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The Development of Epiphytic Diatoms in the Vjosa River and Their Impact on Water Quality Based on the IPS Index

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Abstract

The focus of the biological investigation is a microscopic examination of diatom communities, which are frequently employed bioindicators of the health of freshwater systems. Epiphytic diatoms were gathered from five sampling locations along the Vjosa River, including Mifoli Bridge, Pocem, Memaliaj, Sajmola, and Tre Urat, which lies near the Albanian-Greek border. Between May 2022 and September 2022, a total of three field trips were undertaken on a quarterly basis. Chemical markers are frequently less informative than diatoms for detecting water quality. However, they are the organisms of choice for in situ biomonitoring because their communities can vary in response to rising concentrations of organic and inorganic chemicals. This study demonstrates that the shift in dominance of specific species, as shown by their relative abundances, is an indicator of alterations in the aquatic ecology of the Vjosa River. The detected dominating species comprise 131 diatom species, including, among others, Achnanthes neoexilis, Diatoma moniliformis, Brachisyra neoexilis, Achnanthes minutissima KŸtz. var. affinis, and Gomphonema clavatum Ehr. There were 129 penate species and 2 centric species. A penate diatom was the most abundant species at five survey sites across all sampling times. Therefore, we have computed the IPS (sensitive pollution index) Index in order to demonstrate the relationships between organic pollution (BOD, COD, total and P determination), ionic strength (chlorates, sulphates), and eutrophication (chlorophyll and nitrate). The Sensitive Pollution Index varied between good and excellent quality.

Keywords*:* Vjosa river, Epiphytic diatom, water quality, IPS

INTRODUCTION

Epiphytic diatoms have more specific environmental preferences and tolerances than most aquatic biota, and they are vital biological organisms because, like other algal divisions, they are a source of oxygen and sit at the base of aquatic food chains [1]. While some diatoms can exist as filamentous colonies, most are unicellular. Diatoms are siliceous cell walls that accumulate in rivers, lakes, and oceans. They can also act as epiphytes on macrophytes [2]. Diatom communities serve as an effective tool for the monitoring of environmental conditions, both in the past and in the present. They are typically employed in water quality studies. Biomonitoring techniques have been in use for more than a century [3] to assess the impacts of various types of pollution in freshwater. Diatoms are more prevalent in freshwater and inhabit all water basins [4]. They are essential organisms in ecological quality analyses of watercourses and have been used for over a decade in several European countries. The Vjosa River stands out as one of the last remaining free-flowing rivers in Europe, boasting an impressive range of hydro-morphological features. It flows through a vast area that includes Greece and Albania, forming an important delta in the Adriatic Sea. About the taxonomic

approach in Vjosa catchments, we identified 252 diatom taxa. More than 110 taxa have been identified in the Vjosa River, and more than 50 taxa have been identified in the Mifoli station (Vjosa River). The diatom community is dominated by Diatoma vulgaris, Achnanthe sminutissima, Cocconeis pediculus, Diatoma moniliformis, and Gomphonema olivaceum [5]. From the measured results, it is evident that the river has an annual average discharge of 0.20 m3/sec into the lake. The upper part is characterized by mountainous-low relief with a moderate slope that descends into a field relief before pouring into the lake. Upstream, the soil is predominantly clayey, while downstream, the soil is clayey. The distribution of diatom communities reflects the impact of organic and inorganic matter. More information is provided by trophic and saprobic indices, in which the trophic index correlates with inorganic material and the saprobic index correlates with organic material. The aim of this study is the assessment of the species composition of microscopic algae (diatoms) as indicators for evaluating water quality according to EU directives. The research applies various biological indicators like Pollution Index (IPS), to show the connections between organic pollution (BOD, COD, total and P determination), ionic strength (chlorates, sulphates), and eutrophication (chlorophyll and nitrate), etc. The presence of water eutrophication, resulting from nutrient alterations, can lead to substantial modifications within an ecosystem. The measurement of diatom population variance across seasons and sites is assessed through the computation of various indices to determine their suitability to monitor the relatively unpolluted waters of the Vjosa.

MATERIAL AND METHODS

The Vjosa River originates from the Pindus Mountains in northwest Greece and flows northwest towards Albania. It continues in a northwest direction towards Albania and has a total length of approximately 272 km, with 80 km of its course running through Greece and roughly 192 km located within Albania. The wet area surrounding the Vjosa spans about 6,706 km^2, of which 2,154 km^2 falls within the borders of Greece and 4,552 km^2 within the borders of Albania. The Vjosa Valley encompasses nearly 16% of Albania's land and is renowned for its rich biodiversity. The natural habitats present within this ecosystem promote ecological continuity by supporting diverse wildlife. For this reason, approximately 10 protected areas and almost 130 natural monuments have been designated along the valley. In 2021, the Vjosa River was designated a National Park, cementing its status as Europe's last remaining unspoilt river. Diatom sampling and monitoring were carried out in five different sites (Mifoli Bridge, Pocem, Memaliaj, Sajmola, and Tre Urat, located close to the Albanian-Greek border) between May and September 2022 (see Figure 1).

