for the period of 2009–2015 in the Zarafshan River, are represented in Appendix A Table A1. Appendix A Table A1 shows that the amplitude of fluctuations in the values of the main environmental variables remains relatively constant throughout the year, as indicated by the value of the standard deviation. The value of pesticides was minimal. However, the pollution variables Total Suspended Solids (TSS), Total Dissolved Solids (TDS), and Chemical Oxygen Demand (COD) varied widely in years of monitoring.

The most important thing in this study is to consider changes in the indicators of the environment at the river stations. Even though not all the stations that we examined were represented in the monitoring system, there is still data for each of the three sections of the river. Figure 2 shows the change in the main indicators at the river stations. It is evident that all the stations in the upper and middle reaches of the river have similar and low indicators, whereas starting from station 6 their values increase significantly, excluding oxygen, which in contrast decreases.

We examined separately the dynamics of the macro indicators in Figure 3. COD, TSS, and TDS are critical variables because their values are dramatically changed down the river. The values of mineral pollution increased significantly, several times, starting from station 6, which belongs to the northern branch of the middle reaches of the river.

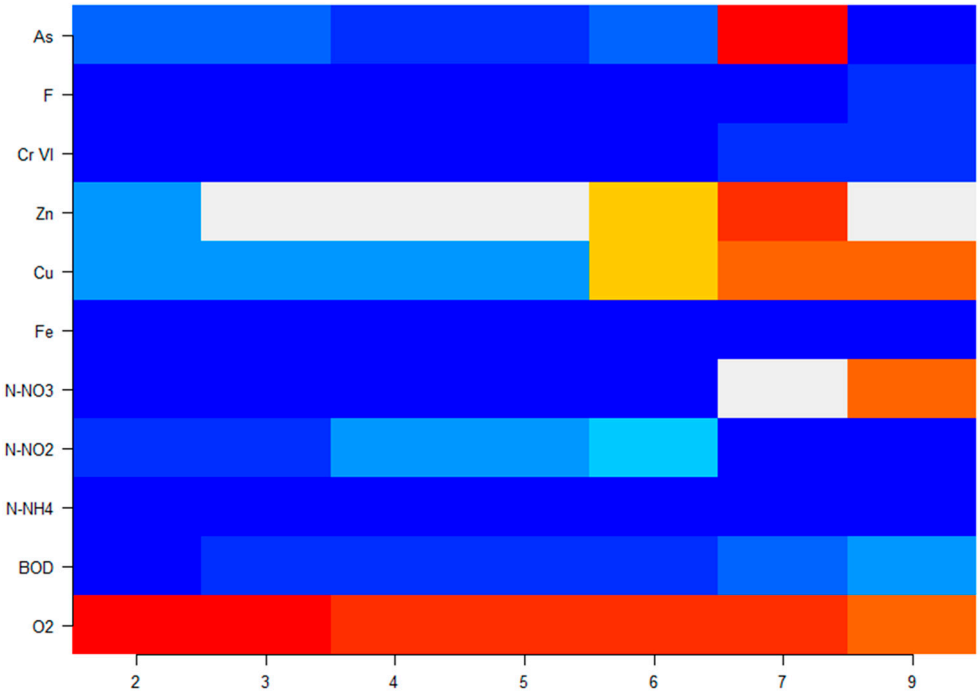


Figure 2. Comparative heat map of chemical variable distribution over sampling stations in the Zarafshan River, Abbreviations in the y-axis and station numbers in the x-axis are the same as in Table 1. The color of the cells changes from blue to red depending on the magnitude of the value of each variable in the amplitude of the values of all variables.

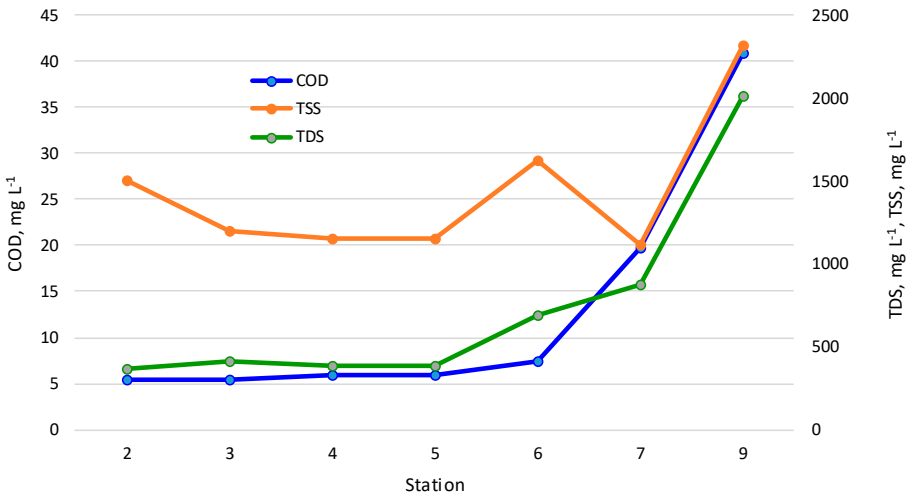


Figure 3. Distribution of critical chemical variables over sampling stations in the Zarafshan River.

3.2. Biological Characteristics of the Zarafshan River

The diversity of diatoms in the Zarafshan River, which crosses the entire territory of Uzbekistan, amounted to 428 species (Appendix A Table A2). The diatom species distribution over the sampling stations shows the greatest species richness from 96 to 109 at stations 1, 11, and 12. Here, as well as at stations 5–7 and 9, the abundance of algae in the communities was also the greatest. Despite significant fluctuations in the species composition of diatom communities at the river stations, the species richness in the river sections remains approximately the same: upper—185 species, middle—200 species, and lower—194 species (Appendix A Table A2). The most abundant species in the upper part were *Diploneis ovalis* and *Odontidium hyemale* that were presented across all stations of the part. The middle part communities were dominated by *Diatoma vulgaris* across

most of the sampled stations. In the lower part stations, *Navicula rostellata* prevailed in most communities.

Figure 4 shows comparative fluctuations in the variables of the biotic part of the Zarafshan River ecosystem. The smallest number of species was at station 4, and it was also low at stations 8 and 10. The trend line for this species distribution sags in the middle part of the river, showing a vulnerable area. Despite significant variability in the abundance of diatoms in communities, the trend line shows a significant increase in abundance towards the mouth of the river. At the same time, the saprobity index, S, varied within the 2 and 3 water quality classes, and its trend had a slight increase in the middle of the river.

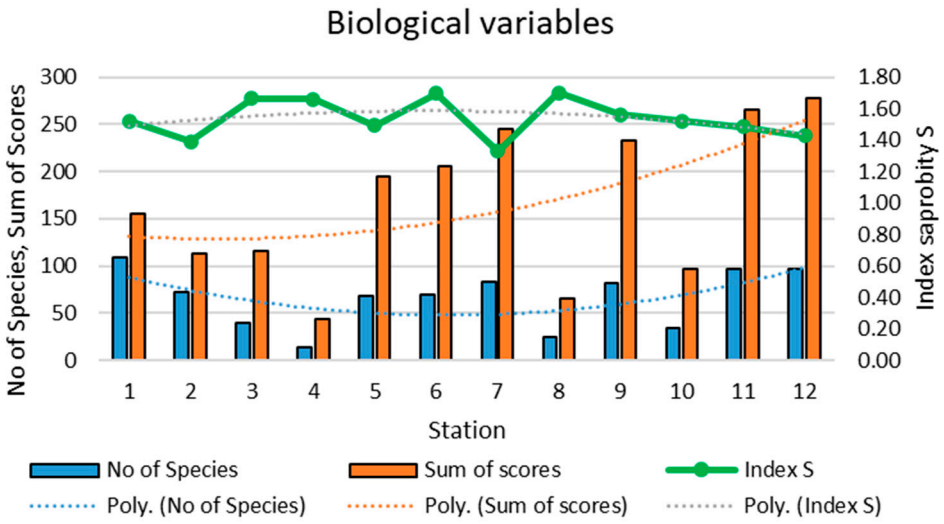


Figure 4. Distribution of biological variables: species number, sum of scores, and Index saprobity, S, over sampling stations in the Zarafshan River. Poly. Is the polynomial trend line.

3.3. Bioindicators

Based on the database of identified species and their ecological preferences (Appendix A Tables A2 and A3), indicator taxa of diatoms were determined at 12 stations of the Zarafshan River. Diatom indicator species were grouped by three sections of the river according to nine groups of bioindicators (Figure 5). The proportion of benthic species increased downstream of the river (Figure 5a). Water temperature indicators showed water warming in the lower third of the river (Figure 5b). The proportion of slightly acidic and neutral water indicators increased noticeably, and the proportion of alkaliphiles increased (Figure 5c). A slight increase in the proportion of stagnant water species towards the river mouth corresponded to a decrease in water oxygen saturation (Figure 5d). The trend towards water salinization downstream was reflected by chloride indicators, with an increase in mesohalobes in the lower third of the river (Figure 5e). At the same time, the indicators of organic pollution of waters according to Watanabe [36] (diatoms only) showed a noticeable increase in the proportion of saproxenes, inhabitants of water unpolluted by organics, in the lower third of the river (Figure 5f). The indicators of the type of nutrition were 80–85% represented by autotrophs, but in the second and third parts of the river mixotrophs (hne, hce) appeared in the communities, the development of which is not hindered by the presence of toxicants (Figure 5g). A noticeable increase in the proportion of oligotrophy indicators downstream of the river shows a decrease in the trophicity of its ecosystems (Figure 5h).

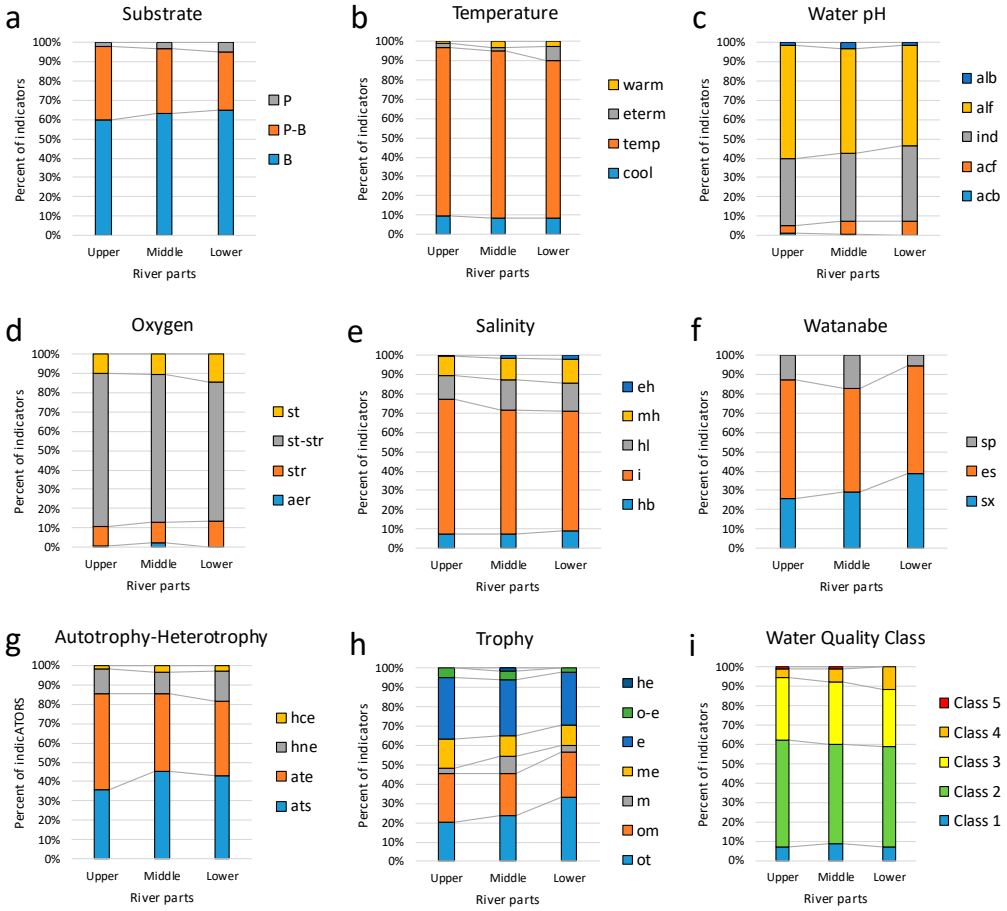


Figure 5. Distribution of bioindicators over the upper, middle, and lower parts of the Zarafshan River. Abbreviation for ecological groups: Substrate preferences (**a**): B, benthic; P-B, planktonic-benthic; P, planktonic. Water temperature (**b**): cool, cool-loving species; temp, temperate temperature water inhabitants; eterm, eurythermic species; warm, warm water inhabitants. Water pH (**c**): acb, acidobiontic species; acf, acidophilic species; ind, indifferent species; alf, alkaliphilic species; alb, alkalibiontic species. Oxygen (**d**): aer, aerophiles; str, streaming waters inhabitant; st-str, low streaming waters inhabitant; st, standing water inhabitant. Water salinity (**e**): hb, halophobe; i, oligohalobious-indifferent; hl, oligohalobious-halophilous; mh, mesohalobious; eh, euhalobous. Organic pollution, Watanabe (**f**): sx, saproxenes; es, eurysaprobes; sp, saprophiles. Autotrophy-Heterotrophy, Nutrition type as Nitrogen uptake metabolism (**g**): ats, nitrogen-autotrophic taxa, tolerating very small concentrations of organically bound nitrogen; ate, nitrogen-autotrophic taxa, tolerating elevated concentrations of organically bound nitrogen; hne, facultatively nitrogen-heterotrophic taxa, needing periodically elevated concentrations of organically bound nitrogen; hce, nitrogen-heterotrophic taxa, needing elevated concentrations of organically bound nitrogen. Trophic state (**h**): ot, oligotrafentic; o-m, oligo-mesotraphentic; m, mesotraphentic; me, meso-eutraphentic; e, eutraphentic; o-e, oligo- to eutraphentic; he, hypereutraphentic. Water quality class of organic pollution according to species-specific index saprobity S of Sládeček (**i**).

3.4. Species Environment Relationships

Figures 6–8 were constructed to compare the importance of chemical, biological, and combined data results at the same set of stations. It was the limited set of stations where chemical data were available that determined the order of data selection for all three plots. Therefore, statistical comparison of the data was performed using three combinations based on Appendix A Table A3. To construct the similarity tree in Figure 6, only hydrochemical environmental parameters (Appendix A Table A1) were selected, which were available for seven stations only. It is evident that significant similarity was observed only for the upper stations from 1 to the southern channel of station 5.

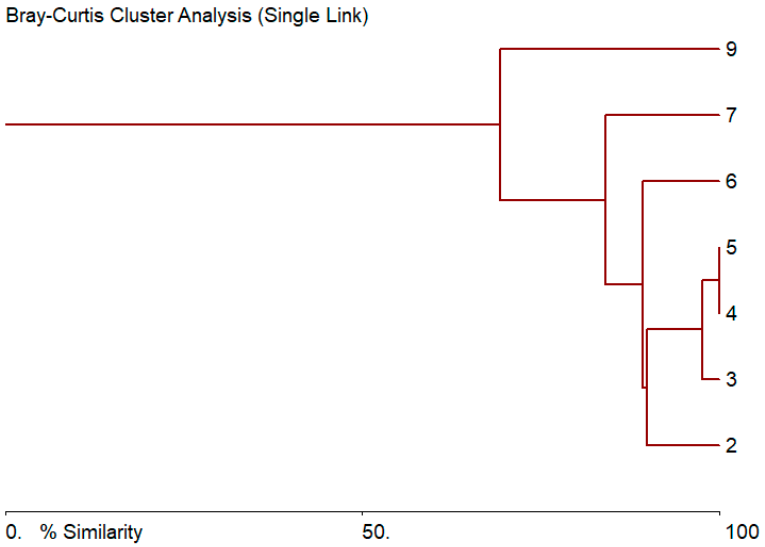


Figure 6. Bray–Curtis tree of similarity for chemical variables in sampling stations 2–9 of the Zarafshan River.

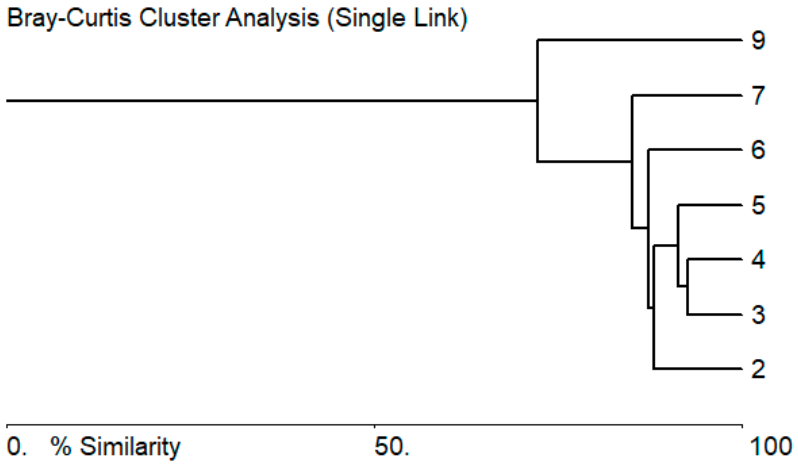


Figure 7. Bray–Curtis tree of similarity for chemical variables and bioindicators in sampling stations 2–9 of the Zarafshan River.

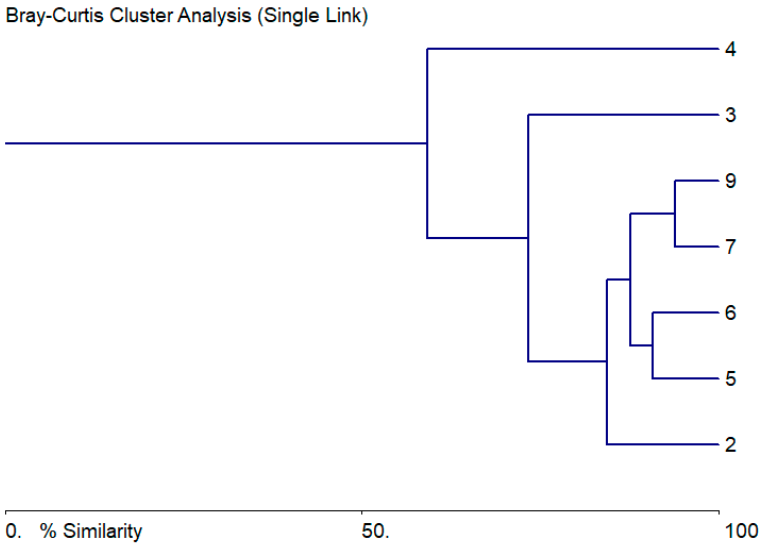


Figure 8. Bray–Curtis similarity tree of bioindicators in sampling stations 2–9 of the Zarafshan River.

The tree in Figure 7 included, in addition to Appendix A Table A1 data, also bioindicator parameters (Appendix A Table A3), but for the same seven stations. The similarity of the constructed Figures 6 and 7 is obvious, indicating the predominance of chemical data in the assessments. Figure 8 is constructed using bioindicator data only, but for the same seven stations. A significant similarity of bioindicators is observed for stations 2, 5, 6, 8 and 9, while the data from stations 3 and 4 fall into separate branches. Stations 3 and 4 belong to the Samarkand region. This shows the importance of more detailed assessments of the bioindicators separately, but for the entire data set over all studied stations (Appendix A Table A3). Therefore, we continue the data comparison with other statistics. For a detailed analysis of the links between biodiversity and chemical data, graphs were constructed in the JASP program.

A statistical comparison of chemical and bioindicator variable values with JASP at seven stations of the Zarafshan River showed that the river can be divided into two sections (Figure 9). Cluster 1 combines the values at the stations of the upper and middle sections, while cluster 2 includes only the stations of the lower section of the river.

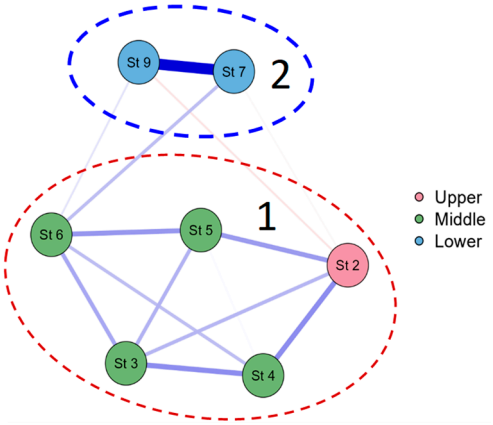


Figure 9. JASP Network plot of correlation on the level greater than 50% for chemical and bioindicator variable values for seven stations (St.) of the Zarafshan River. The line thickness between stations reflects the correlation value (only significant results are represented); blue is positive, red is negative. Clusters 1 and 2 are outlined by color dashed lines.

However, if all river stations for which data are available (St. 1–St. 12) are included in the analysis, then only biological indicators form the basis for the analysis. The JASP Network plot (Figure 10) groups biological data into two clusters. Cluster 1 includes the upstream stations and two middle-section stations 5 and 6, located on two parallel branches of the river. The remaining stations are united by cluster 2, which includes all the stations of the downstream section of the river plus two stations 3 and 4, related to the middle course of the river. Thus, the communities at stations 3 and 4, as well as 5 and 6, reflect the complexity of the impact of the environment around the city of Samarkand.

3.5. Integral Indices of Water Toxicity (WESI) and River Pollution (RPI)

Based on the available chemical and biological data, the WESI was calculated, showing the inhibition of photosynthesis in the studied communities at the river stations. The index was calculated considering that the river is divided into two branches and flows in one branch through station 5 and in the second branch through station 6, then merges. This is why in Figure 11, the index data are separate for stations 5 and 6. Figure 11 shows that the communities at the lower reaches of the river stations 7 and 9 were inhibited, since the index was less than one. The remaining communities vegetated successfully, but at station 5 of the northern branch of the river they experienced some toxic effect, which was higher than at station 6.

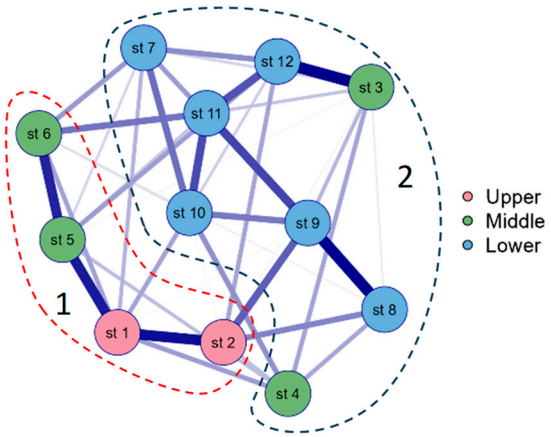


Figure 10. JASP Network plot of correlation on the level greater than 50% for bioindicator variable values only for twelve stations (St.) of the Zarafshan River. The line thickness between stations reflects the correlation value (only significant results are represented); blue is positive, red is negative. Clusters 1 and 2 are outlined by color dashed lines.

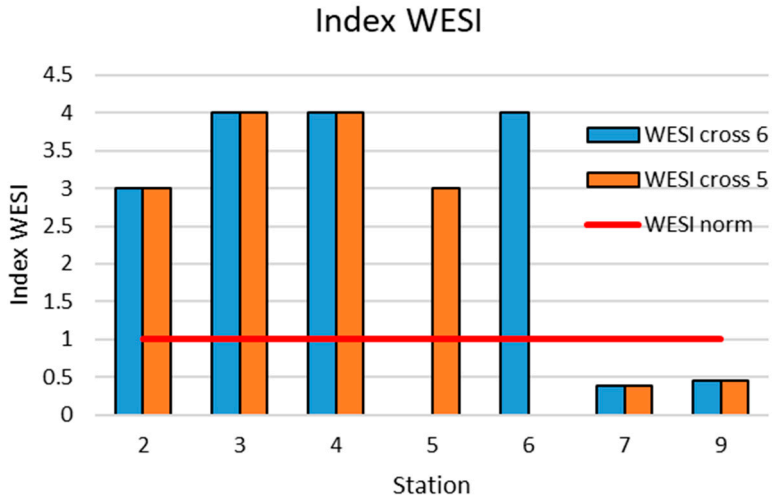


Figure 11. Index toxicity (WESI) distribution over sampling stations 2–9 in the Zarafshan River. The dynamics of the WESI values can be traced along the entire river through the southern branch cross station 5 with the orange color and through the northern branch cross station 6 with the blue color.

Although the toxic heavy metal pollution is particularly high at the river headwaters at station 2 and then at the end of the riverbed at stations 7 and 9, the toxic organic pollution fluctuates significantly depending on the source (Appendix A Table A1). The fluctuation of pesticides Alpha-HCH (Hexachlorocyclohexane) and DDT (dichlorodiphenyl-trichloroethane) is particularly noticeable, with its highest concentration at the river headwaters at station 2 and then repeated at stations 4, 5, and 7, where the drainage channels flow in. At the same time, the pollution caused by dissolved organic matter is not as high. The calculated saprobity indices, S, characterize the studied sections of the river according to water quality class from 2 to 3. Based on these data, we compiled a map of organic pollution class and accordingly colored not only the riverbed but also the section of the catchment basin related to each station. Figure 12a shows that organically enriched waters of Class 3 come from the out-border area of the Zarafshan River. Stations of the upper (3, 4, and 6) as well as the middle parts of the river (8, 9, and 10) were also marked as Class 3 in terms of water quality. All other parts of the river basin contain low organic matter in its water. We did not reveal any stations with waters of Classes 4 and 5. At the same time, the map of WESI distribution over the river (Figure 12b) takes attention to the middle part of the basin with stations 7, 8, and 9. This is part of the river basin with a

narrow catchment area but is very enriched by settlements and saturated with enterprises discharging wastewater from processes with heavy metals. Both these maps show that the toxic effect in the middle part of the Zarafshan River landscape is due to the influence of metal discharges, but not organic pollution. Overall, the river has a high potential for self-purification, as can be seen on the maps in Figure 12, where the downstream stations already contain higher-quality non-toxic water.

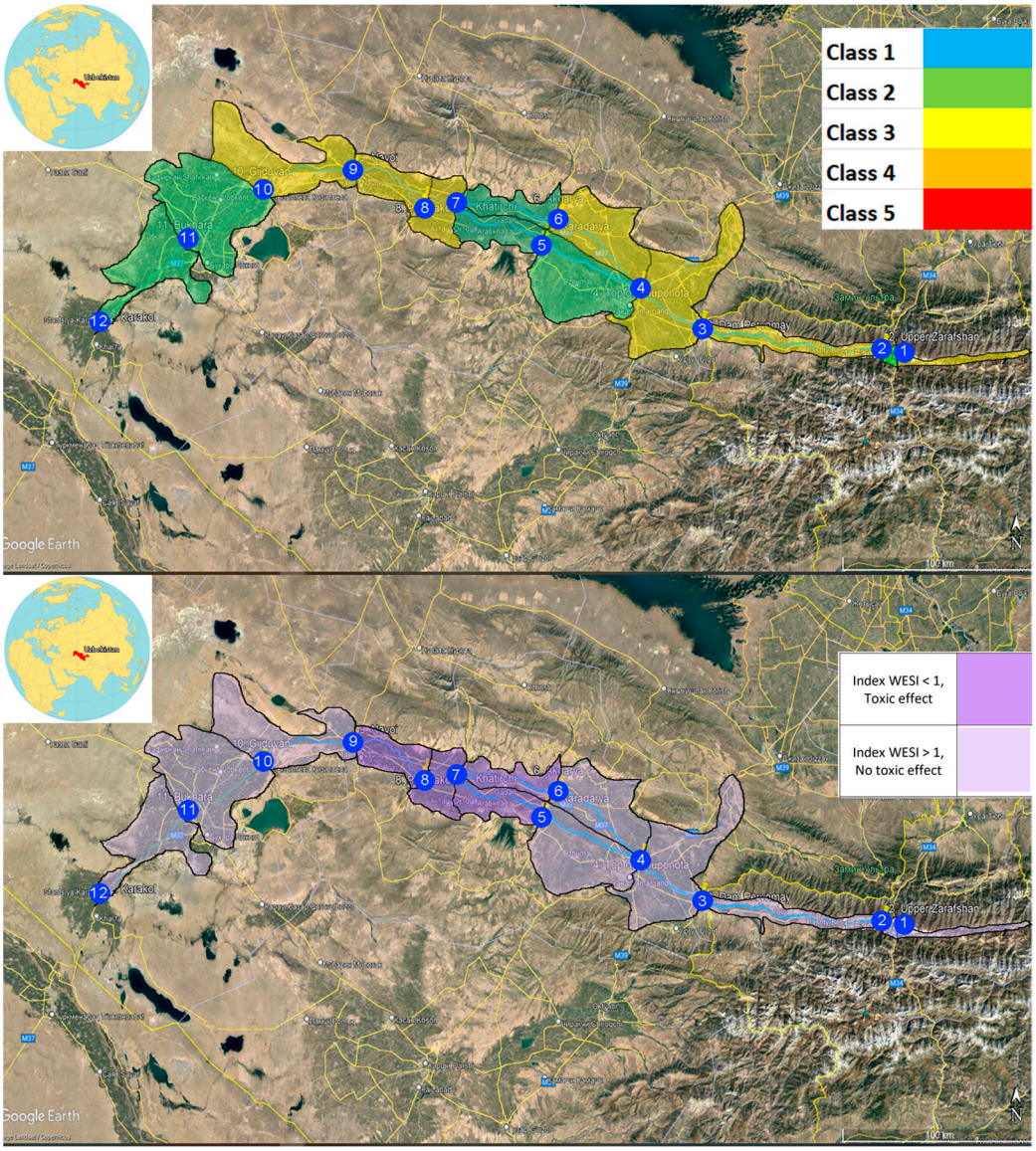


Figure 12. Distribution of Water Quality Class in organic pollution (**a**) and Index WESI (**b**) over sampling stations and catchment basin areas in the Zarafshan River.

The integrated index of river pollution, RPI, was calculated based on the available chemical and biological data, also considering the division of the river into two branches with stations 5 and 6. Table 2 shows in bold the index values for the river parameters passing through station 6, which exceed those for the southern branch of the river passing through station 5. The greatest difference in the RPI indices was observed for TSS and TDS. Apparently, the excesses of the index for zinc, copper, phenols, fluorine, and detergents are associated with the influx of turbid and salted waters. The excesses of nitrites and COD indicate that the northern branch of the river is actively decomposing the influx of both organic and mineral pollutants. However, the relatively close values of the index for the abundance and number of species in both streams passing through the northern and

southern branches of the river indicated that, in general, the river ecosystem successfully copes with the pollution entering the northern branch and the impact is leveled out.

Table 2. River pollution index (RPI) for environmental and biological variables crosses two different channels of the Zarafshan River.

Variable	RPI Cross 5 Average	RPI Cross 6 Average
km	479.7	469.1
O_2 mg L^{-1}	7.40	7.77
BOD, mgO L^{-1}	1.10	1.11
COD, mgO L^{-1}	7.54	**8.01**
N-NH_4, mg L^{-1}	0.05	**0.06**
N-NO_2, mg L^{-1}	0.55	**0.90**
N-NO_3, mg L^{-1}	0.95	0.96
Fe, mg L^{-1}	0.02	0.02
Cu, mcg L^{-1}	2.84	**3.30**
Zn, mcg L^{-1}	2.96	**3.29**
Phenols, mg L^{-1}	0.002	**0.003**
Oil, mg L^{-1}	0.01	**0.02**
Detergents, mg L^{-1}	0.00	**0.01**
TSS, mg L^{-1}	380.3	**507.0**
DDT, mg L^{-1}	0.0	0.0
Alpha-HCH, mcg L^{-1}	0.0004	0.0004
Gamma-HCH, mcg L^{-1}	0.0	0.0
Cr VI, mcg L^{-1}	0.48	0.46
F, mg L^{-1}	0.33	**0.36**
As, mcg L^{-1}	0.92	**1.09**
TDS, mg L^{-1}	505.7	**545.8**
No of Species	58.48	58.65
Sum of scores	154.03	155.07
Index S	1.53	1.56

Note: Maximal critical values of RPI are given in bold.

4. Discussion

For the first time, a study was conducted on the dynamics of environmental parameters and diatom communities along the entire length of the Zarafshan River, which crosses the territory of Uzbekistan from the border with Tajikistan to its confluence with the Amu Darya. The transboundary river has not been previously fully surveyed. However, according to the hydrochemical data of the upper transboundary section, a study was conducted [21] and showed a high water quality, with an excess of some metals as echoes of discharges from ore processing industries in Tajikistan. A complete list of algae inhabiting the riverbed in Uzbekistan and responsible for the self-purification processes of waters has not yet been compiled. Separate works were devoted to algal communities of some sections of the river, its tributaries, and reservoirs of its subordinate system [18,20]. Our study identified 428 species of diatoms, 98% of which can be used as indicators for nine environmental parameters for water quality monitoring that have not been used by UzHydromet up to now.

Our research in rivers has shown that the RPI can show the dynamics of chemical or biological indicators, but also indicate those places in the river channel where negative changes occur [37]. The RPI showed that the northern channel introduces noticeable pollution into the riverbed, of which the TSS values had the greatest gradient compared to the southern channel. Along with turbidity, the influx of metals and phenols was detected. However, in general, the dynamics of hydrochemical indicators underwent sharp changes at the stations of the lower reaches of the river, where TSS and TDS increased sharply. However, the saprobity index, S, was generally within the limits of 2–3 water quality classes, which indicates a large influence of inorganic pollution, rather than organic matter

Statistical analysis also confirms this conclusion, since separately calculated similarity coefficients for chemical data, for biological data, and for both together show the prevalence of the influence of chemical components of the ecosystem on its species composition. An assessment of the ecological state for the lower third of the river, carried out by us earlier [19], showed the sources of pollution and how the river ecosystem responded to their entry into the water, especially highlighting the stations near Navoi and Khatirchi. Arsenic and zinc entries were detected here. However, when analyzing the entire Uzbek section of the river, our attention was drawn to the stations near the city of Samarkand, where the middle reaches of the river begin. Bioindicator analysis of river communities, divided into three sections, showed that as the temperature and salinity of the waters as a whole increase towards the mouth of the river, oxygen and pH decrease. Organic pollution also decreases down the river. Communities tend to occupy substrates downriver rather than inhabit the water column and were mostly autotrophs. Along the river, the water became more oligotrophic, remaining at quality Class 2–3.

Alarming levels of some of the legacy persistent organic pollutants (POPs) may pose adverse effects on the aquatic species dwelling in the riverine communities [38]. However, in the case of the Zarafshan River in the Uzbekistan part, it can be seen that the Zarafshan Nature Reserve plays a very important role in decreasing the risk of pesticide impact.

In the nearby region of the southern Caspian Sea, rivers flowing in from the south [39] have, as in our case, fluctuations in water quality, and the most polluted stations there were, on the contrary, in the upper, mountainous sections, which the authors associate with anthropogenic activity. The presence of heavy metals is also characteristic of mountainous sections of rivers in southern Europe, since it is associated with the presence of industry in the region [40]. In large European rivers, the combined effects of both heavy metals and pesticides lead to the suppression of biodiversity because of the combined toxic effects [38,41]. Among the large rivers in the immediate region, studies on hydrochemical indicators are known in the Tigris River, Iraq [42]. Here, the opposite trend of increasing organic pollution downstream and deteriorating water quality is noted. In the case of the Zarafshan River, we see a trend towards improving water quality in both hydrochemical and biological indicators. Even though pollution is significantly greater in the northern branch of the middle course that is reflected in a decrease in biodiversity and the abundance of diatoms, and comes from subsequent industrially saturated stations, the general state of the river ecosystem, as a whole, is improving. It can be assumed that the protected area of the Zarafshan Nature Reserve, which reduces transboundary pollution, plays a significant role in this.

Our data on indicator assessments were obtained for the first time for a transboundary landscape-forming river flowing through the entire territory of Uzbekistan. Currently, the catchment area of the Zarafshan River has a very limited volume even in the flat sections of the river. The influx of pollutants is, therefore, limited by the properties of the landscape, i.e., it comes from the mountainous transboundary area of the upper reaches and the water flows of the irrigation system of the middle and lower reaches. At the same time, the analysis of water for irrigation reduces the water content of the river and leads to a decrease in the self-purification capacity of its ecosystem. This is also facilitated by the high turbidity of the water, which suppresses the development of algae. Our previous studies in the Central Asian region have demonstrated the effectiveness of ecological mapping of water quality indicators and indices for the Arys River basin in Kazakhstan [11]. Our first basin-based water quality map for the transboundary Zarafshan River showed problem areas where elevated pollutant levels were also detected and, therefore, the effectiveness of mapping for future monitoring. Water quality monitoring in Uzbekistan is currently carried out only by hydrochemical indicators. Our work has shown that biological indicators should also be included in the monitoring system, since transboundary impacts and internal sources lead to a decrease in diversity. For this purpose, we have already created a database of diatom indicator algae for the largest river, the Zarafshan.

5. Conclusions

For the first time, we compiled a general list of 428 diatom species in the Zarafshan River and conducted a comprehensive ecological assessment of water quality and the state of the aquatic ecosystem based on their communities using bioindication and statistics. Of the entire list, 91 percent of the species were indicators for 9 environmental parameters. Community at stations 3 and 4, as well as 5 and 6, reflect the complexity of the impact of the environment around the city of Samarkand and further in the middle reaches of the river. The indicator species reflect the dynamics of water quality in the river downstream, where organic pollution and general toxic impact are not yet tracked by the monitoring system. Analysis of the distribution of bioindicators, organic pollution indices and WESI, as well as statistics, show an increase in salinity and turbidity and a decrease in organic pollution downriver. At the same time, the Navoi section is also a source of water acidification. Our analysis shows that nutrients and heavy metals, as well as phenol and pesticides pollution, enter the river from various sources mainly in the middle reaches of the river. The small catchment area in a dry climate can be regarded as a positive factor, reducing the irrigation area and the pollution coming from it. The integrated index of river pollution RPI shows most pollution comes from the northern canal of the river in the middle reaches. For the first time in Uzbekistan, ecological mapping of the river was used to visualize problem areas of the river. Based on the results of bioindication, an increase in self-purification with an increase in the species richness and number of diatoms in the middle section of the Zarafshan River was found. This indicates that the river ecosystem is successfully coping with incoming pollutants. Such a conclusion could not be made based on chemical analysis of the water alone. This allowed us to recommend the inclusion of biological indicators and the expansion of state monitoring points to the lower section of the Karakul.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Averaged chemical variables over stations in the Zarafshan River according to [24] with standard deviation.

Station	2	2	3	3	4	4	5	5	6	6	7	7	9	9
Variable	**Average**	**Max.**	**Average**	**Max.**	**Average**	**Max.**	**Average**	**Max.**	**Average**	**Max.**	**Average**	**Max.**	**Average**	**Max.**
O_2 mg L^{-1}	8.72 ± 1.16	10.36	8.7 ± 1.14	10.31	6.3 ± 2.09	9.25	6.3 ± 2.09	9.25	8.415 ± 1.28	9.69	7.295 ± 2.17	9.54	6.983 ± 1.69	8.44
BOD, mgO L^{-1}	0.53 ± 0.30	0.95	0.8 ± 0.28	1.2	0.84 ± 0.40	1.4	0.84 ± 0.40	1.4	0.86 ± 0.24	1.1	1.638 ± 0.97	2.7	2.86 ± 0.99	3.8
COD, mgO L^{-1}	3.32 ± 1.46	5.39	3.29 ± 1.48	5.39	3.3 ± 1.9	5.98	3.3 ± 1.90	5.98	5.71 ± 1.76	7.47	12.438 ± 6.49	19.7	31.125 ± 6.93	40.9
N-NH_4, mg L^{-1}	0.03 ± 0.04	0.08	0.04 ± 0.03	0.08	0.03 ± 0.01	0.07	0.03 ± 0.03	0.07	0.1 ± 0.05	0.15	0.043 ± 0.03	0.07	0.165 ± 0.08	0.25
N-NO_2, mg L^{-1}	0.86 ± 0.64	1.77	0.59 ± 0.33	1.05	0.8 ± 1.65	3.14	1.65 ± 1.65	3.14	2.965 ± 1.59	4.55	0.025 ± 0.01	0.035	0.12 ± 0.06	0.178
N-NO_3, mg L^{-1}	0.005 ± 0.12	0.17	0.007 ± 0.01	0.028	0.007 ± 0.01	0.023	0.007 ± 0.01	0.023	0.025 ± 0.01	0.037	2.688 ± 2.27	5.57	4.83 ± 3.28	8.79
Fe, mg L^{-1}	0.01 ± 0.04	0.06	0.01 ± 0.03	0.05	0.01 ± 0.01	0.03	0.01 ± 0.01	0.03	0.025 ± 0.02	0.04	0.03 ± 0.03	0.07	0.09 ± 0.07	0.18
Cu, mcg L^{-1}	1.60 ± 1.34	3.5	2 ± 1.14	4	1.9 ± 1.27	3.7	1.9 ± 1.27	3.7	4.65 ± 2.15	6.8	5.25 ± 3.16	8.9	6.1 ± 2.10	8.2
Zn, mcg L^{-1}	2.0 ± 1.34	3.9	2.1 ± 2.19	5.2	2.3 ± 2.47	5.8	2.3 ± 2.47	5.8	4.35 ± 2.05	6.4	5.65 ± 3.61	9.7	4.275 ± 0.62	5.5
Phenols, mg L^{-1}	0.001 ± 0.0	0.005	0.002 ± 0.0	0.006	0.001 ± 0.0	0.004	0.001 ± 0.0	0.004	0.006 ± 0.003	0.009	0.005 ± 0.0	0.009	0.002 ± 0.0	0.005
Oil, mg L^{-1}	0 ± 0.007	0.01	0.01 ± 0.0	0.01	0.01 ± 0.05	0.08	0.01 ± 0.05	0.08	0.03 ± 0.02	0.05	0.02 ± 0.03	0.05	0.03 ± 0.05	0.09
Detergents, mg L^{-1}	0.01 ± 0.01	0.02	0.01 ± 0.001	0.01	0 ± 0.01	0.01	0 ± 0.01	0.01	0.01 ± 0.01	0.02	0.015 ± 0.01	0.05	0.005 ± 0.01	0.02
TSS, mg L^{-1}	277.3 ± 867.5	1504.2	249.8 ± 669.5	1196.6	230.7 ± 654.3	1156	230.7 ± 654.3	1156	993.8 ± 629.2	1623	591 ± 461.2	1118	1028.1 ± 477.8	2316
DDT, mg L^{-1}	0 ± 0.0	0	0 ± 0.0	0	0 ± 0.0	0	0 ± 0.0	0	0 ± 0.0	0	0 ± 0.0	0	0 ± 0.0	0
Alpha-HCH, mcg L^{-1}	0.001 ± 0.0	0.007	0 ± 0.0	0	0 ± 0.0	0.004	0 ± 0.0	0.004	0 ± 0.0	0	0 ± 0.0	0	0.002 ± 0.0	0.004
Gamma-HCH, mcg L^{-1}	0 ± 0.0	0	0 ± 0.0	0	0 ± 0.0	0	0 ± 0.0	0	0 ± 0.0	0	0 ± 0.0	0	0 ± 0.0	0
Cr VI, mcg L^{-1}	0.1 ± 0.21	0.4	0.3 ± 0.18	0.05	0.4 ± 0.42	1	0.4 ± 0.42	1	0.3 ± 0.0	0.3	0.825 ± 0.60	1.5	1.275 ± 0.50	1.8
F, mg L^{-1}	0.17 ± 0.06	0.26	0.19 ± 0.08	0.3	0.16 ± 0.06	0.25	0.16 ± 0.06	0.25	0.36 ± 0.1	0.46	0.693 ± 0.24	1	0.865 ± 0.20	1.02
As, mcg L^{-1}	0.9 ± 1.48	3.00	0.5 ± 1.14	2.5	0.3 ± 1.20	2	0.3 ± 1.20	2	1.35 ± 0.85	2.2	3.125 ± 5.67	11	0 ± 0.0	0
TDS, mg L^{-1}	305 ± 42.2	364.7	300.5 ± 79.1	412.3	292.6 ± 63.1	381.9	292.6 ± 63.1	381.9	515.75 ± 171.4	687.1	728.8 ± 170.6	878.1	1710.8 ± 342.6	2014.5

Table A2. Diatom species distribution over the sampling stations and the river parts of the Zarafshan River with indicator properties. Upper—stations 1 and 2; Middle—stations 3–6; Lower—stations 7–12.

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Achnanthes coarctata (Brébisson ex W.Smith) Grunow 1880	0	1	1	0	0	0	0	0	1	1	0	0	0	0	1	B	-	st-str	hl	ind	-	0.20	o	ats	ot
Achnanthes conspicua var. *brevistriata* Hustedt 1930	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	B	-	-	eh	-	-	-	-	-	-
Achnanthes dispar var angustissima (Jasnitsky) Sheshukova 1950	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	-	-	-	-	-	-	-	-	-	-
Achnanthes gibberula var. *interrupta* Poretzky and Anisimova 1933	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
Achnanthes neoskortzowii Simonsen 1987	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	B	-	-	i	ind	-	-	-	-	-
Achnanthes parvula Kützing 1844	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	B	-	-	mh	alf	-	2.00	b	ats	me
Achnanthes profunda Skvortzov 1937	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	-	-	-	-	-	-	-	-	-	-
Achnanthes striata Skvortzov and K.I. Meyer 1928	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	B	-	-	i	ind	-	-	-	-	-
Achnanthidium exile (Kützing) Heiberg 1863	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	B	-	str	i	alb	sx	1.80	o	ats	om
Achnanthidium minutissimum (Kützing) Czarnecki 1994	1	0	1	0	1	0	0	0	0	1	0	1	1	0	0	P-B	eterm	st-str	i	ind	es	0.95	b	ate	e
Achnanthidium nodosum (Cleve) Tseplik and Chudaev 2020	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	B	-	-	hb	acf	-	1.00	o	-	ot
Achnanthidium pyrenaicum (Hustedt) H. Kobayasi 1997	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	B	temp	-	mh	alf	es	1.10	o	ate	-
Actinella punctata F.W. Lewis 1864	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	B	temp	-	hb	acf	-	1.00	o	-	ot
Adlafia minuscula (Grunow) Lange-Bertalot 1999	0	1	1	0	0	0	0	0	1	0	0	1	0	0	0	P-B. aer	temp	st-str	i	alf	es	2.80	b	hce	ot
Altana cingens (Skvortzov) Kulikovskiy, Metzeltin and Lange-Bertalot 2012	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	B	-	-	i	-	-	-	-	-	-
Amphipleura pellucida (Kützing) Kützing 1844	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	P-B	-	st	i	alf	sp	0.80	b	ate	om

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Amphora ovalis (Kützing) Kützing 1844 var. ovalis	1	1	1	1	0	0	0	0	0	1	0	1	0	0	1	B	temp	st-str	i	alf	sx	1.50	b	ate	e
Amphora commutata Grunow 1880	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	B	-	-	hl. mh	alf	-	-	-	ats	e
Amphora costulata Skvortzov 1937	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	B	-	-	i	-	-	1.00	o	-	-
Amphora gracilis Ehrenberg 1843	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	B	-	-	-	-	-	-	-	-	-
Amphora libyca Ehrenberg 1841	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	B	temp	st	i	alf	es	1.50	o-b	ate	om
Amphora mongolica Østrup 1908	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	B	-	-	i	ind	-	-	-	-	-
Amphora ovalis var. *gracilis* (Ehrenberg) Van Heurck 1885	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	B	-	-	i	alf	sx	1.50	o-b	-	-
Amphora pediculus (Kützing) Grunow 1875	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	B	temp	st	i	alf	es	1.70	b	ate	me
Amphora proteus var. *baikalensis* Skvortzov 1937	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	-	-	-	-	-	-	-	-	-	-
Amphora robusta W. Gregory 1857	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	B	temp	-	eh	-	-	-	-	-	-
Amphora subconstricta Levkov 2009	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	B	-	-	i	alf	-	-	-	-	-
Aneumastus tusculus (Ehrenberg) D.G. Mann and A.J. Stickle 1990	1	1	1	0	1	0	0	0	0	0	1	1	0	0	0	P-B	-	st	i	alb	-	0.90	b	ate	o-e
Anomoeoneis costata (Kützing) Hustedt 1959	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	B	-	st-str	mh	alf	-	2.70	a-o	hne	e
Aulacoseira ambigua (Grunow) Simonsen 1979	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	P	temp	st-str	i	alf	sp	1.70	b-o	ate	om
Aulacoseira granulata (Ehrenberg) Simonsen 1979 var. *granulata*	1	1	0	1	1	0	0	0	0	0	0	0	0	1	0	P-B	temp	st-str	i	alf	es	2.00	b	ate	e
Aulacoseira granulata var. *angustissima* (O.Müller) Simonsen 1979	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	P	temp	st-str	i	alf	es	2.10	b	ate	e
Aulacoseira italica (Ehrenberg) Simonsen 1979	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	P-B	cool	st-str	i	ind	es	1.45	b	ate	me
Bacillaria paxillifera (O.F.Müller) T.Marsson 1901	1	1	0	0	0	0	0	1	0	1	0	0	0	1	0	P-B	-	st-str	mh	ind	es	2.30	a	ate	e

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Belonastrum berolinense (Lemmermann) Round and Maidana 2001	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	P-B	-	st-str	hl	alf	-	2.20	b	ate	he
Berkeleya fragilis Greville 1827	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
Brachysira microcephala (Grunow) Compère 1986	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	B	-	st-str	i	alf	sx	1.30	b	ats	om
Brachysira serians (Brébisson) Round and D.G.Mann 1981	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	B	-	st-str	hb	acb	-	0.20	o	ats	ot
Brebissonia lanceolata (C.Agardh) R.K.Mahoney and Reimer 1986	1	1	0	1	1	0	0	0	1	0	0	0	0	0	0	P-B	temp	-	hl	alf	-	2.00	x-o	-	-
Caloneis amphisbaena (Bory) Cleve 1894	1	1	1	0	0	0	0	1	0	1	0	0	0	1	1	B	-	st-str	i	alf	-	2.30	a	ate	e
Caloneis bacillum (Grunow) Cleve 1894	1	1	1	0	1	0	0	0	1	0	0	0	0	0	0	B	temp	st-str	i	alf	es	1.30	b	ats	me
Caloneis budensis (Grunow) Krammer 1985	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	B	-	st	hl	alf	-	-	-	-	-
Caloneis dubia Krammer 1987	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	P-B	-	st-str	hb	-	-	1.00	o	-	ot
Caloneis fossilis A.Cleve 1915	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	-	warm	-	eh	-	-	-	-	-	-
Caloneis leptosoma (Grunow) Krammer 1985	0	0	1	0	0	0	0	0	0	1	0	1	0	1	0	B	-	str	i	ind	-	1.00	o	ats	om
Caloneis molaris (Grunow) Krammer 1985	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	B	-	str	i	ind	es	1.00	o	-	ot
Caloneis silicula (Ehrenberg) Cleve 1894	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	B	warm	st	i	ind	sp	1.30	o	ats	om
Campylodiscus echeneis Ehrenberg ex Kützing 1844	0	0	1	0	0	0	0	1	1	0	0	0	0	1	0	P	-	st	mh	-	-	-	-	-	-
Campylodiscus lacus-baikali Skvortzov 1937	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	B	-	-	i	ind	-	-	-	-	-
Campylodiscus rutilus Skvortzov 1937	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
Cavinula scutiformis (Grunow) D.G.Mann and A.J.Stickle 1990	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	B	-	-	i	-	-	-	-	-	-

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Chamaepinnularia krookii (Grunow) Lange-Bertalot and Krammer 1999	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	P-B	-	aer	i	alf	-	1.00	o	ats	om
Cocconeis diminuta var. *intermedia* Kisselev 1932	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
Cocconeis disculus (Schumann) Cleve 1882	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	B	-	st-str	i	alf	es	0.70	b	ats	me
Cocconeis lineata Ehrenberg 1849	1	0	1	1	0	0	0	1	0	0	0	0	0	0	1	P-B	temp	st-str	i	alf	sx	1.20	b	ate	e
Cocconeis neodiminuta Krammer 1990	0	1	1	0	0	0	0	0	0	0	1	1	0	1	0	P-B	temp	st-str	i	alf	sx	0.90	b	ats	me
Cocconeis pediculus Ehrenberg 1838	0	1	0	1	1	0	0	0	0	0	0	0	0	1	0	B	-	st	hl	alf	-	-	b	ate	e
Cocconeis placentula Ehrenberg 1838 var. *placentula*	1	1	0	1	1	0	0	0	0	1	0	0	0	0	0	P-B	temp	st-str	i	alf	es	1.35	o	ate	me
Cocconeis placentula var. *euglypta* (Ehrenberg) Cleve 1895	1	0	1	0	0	0	0	0	0	0	0	1	0	0	1	P-B	temp	st-str	i	alf	sx	1.30	b	ate	om
Cocconeis placentula var. *intermedia* (M.Peragallo and Héribaud) Cleve 1895	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	B	-	st-str	i	alf	-	1.40	o-b	ate	ot
Cocconeis placentula var. *rouxii* (Héribaud and Brun) Cleve 1895	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	B	-	-	i	alf	-	1.40	o-b	-	-
Cocconeis skvortsovii Sheshukova-Poretskaya 1951	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	B	-	-	i	alb	-	-	-	-	-
Cosmioneis pusilla (W.Smith) D.G.Mann and A.J.Stickle 1990	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	P-B. aer	-	st-str	hl	ind	sp	1.80	o-a	ats	om
Craticula halophila (Grunow) D.G.Mann 1990 var. *halophila*	1	0	1	1	0	0	0	0	0	0	0	0	1	0	0	B	temp	st-str	mh	alf	es	3.00	a	ate	e
Craticula halophila var. *subcapitata* (Østrup) Czarnecki 1995	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	B	-	st-str	mh	alf	es	-	-	-	-
Craticula simplex (Krasske) Levkov 2016	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	B	-	-	i	alb	-	-	-	-	-
Crenotia thermalis (Rabenhorst) Wojtal 2013	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	B	eterm	st-str	mh	ind	sx	0.30	o	-	om

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Ctenophora pulchella (Ralfs ex Kützing) D.M.Williams and Round 1986 var. *pulchella*	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	P-B. Ep	temp	st-str	mh	alf	sx	2.30	a	ate	e
Ctenophora pulchella var. *lacerata* (Hustedt) Bukhtiyarova 1995	1	1	0	0	1	0	0	0	1	0	0	0	0	0	0	B	-	-	mh	-	-	-	-	hne	-
Ctenophora pulchella var. *lanceolata* (O'Meara) Bukhtiyarova 1995	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	P-B	-	-	I	alf	-	2.00	b	hne	-
Cyclostephanos dubius (Hustedt) Round 1988	0	1	1	1	0	0	0	0	1	1	0	0	1	0	1	P-B	temp	st-str	hl	alf	es	2.00	a	ate	e
Cyclostephanos mansfeldensis Houk. Kleen and H.Tanaka 2014	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	P	-	-	i	ind	-	-	-	-	-
Cyclotella choctawhatcheeana Prasad 1990	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	P	-	-	hl	-	-	-	-	-	-
Cyclotella comta var. *spectabilis* A.Cleve 1915	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	-	-	-	-	-	-	-	-	-	-
Cyclotella distinguenda Hustedt 1928 var. distinguenda	0	0	1	0	0	0	0	0	0	0	1	1	0	0	1	P	-	str	hl	alf	-	1.30	o	-	om
Cyclotella distinguenda var. *unipunctata* (Hustedt) Håkansson and J.R.Carter 1990	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	P	-	-	i	ind	-	-	-	-	-
Cyclotella melosiroides (Kirchner) Lemmermann 1900	0	0	1	0	0	0	0	0	0	0	1	1	0	1	0	P	-	-	i	-	-	-	-	-	-
Cyclotella meneghiniana Kützing 1844	1	0	1	1	0	0	0	1	0	0	0	1	1	1	1	P-B	temp	st-str	hl	alf	sp	2.80	a	hne	e
Cyclotella operculata var. *mesoleia* Grunnow 1878	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	P	-	-	i	ind	-	-	-	-	-
Cylindrotheca closterium (Ehrenberg) Reimann and J.C.Lewin 1964	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	B	-	-	eh	alf	-	2.00	b	hne	-
Cymatopleura angulata Greville 1862	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	B	-	-	i	alf	-	-	-	-	-
Cymatopleura elliptica (Brébisson) W.Smith 1851	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	P-B	temp	st-str	i	alf	-	1.40	b	ate	e
Cymbella lanceolata C.Agardh 1830 var. lanceolata	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0	B	cool	-	i	ind	sx	-	-	-	-

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Cymbella affinis Kützing 1844	1	0	1	0	0	0	0	1	0	0	0	0	0	0	1	B	-	-	i	-	-	-	-	-	-
Cymbella aspera (Ehrenberg) Cleve 1894	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	B	-	-	i	alf	-	1.00	o	-	ot
Cymbella bergii Kisselev 1932	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	-	-	-	-	-	-	-	-	-	-
Cymbella cistula (Ehrenberg) O.Kirchner 1878 var. *cistula*	1	0	1	1	1	0	0	0	0	0	0	1	0	0	1	B	-	-	i	ind	-	-	-	-	-
Cymbella cistula var. *maculata* (Kützing) Van Heurck 1885	0	1	0	0	1	1	1	0	1	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
Cymbella cymbiformis C.Agardh 1830	1	1	1	1	0	1	0	0	1	0	0	0	0	0	0	B	temp	st-str	i	alf	sx	2.00	b	ats	om
Cymbella helvetica var. *curta* Cleve 1894	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	B	temp	st-str	i	ind	-	0.60	b	ats	me
Cymbella helvetica var. *helvetica* Kützing 1844	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	-	-	-	-	-	-	-	-	-	-
Cymbella helvetica var. *punctata* Hustedt 1922	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	B	-	-	i	-	-	-	-	-	-
Cymbella lacustris f. *baicalensis* Skvortzov and K.I.Meyer 1928	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
Cymbella laevis Nägeli 1863	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	B	-	-	oh	alf	-	-	-	-	-
Cymbella lanceolata var. *notata* Wislouch and Poretzky 1924	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	B	temp	st-str	i	alf	es	2.50	b-a	ate	e
Cymbella obtusiuscula Kützing 1844	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	B	temp	st	i	alf	-	1.20	o	-	om
Cymbella parva (W.Smith) Kirchner 1878	1	1	0	0	0	1	1	0	0	0	0	0	0	0	1	B	-	-	i	ind	-	1.00	o	-	-
Cymbella proschkinae Muzafarov 1965	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
Cymbella skvortzovii Skabichevskij 1936	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	B	-	st	I	ind	sx	2.00	b	ate	m
Cymbella stuxbergii (Cleve) Cleve 1894	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	B	-	-	-	-	-	-	-	-	-
Cymbella tartuensis Molder 1937	0	0	1	0	0	0	0	0	0	1	0	1	0	1	0	B	-	-	i	ind	-	-	-	-	-
Cymbella tumida (Brébisson) Van Heurck 1880 var. tumida	0	1	1	0	0	1	0	1	0	0	0	1	0	1	0	B	-	-	-	-	-	-	-	-	-
Cymbella tumida var. *borealis* (Grunow) Cleve 1894	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	B	temp	st-str	i	alf	sx	2.20	b	ats	me

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Cymbella tumidula Grunow 1875	1	1	1	0	0	0	0	1	0	0	0	0	0	0	1	B	-	-	i	-	-	-	-	-	-
Cymbella turgidula Grunow 1875	0	1	1	0	0	1	0	0	0	1	0	0	0	0	1	P-B	-	str	hb	ind	-	1.00	o	ats	ot
Cymbopleura amphicephala (Nägeli ex Kützing) Krammer 2003	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	B	-	st-str	i	ind	-	-	-	-	-
Cymbopleura austriaca (Grunow) Krammer 2003	0	1	1	0	0	0	0	1	0	0	0	0	0	0	1	B	-	-	i	ind	-	1.00	o	-	ot
Cymbopleura lata (Grunow ex Cleve) Krammer 2003	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	B	-	-	i	ind	-	1.00	o	-	ot
Cymbopleura naviculiformis (Auerswald ex Heiberg) Krammer 2003	1	1	1	0	1	0	0	0	0	0	0	1	0	1	1	B	temp	st-str	i	ind	-	-	-	-	-
Denticula elegans Kützing 1844	1	1	0	1	1	0	0	0	0	1	0	0	0	0	0	B	-	-	oh	alf	-	2.00	b	-	-
Denticula tenuis Kützing 1844	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	B	-	aer	hl	-	es	1.00	o	ats	e
Denticula tenuis var. *crassula* (Nägeli ex Kützing) West and G.S.West 1901	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	B	-	str	i	ind	sx	0.30	o	ats	m
Diatoma elongata (Lyngbye) C.Agardh 1824 var. *elongata*	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	P-B	-	-	-	ind	-	-	a	ats	me
Diatoma elongata var. *pachycephala* (Grunow) Hustedt 1931	1	0	0	1	1	0	0	1	0	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
Diatoma moniliformis subsp. *ovalis* (F.Fricke) Lange-Bertalot. Rumrich and G.Hofmann 1991	1	1	0	1	0	0	0	0	0	0	0	0	0	1	0	P-B	temp	st-str	i	alf	-	0.40	x-o	-	-
Diatoma tenuis C.Agardh 1812	1	1	1	0	0	0	0	0	1	0	0	0	0	0	1	B	-	-	-	-	-	1.30	o	-	om
Diatoma vulgaris Bory 1824 var. vulgaris	1	1	1	1	1	1	1	0	1	1	0	1	0	1	1	P-B	temp	st-str	hl	alf	-	2.40	b-a	-	om
Diatoma vulgaris var. *brevis* Grunow 1862	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	P-B	temp	st-str	i	alf	-	2.40	b-a	-	-
Diatoma vulgaris var. *linearis* Grunow 1881	1	0	0	1	1	0	0	0	1	0	0	0	0	0	0	B	-	-	-	-	sx	2.20	b	ate	me
Diatomella balfouriana Greville 1855	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	B	-	-	-	-	-	0.70	o	ats	m
Diploneis smithii (Brébisson) Cleve 1894 var. *smithii*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	B	-	-	-	-	-	1.00	o	-	ot

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Diploneis smithii var. *pumila* (Grunow) Hustedt 1937	0	1	1	1	0	0	0	0	0	0	0	0	1	0	1	B	-	-	mh	alf	-	-	-	-	-
Diploneis boldtiana Cleve 1891	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	B	-	-	mh	-	-	-	-	-	-
Diploneis domblittensis (Grunow) Cleve 1894	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	B	-	-	hl	alb	-	-	-	-	-
Diploneis ovalis (Hilse) Cleve 1891	1	0	0	1	1	0	0	0	1	0	0	0	0	0	0	B	-	-	oh	-	sx	0.90	o	ats	me
Diploneis subovalis var. *baikalensis* Skvortzov	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
Discostella stelligera (Cleve and Grunow) Houk and Klee 2004	0	0	1	0	0	0	0	0	0	0	1	1	0	1	0	P	temp	st-str	i	ind	-	2.70	a-o	-	-
Dorofeyukea grimmei (Krasske) Kulikovskiy and Kociolek 2019	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	-	-	-	eh	-	-	-	-	-	-
Encyonema ventricosum (C.Agardh) Grunow 1875	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	B	-	st-str	i	ind	-	-	-	ate	-
Encyonema caespitosum var. *ovatum* Grunow 1875	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	-	-	-	-	-	-	1.30	o	hne	-
Encyonema elginense (Krammer) D.G.Mann 1990	1	0	1	1	1	0	0	0	0	0	0	1	0	0	1	B	temp	st	i	alf	es	1.40	o-b	-	-
Encyonema hebridicum Grunow ex Cleve 1891	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	B	-	-	-	acf	-	1.00	o	-	ot
Encyonema leibleinii (C.Agardh) W.J.Silva. R.Jahn. T.A.V.Ludwig and M.Menezes 2013	1	1	0	0	1	1	0	0	0	0	0	0	0	0	1	B	-	-	-	-	-	1.00	o	ats	ot
Encyonema minutum (Hilse) D.G.Mann 1990	0	0	1	1	0	0	0	1	0	0	0	1	0	0	0	B	-	-	i	alf	-	0.30	x	-	-
Encyonema perpusillum (A.Cleve) D.G.Mann 1990	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	B	-	-	-	-	-	1.00	o	-	-
Encyonema ventricosum var. *hankensis* (Skvortzov) Rodionova and Pomazkina 2014	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
Encyonopsis falaisensis (Grunow) Krammer 1997	0	1	1	0	0	0	0	0	0	0	1	1	0	1	0	-	-	-	-	-	-	-	-	-	-

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Encyonopsis microcephala (Grunow) Krammer 1997	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	B	-	-	-	-	-	1.00	o	-	ot
Entomoneis alata (Ehrenberg) Ehrenberg 1845	1	0	1	0	0	0	0	0	0	0	0	0	0	1	1	P-B	-	st	mh	alf	-	2.50	b-a	-	-
Entomoneis japonica (Cleve) K.Osada 2002	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	-	-	-	-	-	-	-	-	-	-
Entomoneis ornata (Bailey) Reimer 1975	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	B	-	st-str	i	alf	-	2.00	b	hne	-
Entomoneis paludosa (W.Smith) Reimer 1975 var. *paludosa*	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	P-B	-	-	mh	alf	-	-	-	-	-
Entomoneis paludosa var. *duplex* (Donkin) Czarnecki and D.C.Reinke 1982	0	0	1	1	0	0	0	0	0	0	0	1	0	0	1	-	-	-	-	-	-	-	-	-	-
Entomoneis paludosa var. *subsalina* (Cleve) Krammer 1987	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	B	-	-	hl	-	-	1.20	o-b	ats	om
Eolimna minima (Grunow) Lange-Bertalot. nom. illeg. 1998	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	B	temp	-	hl	alf	-	-	-	-	-
Epithemia adnata (Kützing) Brébisson 1838	1	1	0	1	1	0	0	0	0	1	0	0	0	0	0	B	temp	st-str	i	alb	-	1.20	o	-	-
Epithemia argus var. *angusta* Fricke 1904	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	B	-	-	i	ind	es	0.70	o-x	hne	m
Epithemia operculata (C.Agardh) Ruck and Nakov 2016	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	P	-	st	i	ind	es	2.00	b	-	-
Epithemia parallela (Grunow) Ruck and Nakov 2016	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	P-B	-	-	-	-	-	1.30	o	-	-
Epithemia turgida (Ehrenberg) Kützing 1844	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	B	temp	st-str	i	alf	-	1.10	-	-	-
Eucocconeis austriaca (Hustedt) Lange-Bertalot 1999	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	B	-	-	i	alf	-	0.20	x	ats	ot
Eucocconeis depressa (Cleve) Lange-Bertalot 1999	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	B	-	-	hb	acf	-	1.00	o	-	ot
Eucocconeis elliptica Saveljewa-Dolgowa 1925	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	B	-	-	i	ind	sx	1.00	o	-	ot

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Eucocconeis flexella (Kützing) F.Meister 1912	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	B	temp	str	mh	ind	-	-	-	-	-
Eunotia exigua (Brébisson ex Kützing) Rabenhorst 1864 var. *exigua*	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	P-B. aer	temp	st-str	hb	acb	-	1.00	o	-	ot
Eunotia exigua var. *bidens* Hustedt 1930	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	B	-	-	hb	acb	es	0.45	x-o	ate	o-e
Eunotia glacialis F.Meister 1912	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	B	-	str	hb	acf	-	0.60	o-x	-	-
Eunotia lunaris var. *capitata* (Grunow) Schönfeldt 1907	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	B	-	st	i	ind	-	-	-	-	-
Eunotia minor (Kützing) Grunow 1881	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	B	temp	st-str	hb	acf	-	-	-	-	-
Eunotia pectinalis (Kützing) Rabenhorst 1864	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	B	-	st-str	i	acf	sx	0.50	x-o	-	ot
Eunotia praerupta Ehrenberg 1843	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	P-B	cool	st-str	hb	acf	-	0.30	x	-	-
Eunotia pseudopectinalis Hustedt 1924	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	B	cool	str	hb	acf	-	1.00	o	-	ot
Eunotia robusta Ralfs. nom. illeg. 1861	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	B	-	st	hb	acf	-	1.00	o	-	ot
Eunotia tenella (Grunow) Hustedt 1913	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	B	temp	st-str	hb	acf	-	-	-	-	-
Eunotia vanheurckii R.M.Patrick 1958	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	B	temp	st-str	i	acf	-	0.50	x-o	ats	ot
Fallacia reichardtii (Grunow) Witkowski. Lange-Bertalot and Metzeltin 2000	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	P-B	-	st-str	i	alf	es	2.70	a-o	hne	e
Fallacia subhamulata (Grunow) D.G.Mann 1990	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	B	temp	str	i	ind	-	-	-	-	-
Fragilaria capucina Desmazières 1830 var. capucina	1	1	1	0	0	0	1	0	1	1	0	0	0	1	0	P-B	temp	st-str	i	ind	-	-	-	-	-
Fragilaria capucina var. *lanceolata* Grunow 1881	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	B	-	-	-	-	-	-	-	-	-
Fragilaria crotonensis Kitton 1869	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	P-B	temp	st-str	i	alf	-	-	-	-	-

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Fragilaria intermedia (Grunow) Grunow 1881	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
Fragilaria septentrionalis (Østrup) Van de Vijver. C.E.Wetzel and Ector 2020	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
Fragilaria vaucheriae (Kützing) J.B.Petersen 1938	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	P-B. Ep	temp	st-str	i	alf	-	-	-	-	-
Fragilariforma bicapitata (A.Mayer) D.M.Williams and Round 1988	0	1	1	0	0	1	0	0	1	0	0	1	1	1	0	P-B	-	st-str	hb	ind	-	-	-	-	-
Fragilariforma nitzschioides (Grunow) Lange-Bertalot 2011	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	B	-	-	i	ind	sx	1.90	o-a	ats	me
Fragilariforma virescens (Ralfs) D.M.Williams and Round 1988	0	1	1	0	0	0	0	0	1	0	0	1	0	1	0	P-B	temp	st-str	hb	ind	-	1.00	o	-	ot
Frustulia vulgaris (Thwaites) De Toni 1891	1	0	0	1	1	0	0	0	0	1	0	0	0	0	0	P-B	temp	st-str	i	alf	-	1.00	o	-	-
Geissleria annulata (Grunow) Lange-Bertalot and Metzeltin 1996	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	-	-	-	-	-	-	-	-	-	-
Geissleria schoenfeldii (Hustedt) Lange-Bertalot and Metzeltin 1996	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	B	temp	st-str	i	alf	-	-	-	-	m
Gogorevia exilis (Kützing) Kulikovskiy and Kociolek 2020	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	B	eterm	st-str	i	alf	-	-	-	-	-
Gomphoneis clevei (Fricke) Gil 1989	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	B	-	-	i	alf	-	2.70	a-o	-	-
Gomphonella calcarea (Cleve) R.Jahn and N.Abarca 2019	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	B	-	st-str	i	alf	-	-	-	-	-
Gomphonella olivacea (Hornemann) Rabenhorst 1853	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	B	temp	st-str	i	alf	-	2.30	b	ate	om
Gomphonema truncatum Ehrenberg 1832	1	1	0	1	0	0	1	1	0	0	0	0	0	0	0	B	temp	st-str	i	ind	-	2.00	b	-	-
Gomphonema acuminatum Ehrenberg 1832 var. *acuminatum*	1	0	0	1	1	0	0	0	0	1	0	0	1	0	0	B	temp	st-str	i	ind	-	0.80	x-b	-	-
Gomphonema acuminatum var. *longiceps* (Ehrenberg) N.Abarca and R.Jahn 2020	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	B	-	str	i	ind	-	-	-	-	-

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Gomphonema angustatum (Kützing) Rabenhorst 1864	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	B	temp	st-str	i	ind	-	1.00	o	-	-
Gomphonema brebissonii Kützing 1849	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	B	-	st	i	ind	-	-	-	-	m
Gomphonema capitatum Ehrenberg 1838	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	B	temp	st	i	alf	-	1.20	o	-	om
Gomphonema gracile Ehrenberg 1838	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	B	temp	st-str	i	alf	-	-	-	-	-
Gomphonema grunowii R.M.Patrick and Reimer 1975	1	0	1	1	1	0	0	0	0	0	0	1	0	0	1	B	temp	-	i	alf	es	0.80	x-b	ats	m
Gomphonema intricatum Kützing 1844	1	0	1	0	0	0	0	0	0	0	1	1	1	1	0	B	-	st-str	i	ind	-	-	-	-	-
Gomphonema lagenula Kützing 1844	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	B	-	-	-	-	-	-	b	ate	e
Gomphonema lanceolatum var. *capitatum* Skvortzov 1937	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	B	-	-	i	ind	-	1.30	o	ats	ot
Gomphonema micropus Kützing 1844	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	B	temp	st-str	i	ind	-	1.10	-	-	-
Gomphonema olivaceum var. *minutissimum* Hustedt 1930	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	B	-	str	i	alf	-	-	-	-	-
Gomphonema parvulum (Kützing) Kützing 1849	1	0	1	0	0	0	0	1	0	0	0	1	1	1	0	B	temp	st-str	i	ind	-	0.70	o-x	ats	ot
Gomphonema tergestinum (Grunow) Fricke 1902	0	1	1	1	0	1	0	0	0	1	0	0	0	0	1	B	-	str	i	ind	-	1.00	o	-	-
Gomphonema vibrio var. *bohemicum* (Reichelt and Fricke) R.Ross 1986	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	B	-	-	hb	ind	es	-	-	-	-
Grunowia tabellaria (Grunow) Rabenhorst 1864	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	B	-	str	i	ind	-	3.60	a-b	ats	me
Gyrosigma acuminatum (Kützing) Rabenhorst 1853 var. *acuminatum*	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	B	temp	st-str	i	alf	-	-	-	-	-
Gyrosigma acuminatum var. *gallicum* (Grunow) Cleve 1894	0	1	1	0	0	0	0	0	1	0	0	0	1	1	0	B	-	st-str	hl	alf	-	-	-	-	-
Gyrosigma acuminatum var. *lacustre* (W.Smith) F.Meister 1912	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	B	-	-	i	ind	-	-	a	ats	e

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Gyrosigma attenuatum (Kützing) Rabenhorst 1853	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	P-B	temp	st-str	i	alf	-	-	-	-	-
Gyrosigma eximium (Thwaites) Boyer 1927	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	B	-	-	hl	alb	-	-	-	-	-
Gyrosigma kuetzingii (Grunow) Cleve 1894	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	-	-	-	-	-	-	-	-	-	-
Gyrosigma peisonis (Grunow) Hustedt 1930	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	B	-	st-str	mh	alf	sp	2.00	b	ate	e
Gyrosigma scalproides (Rabenhorst) Cleve 1894	1	1	1	1	1	0	0	0	0	1	0	1	0	0	1	B	-	str	i	alf	-	-	-	-	-
Halamphora acutiuscula (Kützing) Levkov 2009	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	P-B	warm	-	mh	alf	-	1.30	o	-	-
Halamphora coffeiformis (C.Agardh) Mereschkowsky 1903	1	1	0	0	0	1	0	1	0	1	0	0	0	0	0	B	-	st-str	mh	alf	-	-	-	-	-
Halamphora holsatica (Hustedt) Levkov 2009	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	P-B	-	st-str	hl	alf	-	-	-	-	-
Halamphora hybrida (Grunow) Levkov 2009	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	B	-	-	mh	-	-	-	-	-	-
Halamphora perpusilla (Grunow) Q.M.You and Kociolek 2015	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	B	-	-	mh	alf	-	1.00	o	-	-
Halamphora subcapitata (Kisselev) Levkov 2009	0	1	1	1	0	0	0	0	0	1	0	0	1	0	0	B	temp	str	hl	alf	-	-	-	-	-
Halamphora transcaspica (J.B.Petersen) Q.M.You and Kociolek 2015	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	-	-	-	-	-	-	-	-	-	-
Halamphora veneta (Kützing) Levkov 2009	1	0	1	0	0	0	0	0	0	0	0	1	0	1	0	B	temp	st-str	hl	alf	-	-	-	-	-
Hannaea arcus (Ehrenberg) R.M.Patrick 1966 var. *arcus*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	B	cool	str	i	-	es	0.30	x	ats	om
Hannaea arcus var. *amphioxys* (Rabenhorst) R.M.Patrick 1966	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	B	cool	str	i	alf	sx	0.30	x	-	-
Hantzschia amphioxys (Ehrenberg) Grunow 1880	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	B. aer	temp	st-str	i	ind	-	3.00	a	-	me

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Hantzschia amphioxys f. *capitata* O.Müller 1909	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	B	-	st-str	I	ind	es	1.90	a	ate	o-e
Hantzschia spectabilis (Ehrenberg) Hustedt 1959	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	B	-	-	hl	alf	-	-	-	-	-
Hantzschia virgata var. *capitellata* Hustedt 1930	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	B	-	-	hl	alf	-	-	-	-	-
Hantzschia weiprechtii Grunow 1880	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	B	-	-	hl	-	-	-	-	-	-
Haslea crucigera (W.Smith) Simonsen 1974	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	B	-	-	mh	-	-	-	-	-	-
Hippodonta linearis (Østrup) Lange-Bertalot, Metzeltin and Witkowski 1996	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	B	-	st-str	i	alf	-	-	o	ats	-
Hippodonta luneburgensis (Grunow) Lange-Bertalot, Metzeltin and A.Witkowski 1996	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	B	-	st-str	hl	ind	es	2.40	b-a	-	e
Iconella hibernica (Ehrenberg) Ruck and Nakov 2016	1	0	0	1	1	0	0	1	0	0	0	0	0	0	0	B	-	st-str	-	ind	-	-	-	-	-
Iconella linearis (W.Smith) Ruck and Nakov 2016	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	B	-	-	-	-	-	0.55	x-o	ats	om
Iconella nervosa (A.W.F.Schmidt) C.Cocquyt and R.Jahn 2017	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	P-B	-	st-str	i	ind	-	-	-	-	-
Iconella splendida (Ehrenberg) Ruck and Nakov 2016	0	1	1	0	0	0	0	0	0	0	0	1	0	1	0	P-B	-	st-str	i	alf	-	-	-	-	-
Iconella tenera (W.Gregory) Ruck and Nakov 2016	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	B	-	str	i	alf	-	1.10	o	-	-
Kurtkrammeria aequalis (W.Smith) Bahls 2015	1	1	1	1	1	0	0	0	1	0	0	1	0	0	1	B	-	-	hb	acf	-	1.00	o	-	ot
Lacustriella lacustris (W.Gregory) Lange-Bertalot and Kulikovskiy 2012	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	B	-	-	hb	ind	-	-	-	-	e
Lindavia antiqua (W.Smith) Nakov, Guillory, M.L.Julius, E.C.Theriot and A.J.Alverson 2015	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	P-B	temp	-	hb	acf	-	1.20	o	-	-

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Lindavia bodanica (Eulenstein ex Grunow) T.Nakov, Guillory, Julius, Theriot and Alverson 2015	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	P	-	st-str	i	ind	-	-	-	hne	-
Lindavia comta (Kützing) T.Nakov et al. 2015	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	P	temp	st	i	alf	-	-	-	-	-
Luticola kotschyana var. *robusta* J.Y.Li and Y.Z.Qi	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	B	-	-	i	acf	-	-	-	-	-
Luticola cohnii (Hilse) D.G.Mann 1990	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	B. aer	-	st-str. aer	i	alf	-	-	-	-	-
Luticola mutica (Kützing) D.G.Mann 1990	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	B.S	temp	st-str	hl	ind	-	1.90	o-a	ats	e
Mastogloia braunii Grunow 1863	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	P-B	-	-	mh	alf	-	-	-	-	-
Melosira normanii Arnott ex Van Heurck 1882	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	-	-	-	-	-	-	-	-	-	-
Melosira undulata (Ehrenberg) Kützing 1844	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	P-B	-	-	i	ind	-	2.80	a-o	-	-
Melosira varians C.Agardh 1827	1	1	1	1	0	0	0	0	1	0	0	0	1	0	1	P-B	temp	st-str	hl	ind	-	2.40	b-a	-	-
Meridion circulare (Greville) C.Agardh 1831	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	P-B	temp	st-str	i	ind	-	-	-	-	-
Meridion constrictum Ralfs 1843	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	P-B	temp	st-str	hb	ind	-	-	-	-	-
Navicula arenaria Donkin 1861	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	B	-	-	hl	-	-	2.40	b-a	-	-
Navicula bicapitellata Hustedt 1925	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	B	-	-	i	acf	-	-	-	-	e
Navicula capitatoradiata H.Germain ex Gasse 1986	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	P-B	temp	st-str	mh	alf	-	-	-	-	-
Navicula cincta (Ehrenberg) Ralfs 1861	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	B	temp	st-str	hl	alf	-	-	-	-	-
Navicula crucicula var. *obtusata* Grunow 1880	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	B	-	-	mh	-	-	-	-	-	-

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Navicula cryptocephala Kützing 1844	1	0	0	1	1	0	0	0	0	0	0	1	0	1	0	P-B	temp	st-str	i	ind	-	2.40	b-a	-	-
Navicula exigua var. *elliptica* Hustedt 1927	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	B	-	-	i	-	-	-	b	ate	-
Navicula exilis Kützing 1844	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	B	-	-	-	-	-	-	-	-	-
Navicula fluens Hustedt 1930	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	B	-	-	-	-	-	-	-	-	-
Navicula gottlandica Grunow 1880	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	P-B	-	-	hl	alf	es	2.50	b-a	ate	e
Navicula gregaria Donkin 1861	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	P-B	temp	st-str	i	alf	-	-	-	-	-
Navicula johncarteri D.M.Williams 2001	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	B	-	st-str	i	alf	-	1.50	o-b	ats	om
Navicula karelica var. *baicalensis* Skvortzov and K.I.Meyer	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	-	-	-	-	-	-	-	-	-	-
Navicula kolbei Meister 1932	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	-	-	-	-	-	-	-	-	-	-
Navicula lacustris var. *paulseniana* (J.B.Petersen) Zabelina 1951	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	B	-	-	i	-	-	1.00	o	-	-
Navicula lanceolata Ehrenberg 1838 var. *lanceolata*	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
Navicula lanceolata var. *tenella* Cleve	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	B	-	-	i	-	es	2.00	b	-	om
Navicula lanceolata var. *tenuirostris* Skvortzov 1937	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	B	-	-	i	alf	-	1.00	o	-	-
Navicula laterostrata Hustedt 1925	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	P-B	-	str	i	alf	-	1.10	o	-	-
Navicula libonensis Schoeman 1970	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	P-B	-	-	i	alf	-	-	-	-	-
Navicula meniscus Schumann 1867	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	-	temp	-	hl	alf	-	1.40	o-b	-	-
Navicula minima Grunow 1880	1	0	0	1	1	0	0	0	0	1	0	0	0	0	0	P-B	temp	st-str	hl	alf	-	1.00	o	hce	e
Navicula oblonga (Kützing) Kützing 1844	0	0	1	1	0	0	0	0	0	0	0	1	0	0	1	B	-	st-str	i	alf	sx	1.50	o-b	ate	om

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Navicula peregrina (Ehrenberg) Kützing 1844 var. *peregrina*	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	P-B	-	-	mh	alf	-	1.00	o	-	om
Navicula peregrina var. *lanceolata* Skvortzov 1929	0	1	0	0	0	1	1	0	0	0	0	0	0	0	1	B	-	-	i	alf	-	-	-	-	-
Navicula peregrina var. *minuta* Skvortzov 1929	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	B	-	-	mh	-	es	-	-	-	-
Navicula placentula f. *minuta* J.B.Petersen 1946	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	B	-	-	i	-	-	-	-	-	-
Navicula radiosa Kützing 1844	1	1	1	1	1	1	0	0	0	0	0	1	0	0	0	B	temp	st-str	i	ind	sx	-	-	-	-
Navicula rhynchocephala Kützing 1844	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	B	temp	st-str	hl	alf	-	1.30	o	-	-
Navicula rostellata Kützing 1844	0	1	1	1	0	0	0	0	0	1	0	1	0	1	1	B	-	st-str	i	alf	-	0.70	o-x	ate	ot
Navicula rotaeana (Rabenhorst) Grunow 1880	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	P-B	-	st	i	ind	-	-	-	-	-
Navicula salinicola Hustedt 1939	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	B	-	-	mh	-	-	-	-	-	-
Navicula slesvicensis Grunow 1880	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	P-B	-	st-str	hl	alf	-	-	-	-	-
Navicula tripunctata (O.F.Müller) Bory 1822	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	P-B	temp	st-str	i	alf	es	-	-	-	e
Navicula viridula (Kützing) Ehrenberg 1836	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	B	-	st-str	hl	alf	-	-	-	-	-
Navicymbula pusilla (Grunow) Krammer 2003	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	B	-	-	mh	alf	-	-	-	-	-
Neidium bisulcatum (Lagerstedt) Cleve 1894	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	B	-	st-str	i	ind	-	1.00	o	-	-
Neidium iridis (Ehrenberg) Cleve 1894	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	B	temp	st-str	hb	ind	-	-	-	-	-
Neidium kozlowii Mereschkovsky 1906	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	B	-	-	i	ind	-	-	-	-	-
Neidium lanceolata Skvortzov 1937	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	-	-	-	-	-	-	-	-	-	-

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Neidium punctulatum Hustedt	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	B	-	-	-	-	-	0.80	x-b	-	-
Nitzschia frustulum var. *asiatica* Hustedt 1922	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	B	-	-	hl	-	-	2.40	b-a	-	e
Nitzschia acicularis (Kützing) W.Smith 1853	0	1	1	0	0	1	0	0	1	0	1	1	1	0	0	P-B	temp	st	i	alf	es	1.40	o-b	ats	om
Nitzschia angularis W.Smith 1853	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	B	-	-	eh	-	-	2.00	b	hne	-
Nitzschia angustata var. *curta* Grunow 1881	0	1	1	0	0	1	0	0	1	0	0	0	1	1	0	P-B	-	-	i	ind	-	-	-	-	-
Nitzschia commutata Grunow 1880	1	0	0	1	1	0	0	0	1	0	0	0	0	0	0	P-B	-	st-str	mh	alf	-	-	-	-	-
Nitzschia dissipata (Kützing) Rabenhorst 1860	1	0	1	0	0	0	0	0	0	0	1	1	1	1	0	B	temp	st-str	i	alf	sx	1.40	o-b	-	-
Nitzschia distans W.Gregory 1857	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	B	-	-	eh	-	-	3.60	a-b	-	e
Nitzschia dubia W.Smith 1853	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	P-B	temp	st-str	hl	alf	-	1.00	o	-	-
Nitzschia gracilis Hantzsch 1860 var. *gracilis*	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	P-B	temp	st-str	i	ind	-	-	-	-	-
Nitzschia gracilis var. *minor* Skabichevskij 1950	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	B	-	-	i	ind	-	-	-	-	-
Nitzschia gradifera Hustedt 1922	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	B	-	-	hl	-	es	0.50	x-o	ats	m
Nitzschia heufleriana Grunow 1862	1	1	0	0	0	1	0	0	1	1	0	0	0	0	1	P-B	-	str	i	alf	-	-	-	ats	-
Nitzschia holsatica Hustedt 1924	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	P-B	-	-	i	ind	-	-	-	-	-
Nitzschia inconspicua Grunow 1862	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	B	temp	st-str	hl	alf	-	-	-	-	-
Nitzschia incurva Grunow 1878	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	B	-	-	mh	-	-	-	-	-	-
Nitzschia intermedia Hantzsch ex Cleve and Grunow 1880	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	P-B	temp	-	i	ind	-	-	-	-	-

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Nitzschia lanceolata var. *minor* (Grunow) H.Peragallo and M.Peragallo 1900	0	1	0	0	0	0	1	1	1	0	0	0	0	0	0	B	-	-	hl	-	-	-	-	-	-
Nitzschia lanceolata W.Smith 1853 var. *lanceolata*	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	B	-	-	hl	alf	-	-	-	-	-
Nitzschia linearis W.Smith 1853	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	B	temp	st-str	i	alf	-	-	-	-	-
Nitzschia lorenziana var. *subtilis* Grunow 1880	0	1	1	0	0	0	0	0	0	1	0	1	0	0	0	B	-	-	mh	-	-	-	-	-	-
Nitzschia microcephala Grunow 1880	1	1	0	1	0	1	0	0	0	1	0	0	0	0	0	P-B	temp	st-str	i	alf	-	-	-	-	-
Nitzschia palea (Kützing) W.Smith 1856 var. *palea*	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	P-B	temp	st-str	i	ind	-	2.00	b	-	-
Nitzschia palea var. *capitata* Wislouch and Poretsky 1924	1	1	0	0	0	1	0	0	1	0	0	0	0	0	0	B	-	-	i	ind	-	-	-	-	-
Nitzschia palea var. *debilis* (Kützing) Grunow 1880	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	B	temp	-	i	ind	-	-	-	-	-
Nitzschia paleacea (Grunow) Grunow 1881	1	1	1	1	1	0	0	0	0	0	1	1	0	0	0	P-B	temp	st-str	i	alf	es	2.00	b	ate	o-e
Nitzschia pamirensis Hustedt 1922	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
Nitzschia pusilla Grunow 1862	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	P-B. S	temp	st-str	i	alf	-	1.00	o	-	-
Nitzschia recta Hantzsch ex Rabenhorst 1862	1	0	1	1	0	0	0	0	0	0	0	0	1	0	1	B	temp	st-str	i	alf	-	1.00	o	-	-
Nitzschia regula Hustedt 1922	0	1	1	0	0	0	0	0	0	1	0	1	0	1	0	-	-	-	-	-	-	1.40	o-b	-	-
Nitzschia scalpelliformis Grunow 1880	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	B	-	-	mh	alf	-	-	-	-	-
Nitzschia sigma (Kützing) W.Smith 1853	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	B	temp	st-str	mh	alf	-	-	-	-	-
Nitzschia sigmoidea (Nitzsch) W.Smith 1853	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	P-B	-	st-str	i	alf	-	-	-	-	-
Nitzschia sinuata (Thwaites) Grunow 1880	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	B	-	st-str	i	alf	-	1.90	o-a	ate	e

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Nitzschia sublinearis Hustedt 1930	1	1	1	1	1	1	0	0	1	0	0	1	0	1	0	P-B	-	-	i	alf	-	-	-	-	-
Nitzschia subtilis (Kützing) Grunow 1880	1	1	0	0	0	1	0	1	0	1	0	0	0	0	0	-	-	-	i	-	-	-	-	-	-
Nitzschia telezkoensis Sheshukova 1950	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
Nitzschia thermalis (Ehrenberg) Auerswald 1861	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	P-B	-	-	i	ind	es	-	-	-	-
Nitzschia tryblionella Hantzsch 1860	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	B	-	st-str	i	ind	-	-	-	-	-
Nitzschia tubicola Grunow 1880	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	B	temp	-	mh	ind	es	2.80	a-o	hce	e
Nitzschia vermicularis (Kützing) Hantzsch 1860	0	1	1	1	0	1	0	0	1	0	0	1	0	0	1	P-B	temp	st-str	i	alf	-	-	-	-	-
Nitzschia vitrea G.Norman 1861	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	P-B	temp	st	mh	alf	-	2.70	a-o	ats	e
Nupela neogracillima Kulikovskiy and Lange-Bertalot 2009	0	1	1	0	0	0	0	0	1	0	0	0	0	1	0	P-B	-	-	i	ind	-	-	-	-	ot
Odontidium anceps (Ehrenberg) Ralfs 1861	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	P-B	cool	st-str	hb	ind	-	-	-	-	-
Odontidium elongatum var. *actinastroides* (Krieger) R.M.Patrick 1939	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	B	-	st-str	hl	alf	sx	0.40	x-o	ats	ot
Odontidium hyemale (Roth) Kützing 1844	1	1	1	1	1	1	0	0	0	0	1	1	0	1	1	P-B	cool	st-str	hb	ind	-	-	-	-	-
Odontidium mesodon (Kützing) Kützing 1849	1	1	1	0	0	1	0	0	0	0	0	1	0	1	0	B	cool	st-str	hb	ind	-	0.90	x-b	-	-
Pantocsekiella kuetzingiana (Thwaites) K.T.Kiss and E.Ács 2016	1	0	1	1	0	0	0	0	0	1	1	1	0	0	0	P-B	temp	st	I	ind	-	-	-	-	-
Pantocsekiella ocellata (Pantocsek) K.T.Kiss and Ács 2016	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	P-B	cool	st-str	hl	alf	-	0.90	x-b	-	ot
Pantocsekiella rossii (H.Håkansson) K.T.Kiss and E.Ács 2016	0	1	1	0	0	0	0	1	1	0	0	0	0	0	1	P	temp	st	i	alf	-	1.00	o	-	ot
Paralia scabrosa (Østrup) Moiseyeva 1986	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	B	-	-	i	ind	-	3.00	a	-	-

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Paraplaconeis placentula (Ehrenberg) Kulikovskiy and Lange-Bertalot 2012	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	B	temp	st-str	i	alf	-	2.00	b	-	ot
Peroniopsis heribaudii (J.Brun and M.Peragallo) Hustedt 1952	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	B	-	-	i	acf	-	2.00	b	-	-
Pinnularia angulosa Krammer 2000	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	B	-	-	i	ind	-	-	-	ats	-
Pinnularia bogotensis (Grunow) Cleve 1895	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	B	-	-	i	acf	-	-	-	-	-
Pinnularia borealis Ehrenberg 1843	1	0	1	1	1	0	0	0	0	0	1	1	0	0	0	B. aer	-	st-str.aer	i	ind	-	1.00	o	-	ot
Pinnularia brauniana (Grunow) Studnicka 1888	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	P-B	-	st-str	i	acf	-	-	-	-	-
Pinnularia brebissonii (Kützing) Rabenhorst 1864	1	0	1	1	0	0	0	0	0	0	1	1	0	0	0	B	temp	st-str	i	ind	-	1.00	o	-	-
Pinnularia intermedia (Lagerstedt) Cleve 1895	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	P-B	cool	st-str	i	ind	-	1.00	o	-	-
Pinnularia isostauron (Ehrenberg) Cleve 1895	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	B	-	-	i	ind	-	-	o	ats	om
Pinnularia karelica var. *baicalensis* Skvortzov and K.I.Meyer 1928	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
Pinnularia microstauron (Ehrenberg) Cleve 1891 var. *microstauron*	0	1	1	0	0	0	0	0	0	1	0	0	1	1	0	P-B	temp	st-str	i	ind	-	0.30	x	ats	ot
Pinnularia microstauron var. *diminuta* Shirshov 1935	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	B	-	-	i	-	-	1.00	o	-	-
Pinnularia oriunda Krammer 1992	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	B	-	-	i	neu	-	1.00	o	ats	ot
Pinnularia paragracillima Kulikovskiy, Lange-Bertalot and Witkowski 2010	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	B	-	str	i	ind	-	1.00	o	-	om
Pinnularia pectinalis var. *rostrata* Skvortzov 1937	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
Pinnularia subborealis Hustedt 1922	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	B	-	-	i	-	-	0.20	x	ats	ot
Pinnularia subcapitata W.Gregory 1856	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	B	temp	st-str	i	acf	-	0.60	o-x	-	-

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Pinnularia sudetica Hilse 1861	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0	B	-	-	hb	neu	-	1.00	o	-	-
Placoneis exigua (W.Gregory) Mereschkovsky 1903	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	B	-	str	i	ind	es	1.40	o-b	-	-
Placoneis dicephala (Ehrenberg) Mereschkowsky 1903	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	B	-	-	i	ind	es	2.00	b	ate	me
Placoneis elginensis (W.Gregory) E.J.Cox 1988	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	P-B	-	st-str	i	alf	-	-	-	-	-
Placoneis placentula var. *lanceolata* (Grunow) Aboal 2003	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	B	-	-	i	alf	-	-	-	-	-
Planothidium grimmei (Krasske) I.W.Bishop and Spaulding 2018	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	B	-	-	-	-	-	1.00	o	ats	om
Planothidium lanceolatum (Brébisson ex Kützing) Lange-Bertalot 1999	1	1	0	1	1	1	0	0	1	0	0	0	0	0	0	B	warm	-	i	alf	sx	1.60	b-o	ate	e
Planothidium rostratoholarcticum Lange-Bertalot and Bak 2015	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	B	-	st-str	i	alf	-	1.60	b-o	-	om
Pleurosira laevis (Ehrenberg) Compère 1982	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	P-B	eterm	-	eh	alf	-	-	-	-	-
Prestauroneis protracta (Grunow) Kulikovskiy and Glushchenko 2016	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	P-B	-	st-str	mh	ind	-	0.40	x-o	ate	e
Psammothidium marginulatum (Grunow) Bukhtiyarova and Round 1996	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	B	temp	st-str	hb	acf	sx	0.20	x	ats	ot
Pseudostaurosira brevistriata var. *capitata* (Héribaud) N.A.Andresen. Stoermer. and R.G.Kreis. Jr. 2000	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	P-B	-	-	i	alf	es	1.20	o	ats	o-e
Rhoicosphenia abbreviata (C.Agardh) Lange-Bertalot 1980	1	0	1	1	0	0	0	0	0	0	0	1	1	0	0	B	temp	st-str	i	alf	es	1.90	o-a	ate	me
Rhopalodia gibba (Ehrenberg) O.Müller 1895 var. *gibba*	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	P-B	temp	st-str	i	alf	es	1.40	x-o	ate	om
Rhopalodia gibba var. *mongolica* (Østrup) Proshkina-Lavrenko 1950	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	-	-	-	-	-	-	-	-	-	-
Rhopalodia gibberula var. *producta* (Grunow) O.Müller 1900	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	B	-	str	hl	alf	-	-	-	-	-

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Sellaphora americana (Ehrenberg) D.G.Mann 1989	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	B	-	str	i	alf	-	1.50	o-b	ats	ot
Sellaphora bacillum (Ehrenberg) D.G.Mann 2018	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	B	-	st-str	i	alf	sx	1.50	o-b	ats	me
Sellaphora hustedtii (Krasske) Lange-Bertalot and Werum 2004	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	B	-	str	i	ind	sx	0.30	x	-	-
Sellaphora lambda (Cleve) Metzeltin and Lange-Bertalot 1998	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	B	-	-	i	-	-	-	-	-	-
Sellaphora mutata (Krasske) Lange-Bertalot 1996	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	B	-	st-str	hl	ind	es	1.90	b	hne	om
Sellaphora parapupula Lange-Bertalot 1996	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	B	-	st	i	ind	-	1.00	o	ate	m
Sellaphora pupula (Kützing) Mereschkovsky 1902	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	B	eterm	st-str	hl	ind	sx	1.90	o-a	ate	me
Sellaphora rostrata (Hustedt) J.R.Johansen 2004	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	B	temp	-	hl	ind	-	1.90	o-a	hne	-
Sellaphora seminulum (Grunow) D.G.Mann 1989	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	P-B	temp	st-str	i	ind	sp	2.50	b-a	hne	e
Sellaphora verecunda (Hustedt) C.E.Wetzel, L.Ector, B.Van de Vijver, Compère and D.G.Mann 2015	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
Sellaphora wummensis J.R.Johansen 2004	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	B	-	-	hl	ind	es	1.90	o-a	hne	me
Stauroneis anceps Ehrenberg 1843	1	1	1	1	0	0	0	0	0	1	1	0	1	1	0	P-B	temp	st-str	i	ind	sx	1.30	o	ats	om
Stauroneis parvula (Grunow) Cleve. nom. illeg. 1894	0	1	1	0	0	0	0	0	0	1	0	1	0	1	0	B	-	st	mh	ind	-	-	-	-	-
Stauroneis smithii Grunow 1860 var. smithii	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	P-B	-	st-str	i	alf	-	1.00	o	-	om
Stauroneis smithii var. *karelica* Wislouch and Kolbe 1917	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	B	cool	-	i	-	-	1.00	o	-	ot

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Staurophora wislouchii (Poretzsky and Anisimova) D.G.Mann 1990	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	B	-	-	mh	-	-	-	-	-	-
Staurosira construens var. *triundulata* (Reichelt) Bukhtiyarova 1995	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	P-B	temp	st-str	i	alf	-	1.00	o	-	-
Staurosira dubia Grunow. nom. inval. 1879	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	P	-	-	i	alf	sp	1.30	o	ate	me
Staurosira leptostauron (Ehrenberg) Kulikovskiy and Genkal 2011	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	P-B	temp	st-str	i	alf	-	1.30	o	-	-
Staurosira subsalina (Hustedt) Lange-Bertalot 2004	1	1	1	1	1	0	0	0	0	0	0	1	0	0	0	P-B	-	st-str	hl	alf	-	-	-	-	-
Staurosira venter (Ehrenberg) Cleve and J.D.Möller 1879	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	P-B	temp	st-str	i	alf	-	1.30	o	-	ot
Staurosirella martyi (Héribaud) Morales and Manoylov 2006	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	B	-	-	-	-	es	2.70	a-o	-	-
Staurosirella pinnata (Ehrenberg) D.M.Williams and Round 1988	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	P-B	temp	st-str	hl	alf	es	1.10	o	ats	om
Staurosirella rhomboides (Grunow) E.A.Morales and K.M.Manoylov 2010	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	B	-	st	hb	alf	-	1.00	o	-	-
Stenopterobia intermedia (F.W.Lewis) Van Heurck ex Hanna 1933	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	B	-	-	hb	acf	-	1.00	o	-	ot
Stephanodiscus minutulus (Kützing) Cleve and Möller 1882	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	P	temp	-	i	alb	-	-	-	-	-
Surirella conifera var. *punctata* Skvortsov	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
Surirella angusta Kützing 1844	1	0	1	1	1	0	0	0	0	1	0	0	0	0	0	B	-	-	i	ind	-	-	-	-	-
Surirella capronii var. *hankensis* Skvortzov 1929	0	1	0	0	0	0	0	1	1	0	0	0	0	0	1	-	-	-	-	-	-	-	-	-	-
Surirella didyma var. *minor* Skvortzov 1937	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	B	-	-	i	alf	-	-	-	-	-
Surirella grunowii Kulikovskiy, Lange-Bertalot and Witkovski 2010	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	B	-	-	i	ind	-	-	-	-	-

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Surirella librile (Ehrenberg) Ehrenberg 1845	1	1	0	1	1	0	1	1	0	1	0	0	0	0	0	P-B	temp	st-str	i	alf	-	-	-	hne	-
Surirella minuta Brébisson ex Kützing. nom. illeg. 1849	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0	B	temp	st-str	i	alf	-	-	-	-	-
Surirella ovalis Brébisson 1838	1	0	1	1	0	0	0	0	0	0	0	1	0	0	0	P-B	-	st-str	mh	alf	es	1.70	b-o	-	-
Surirella quadricornis Jasnitsky 1936	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
Surirella salina W.Smith 1851	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	B	-	st-str	i	ind	es	1.20	o	ats	ot
Surirella turgida var. *skvortzowii* (K.I.Meyer) Kisselev 1950	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	-	-	-	-	-	-	-	-	-	-
Synedra famelica Kützing 1844	1	0	1	0	0	0	0	1	0	0	0	1	0	0	0	P-B	-	str	i	alf	-	1.50	o-b	-	ot
Synedra goulardii Brébisson ex Cleve and Grunow 1880 var. *goulardii*	1	0	0	1	1	0	0	0	0	1	0	0	0	0	0	P-B	-	-	i	ind	-	-	-	-	-
Synedra goulardii var. *telezkoensis* Poretzky ex Proshkina-Lavrenko 1950	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	-	-	-	-	-	es	-	-	-	-
Synedra actinastroides (Lemmermann) Lemmermann 1900	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
Tabellaria fenestrata (Lyngbye) Kützing 1844	0	1	1	0	0	1	0	0	0	0	0	1	1	0	0	P-B	-	st-str	i	ind	-	1.90	o-a	-	-
Tabellaria flocculosa (Roth) Kützing 1844	0	1	1	0	0	0	0	0	1	1	0	1	0	1	0	P-B	eterm	st-str	i	acf	-	3.00	a	-	-
Tabularia parva (Kützing) D.M.Williams and Round 1986	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	mh	alf	-	-	-	-	-
Tabularia tabulata (C.Agardh) Snoeijs 1992	1	0	1	0	1	0	0	0	0	0	1	1	0	0	1	B	-	-	mh	alf	-	-	-	-	-
Tryblionella angustata W.Smith 1853	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	P-B	temp	st	i	alf	sx	1.50	o-b	ats	e
Tryblionella apiculata W.Gregory 1857	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	B	-	st-str	mh	alf	es	2.70	a-o	ate	e

Table A2. *Cont.*

Taxa	Upper	Middle	Lower	1	2	3	4	5	6	7	8	9	10	11	12	Hab	T	OXY	HAL	pH	D	Index S	SAP	AUT-HET	TRO
Tryblionella debilis Arnott ex O'Meara 1873	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	P-B	temp	st-str. aer	i	alf	es	2.60	a-o	ate	e
Tryblionella hungarica (Grunow) Frenguelli 1942	1	0	0	1	1	0	0	0	1	0	0	0	0	0	0	P-B	-	st-str	mh	alf	sp	2.90	a	ate	e
Tryblionella levidensis W.Smith 1856	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	P-B	-	st-str	hl	alf	sp	2.60	a-o	ate	e
Tryblionella victoriae Grunow 1862	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	B	-	st-str	hl	alf	sp	2.60	a-o	ate	e
Ulnaria oxyrhynchus (Kützing) Aboal 2003	0	1	0	0	0	0	0	0	1	1	0	0	0	0	1	P-B	-	st-str	i	alf	es	2.40	b-a	ats	e
Ulnaria ulna (Nitzsch) Compère 2001 var. *ulna*	1	1	1	1	1	0	1	1	0	0	1	0	0	0	0	P-B	temp	st-str	i	alf	es	2.40	b-a	ate	e
Ulnaria aequalis (Kützing) D.M.Williams and Van de Vijver 2021	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	P-B	-	-	i	alf	sp	2.00	b	-	om
Ulnaria amphirhynchus (Ehrenberg) Compère and Bukhtiyarova 2006	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	P-B	-	-	i	alf	es	2.00	b	hne	om
Ulnaria capitata (Ehrenberg) Compère 2001	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	P-B	-	st-str	i	alf	es	2.00	b	ats	e
Ulnaria danica (Kützing) Compère and Bukhtiyarova 2006	1	0	0	1	1	0	0	0	1	0	0	0	0	0	0	P-B	temp	-	i	alf	es	1.70	b-o	hne	om
Ulnaria delicatissima var. *angustissima* (Grunow) Aboal and P.C.Silva 2004	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	P-B	-	-	i	alf	es	1.70	b-o	-	om
Ulnaria ulna var. *spathulifera* (Grunow) Aboal 2003	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0	B	-	st-str	i	alf	-	1.70	b-o	ats	e

Note: Upper—St. 1, 2; Middle—St 3, 4, 5, 6; Lower—St. 7, 8, 9, 10, 11, 12. Abbreviation for ecological groups: Habitat preferences (Hab): B, benthic; P-B, planktonic-benthic; P, planktonic. Water temperature (T): cool, cool-loving species; temp, temperate temperature water inhabitants; eterm, eurythermic species; warm, warm water inhabitants. Streaming and Oxygenation (OXY): aer, aerophiles; str, streaming waters inhabitant; st-str, low streaming waters inhabitant; st, standing water inhabitant. Water pH (pH): acf, acidophilic species; ind, indifferent; alf, alkaliphilic species; alb, alkalibiontes. Water salinity (HAL): hb, halophobe; i, oligohalobious-indifferent; hl, oligohalobious-halophilous; mh, mesohalobious. Organic pollution, Watanabe (D): sx, saproxenes; es, eurysaprobes; sp, saprophiles. Organic pollution and self-purification zones by Sládeček (SAP): indicators of Class of Water Quality I: x—0.0—xenosaprobiont; x-o—0.4—xeno-oligosaprobiont; Class of Water Quality II: o-x—0.6—oligo-xenosaprobiont; x-b—0.8—xeno-beta-mesosaprobiont; o—1.0—oligosaprobiont; o-b—1.4—oligo-beta-mesosaprobiont; Class of Water Quality III: b-o—1.6—beta-oligosaprobiont; o-a—1.8—oligo-alpha-mesosaprobiont; b—2.0—beta-mesosaprobiont; b-a—2.4—beta-alpha-mesosaprobiont; Class of Water Quality IV: a-o—2.6—alpha-oligosaprobiont; a—3.0 –alpha-mesosaprobiont; Class of Water Quality V: a-b—3.6—alpha-beta-mesosaprobiont. Index saprobity s (S): species-specific index saprobity according Sládeček. Trophic state (TRO): ot, oligotraphentic; o-m, oligo-mesotraphentic; m, mesotraphentic; me, meso-eutraphentic; e, eutraphentic; o-e, oligo- to eutraphentic. Nutrition type as Nitrogen uptake metabolism (AUT-HET): ats, nitrogen-autotrophic taxa, tolerating very small concentrations of organically bound nitrogen; ate, nitrogen-autotrophic taxa, tolerating elevated concentrations of organically bound nitrogen; hne, facultatively nitrogen-heterotrophic taxa, needing periodically elevated concentrations of organically bound nitrogen; hce, nitrogen-heterotrophic taxa, needing elevated concentrations of organically bound nitrogen.

Table A3. Diatom indicator species distribution over the sampling stations of the Zarafshan River.

Variable	St.1	St.2	St.3	St.4	St.5	St.6	St.7	St.8	St.9	St.10	St.11	St.12
Habitat												
B	59	38	23	7	40	26	44	8	43	22	52	64
P-B	43	28	13	5	18	31	27	13	30	11	26	18
P	1	2	1	0	3	2	1	3	4	0	7	5
Temperature												
cool	3	1	2	0	0	1	1	1	4	2	4	2
temp	48	29	9	8	17	20	27	12	27	16	21	26
eterm	0	1	0	0	0	1	2	1	3	1	3	0
warm	1	1	1	0	1	1	1	0	0	0	1	1
Oxygen												
aer	0	0	0	0	1	1	1	0	0	0	0	0
str	6	5	4	0	3	1	8	1	5	1	3	11
st-str	55	30	13	8	29	28	39	13	40	22	40	28
st	8	7	1	0	5	5	3	3	5	1	8	7
Salinity												
eh	0	1	2	0	0	0	2	1	2	0	1	4
mh	10	9	2	0	4	6	9	5	9	4	9	8
hl	17	7	3	2	9	9	11	1	9	7	13	10
i	65	42	25	9	40	37	47	16	48	18	51	51
hb	5	5	4	1	3	3	6	1	8	4	7	9
pH												
acb	1	1	0	0	1	0	1	0	0	0	0	0
acf	4	3	1	0	2	2	5	0	2	2	6	9
ind	30	18	14	4	16	17	24	7	28	15	33	25
alf	57	36	14	6	31	30	32	15	38	15	33	35
alb	1	2	1	0	1	1	2	1	1	0	1	2
Watanabe												
sx	11	5	4	1	5	4	5	4	8	3	8	9
es	22	13	4	2	7	7	11	5	13	9	8	10
sp	5	1	0	0	5	3	3	0	1	1	1	2
Autotrophy-Heterotrophy												
ats	9	6	7	1	11	11	13	3	9	6	13	14
ate	20	12	3	1	12	5	11	6	11	5	9	14
hne	7	3	0	1	4	3	2	2	4	1	4	7
hce	1	1	0	0	0	1	1	0	1	0	0	1
Trophy												
ot	10	6	2	0	9	8	6	1	9	6	13	15
om	10	4	4	1	7	10	7	3	7	2	8	10
m	2	1	1	0	2	2	2	0	1	0	1	3
me	7	6	1	1	4	3	1	1	3	1	4	3
e	18	9	2	1	9	5	12	3	8	6	12	11
o-e	1	3	0	0	0	0	1	2	2	0	0	0
he	0	0	0	0	1	0	0	0	0	0	0	0
Class of Water Quality												
Class 1	4	1	1	0	4	2	5	2	1	1	4	3
Class 2	34	24	8	3	21	17	22	7	26	13	22	38
Class 3	30	13	6	4	10	2	10	5	13	6	16	15
Class 4	4	1	1	0	3	4	3	2	6	3	6	3
Class 5	0	1	1	0	0	0	0	0	0	0	0	1

Note: Abbreviation for ecological groups: Habitat preferences (Hab): B, benthic; P-B, planktonic-benthic; P, planktonic. Water temperature (T): cool, cool-loving species; temp, temperate temperature water inhabitants; eterm, eurythermic species; warm, warm water inhabitants. Streaming and Oxygenation (OXY): aer, aerophiles; str, streaming waters inhabitant; st-str, low streaming waters inhabitant; st, standing water inhabitant. Water pH (pH): acf, acidophilic species; ind, indifferent; alf, alkaliphilic species; alb, alkalibiontes. Water salinity (HAL): hb, halophobe; i, oligohalobious-indifferent; hl, oligohalobious-halophilous; mh, mesohalobious. Organic pollution, Watanabe (D): sx, saproxenes; es, eurysaprobes; sp, saprophiles. Index saprobity s (S): species-specific index saprobity according Sládeček. Trophic state (TRO): ot, oligotraphentic; o-m, oligo-mesotraphentic; m, mesotraphentic; me, meso-eutraphentic; e, eutraphentic; o-e, oligo- to eutraphentic. Nutrition type as Nitrogen uptake metabolism (AUT-HET): ats, nitrogen-autotrophic taxa, tolerating very small concentrations of organically bound nitrogen; ate, nitrogen-autotrophic taxa, tolerating elevated concentrations of organically bound nitrogen; hne, facultatively nitrogen-heterotrophic taxa, needing periodically elevated concentrations of organically bound nitrogen; hce, nitrogen-heterotrophic taxa, needing elevated concentrations of organically bound nitrogen.

References

1. Muzaffarov, A.M. *Algal Flora of the Central Asian Water Bodies*; Uzbekistan Academy of Science: Tashkent, Uzbekistan, 1965; 570p. (In Russian)
2. Shultz, V.L. *Rivers of Central Asia*; LIMIZ: Leningrad, Russia, 1965; 606p. (In Russian)
3. Curtean-Bănăduc, A.; Burcea, A.; Mihuţ, C.-M.; Bănăduc, D. The Benthic Trophic Corner Stone Compartment in POPs Transfer from Abiotic Environment to Higher Trophic Levels—Trichoptera and Ephemeroptera Pre-Alert Indicator Role. *Water* **2021**, *13*, 1778. [CrossRef]
4. Cianfaglione, K.; Pedrotti, F. Italy in the Danube Geography: Territory, Landscape, Environment, Vegetation, Fauna, Culture, Human Management and Outlooks for the Future. In *Human Impact on Danube Watershed Biodiversity in the XXI Century*; Geobotany Studies (Basics, Methods and Case Studies); Bănăduc, D., Curtean-Bănăduc, A., Pedrotti, F., Cianfaglione, K., Akeroyd, J., Eds.; Springer: Cham, Switzerland, 2020; pp. 87–118.
5. Kholmatov, A.P. *Analytical Review "State and Prospects of Integrated Water Resources Management in the Zeravshan River Basin". "Promoting Integrated Water Resources Management and Transboundary Dialogue in Central Asia", EU-UNDP Project (2009–2012)*; Ministry of Melioration and Water Resources of the Republic of Tajikistan. United Nations Development Program: Dushanbe, Tajikistan, 2010; 95p. (In Russian)
6. Snigirova, A.; Bogatova, Y.; Barinova, S. Assessment of River-Sea Interaction in the Danube Nearshore Area (Ukraine) by Bioindicators and Statistical Mapping. *Land* **2021**, *10*, 310. [CrossRef]
7. Curtean–Bănăduc, A.; Bănăduc, D.; Bucşa, C. Watersheds Management (Transylvania/Romania): Implications, risks, solutions, Strategies to enhance environmental Security in transition countries. In *NATO Science for Peace and Security Series C-Environmental Security*; Springer: Berlin/Heidelberg, Germany, 2007; pp. 225–238.
8. Tsoi, W.Y.; Hadwen, W.L.; Sheldon, F. Identifying diatom indicator species of nutrient enrichment: An in situ nutrient enrichment experiment in subtropical upland streams. *Ecol. Indic.* **2020**, *119*, 106744. [CrossRef]
9. Lavoie, I.; Campeau, S.; Darchambeau, F.; Cabana, G.; Dillon, P.J. Are diatoms good integrators of temporal variability in stream water quality? *Freshw. Biol.* **2007**, *53*, 827–841. [CrossRef]
10. Dixit, S.; Smol, J.P.; Kingston, J.C.; Charles, D. Diatoms–Powerful Indicators of Environmental-Change. *Environ. Sci. Technol.* **1992**, *26*, 22–33. [CrossRef]
11. Krupa, E.G.; Barinova, S.S.; Romanova, S.M. Ecological Mapping in Assessing the Impact of Environmental Factors on the Aquatic Ecosystem of the Arys River Basin, South Kazakhstan. *Diversity* **2019**, *11*, 239. [CrossRef]
12. Muzaffarov, A.M.; Musaev, K.Y. Materials for the knowledge of the flora of algae in water bodies of the upper reaches of the river Zarafshan. In *Algae of Reservoirs of Uzbekistan*; Publishing House "Fan": Tashkent, Uzbekistan, 1969; pp. 3–31. (In Russian)
13. Polyansky, V.I. On the flora of algae in Samarkand. In *Proceedings of the Botanical Institute of the USSR Academy of Sciences*; USSR: Saint Petersburg, Russia, 1950; Volume 2, pp. 137–147. (In Russian)
14. Ergashev, A.E. *Patterns of Development and Distribution of Algal Flora in Artificial Reservoirs of Central Asia*; Fan: Tashkent, Uzbekistan, 1976; 360p. (In Russian)
15. Toshpulatov, Y.S. Algal Flora of the Zarafshan River's Middle Course and It's Role in Assessing Ecological-Sanitary State of Water. Ph.D. Dissertation, Institute of Botany of Uzbek Academy of Sciences, Tashkent, Uzbekistan, 2018; 111p. (In Russian).
16. Mamanazarova, K.S. Seasonal development of indicator-system algae of the bottom river basin Zeravshan (Rep. Uzbekistan). *Algologia* **2014**, *24*, 67–74. (In Russian) [CrossRef]
17. Toshpulatov, Y.S. Taxonomic and floristic analysis of the middle stream algoflora of the Zarafshan river. *Bull. Gulistan State Univ. Gulistan* **2015**, *3*, 45–51. (In Uzbek)
18. Toshpolatov, Y.S.; Olimzhonova, K.O. *Algal Flora of the Middle Reaches of the Zarafshan River, Its Significance in Assessing the Ecological and Sanitary State of Waters*; Navroz: Tashkent, Uzbekistan, 2015; 128p. (In Uzbek)
19. Barinova, S.; Mamanazarova, K. Diatom Algae-Indicators of Water Quality in the Lower Zarafshan River, Uzbekistan. *Water* **2021**, *13*, 358. [CrossRef]
20. Dustov, B.S.; Tashpulatov, Y.S. Taxonomic Analysis and Ecological Features of the Algal Flora of the Water Bodies of the West Zarafshan Range. *Am. J. Plant Sci.* **2023**, *14*, 542–551. [CrossRef]
21. Kulmatov, R.; Opp, C.; Groll, M.; Kulmatova, D. Assessment of Water Quality of the Trans-Boundary Zarafshan River in the Territory of Uzbekistan. *J. Water Resour. Prot.* **2013**, *5*, 17–26. [CrossRef]
22. Shultz, V.L.; Mashrapov, R. *Hydrography of Central Asia*; Teacher: Tashkent, Uzbekistan, 1969; 360p. (In Russian)
23. Zarafshon davalt Kurikhonasi (Zarafshan Natural Reserve). Available online: https://qomus.info/encyclopedia/cat-z/zarafshon-davlat-qoriqxonasi-uz/ (accessed on 12 August 2024). (In Uzbek).
24. *Yearbook: Surface Water Quality in the Territory of UzHYDROMET Activity for 2009–2015*; Uzhydromet: Tashkent, Uzbekistan, 2015. (In Russian)
25. Guiry, M.D.; Guiry, G.M. AlgaeBase World-Wide Electronic Publication, National University of Ireland, Galway. Available online: http://www.algaebase.org (accessed on 18 August 2023).
26. Korde, N.V. Methods of biological study of bottom sediments of lakes (field work and biological analyses). In *Life of Fresh Waters of the USSR, Volume 4*; Pavlovsky, E.N., Zhadin, V.I., Eds.; Publishing House of the Academy of Sciences of the USSR: Moscow, Russia, 1956; pp. 383–413. (In Russian)
27. Sládeček, V. Diatoms as indicators of organic pollution. *Acta Hydroch. Hydrobiol.* **1986**, *14*, 555–566. [CrossRef]

28. Barinova, S.S.; Bilous, O.P.; Tsarenko, P.M. *Algal Indication of Water Bodies in Ukraine: Methods and Prospects*; Publishing House of Haifa University: Haifa, Israel, 2019; 367p. (In Russian)
29. Parmar, T.K.; Rawtani, D.; Agrawal, Y.K. Bioindicators: The natural indicator of environmental pollution. *Front. Life Sci.* **2016**, *9*, 110–118. [CrossRef]
30. Barinova, S. Essential and practical bioindication methods and systems for the water quality assessment. *Int. J. Environ. Sci. Nat. Resour.* **2017**, *2*, 79–89. [CrossRef]
31. Barinova, S. On the Classification of Water Quality from an Ecological Point of View. *Int. J. Environ. Sci. Nat. Resour.* **2017**, *2*, 555581. [CrossRef]
32. McAleece, N.; Gage, J.D.G.; Lambshead, P.J.D.; Paterson, G.L.J. *BioDiversity Professional Statistics Analysis Software*; Jointly Developed by the Scottish Association for Marine Science and the Natural History Museum London; Scottish Association for Marine Science: Oban, UK; Natural History Museum London: London, UK, 1997. Available online: https://www.sams.ac.uk/science/outputs/ (accessed on 10 July 2024).
33. Love, J.; Selker, R.; Marsman, M.; Jamil, T.; Dropmann, D.; Verhagen, J.A.; Ly, A.; Gronau, F.Q.; Smira, M.; Epskamp, S.; et al. JASP: Graphical statistical software for common statistical designs. *J. Stat. Softw.* **2019**, *88*, 1–17. [CrossRef]
34. Novakovsky, A.B. Abilities and base principles of program module "GRAPHS". *Sci. Rep. Komi Sci. Cent. Ural. Div. Russ. Acad. Sci.* **2004**, *27*, 28. (In Russian)
35. Sumita, M. A numerical water quality assessment of rivers in Hokuriku District using epilithic diatom assemblage in river bed as a biological indicator. (II) The values of RPID in surveyed rivers. *Diatom Jpn. J. Diatomol.* **1986**, *2*, 9–18.
36. Watanabe, T.; Asai, K.; Houki, A. Numerical estimation of organic pollution of flowing water by using the epilithic diatom assemblage—Diatom Assemblage Index (DAIpo). *Sci. Total Environ.* **1986**, *55*, 209–218. [CrossRef]
37. Khuram, I.; Ahmad, N.; Jan, S.; Barinova, S. Freshwater green algal biofouling of boats in the Kabul River, Pakistan. *Oceanol. Hydrobiol. Stud.* **2014**, *43*, 329–336. [CrossRef]
38. Moore, J.W. Toxic Substances in Water. In *The Changing Environment*; Springer Series on Environmental Management; Springer: New York, NY, USA, 1986; pp. 90–111. [CrossRef]
39. Behrooz, R.D.; Esmaili-Sari, A.; Chakraborty, P. Distribution and ECo-Toxicological Risk Assessment of Legacy Persistent Organic Pollutants in Surface Water of Talar, Babolrood and Haraz Rivers. *Water* **2020**, *12*, 3104. [CrossRef]
40. Pastorino, P.; Bertoli, M.; Squadrone, S.; Brizio, P.; Piazza, G.; Noser, A.G.O.; Prearo, M.; Abete, M.C.; Pizzul, E. Detection of trace elements in freshwater macrobenthic invertebrates of different functional feeding guilds: A case study in Northeast Italy. *Ecohydrol. Hydrobiol.* **2019**, *19*, 428–440. [CrossRef]
41. Barhoumi, B.; Beldean-Galea, M.S.; Al-Rawabdeh, A.M.; Roba, C.; Martonos, I.M.; Bălc, R.; Kahlaoui, M.; Touil, S.; Tedetti, M.; Driss, M.R.; et al. Occurrence, distribution and ecological risk of trace metals and organic pollutants in surface sediments from a Southeastern European river (Someşu Mic River, Romania). *Sci. Total Environ.* **2019**, *660*, 660–676. [CrossRef]
42. Aljanabi, Z.Z.; Al-Obaidy, A.-H.M.J.; Hassan, F.M. A Novel Water Quality Index for Iraqi Surface Water. *Baghdad Sci. J.* **2023**, *20* (Suppl. S6), 2395–2413. [CrossRef]

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