In this research, we present a total of 15 samples in which we have identified multiple diatom species and their ecological status. The diatom communities were examined microscopically for the biological study and collected from epilithic surfaces of stones or various macrophytes such as Chladophora or Potamogeton species. The suspensions resulting from the experiment were collected in small bottles and preserved in 4% formaldehyde for safekeeping, as described in previous studies [1], [4], [6]. Diatom frustules were purified by boiling in H2O2cc (EN13946:2003). Species composition data was collected based on a count of approximately Using 100 oil immersion views, 500 valves per slide were measured. This produced a 95% confidence level. Previous studies by [1], [7], [8] were also consulted.

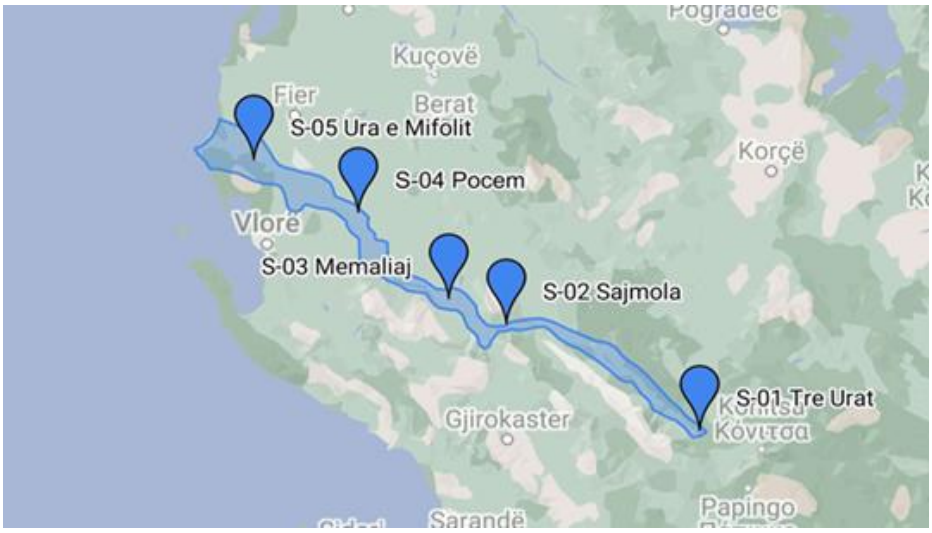

Figure 1. Sampling station location of River Vjosa

Diatoms were identified according to standard literature [9],[10]. In each sample, we calculated the Diversity Index (H') following the [9],[11] methodology. It was originally developed at the Cemagref Institute by Coste (1982) [9], using the formula of Zelinka and Marvan (1961), and elaborated on by Eloranta and Kwandrans (1996) [10]. IPS is likely in use in many countries today, including our own for this study. The IPS indicator assesses the impact of all pollutants, including organic and inorganic pollution, as well as poisons. It is particularly relevant in cases where it is known that organic pollution plays a significant role in the context of the studied sale [12],[13]. Numerous studies have shown that the diatom community changes when exposed to increasing levels of organic and inorganic substances. As a result, diatoms have become the preferred group of organisms for in situ biomonitoring studies in Europe, the USA, and Asia [14-16]. In this publication, efforts towards biomonitoring waters are specified in accordance with international standards, particularly those of the EU, in order to aid their implementation in Albania. Improved knowledge of water quality enhances security by enhancing skills to determine policies and measures.

RESULTS AND DISCUSSION

Diatom species composition

Comparing the results obtained over three different seasons in 2022 (May, July, and September), we observed an increase in the number of taxonomic groups and variations in the dominant taxa. Each species has distinct preferences for inhabiting specific environments [7]. Diatoms are the most important group of microscopic algae, capable of indicating the environmental status where samples are collected. It has been shown that nutrient enrichment can lead to detectable changes in the diatom community at the species level [17]. There is a variation in the number and occurrence of species within an equivalent grouping. During the wet period of the year (May 2022), approximately 100 species were identified, with a prevalence of species including Cyclotella ocellata Pantocsek, which had a frequency of 13.3% at Tre Urat-Aos River station. Technical term abbreviations have been explained upon first use. Achnanthes exilis Kützing, with a frequency of 123.3% at Tre Urat and 16.2% in Pocem (Memaliaj); and Cocconeis placentula var. lineata Ehrenberg. Van Heurck was present in all stations, with a frequency of 143% in the three bridge stations and 93.3% in Mifol, as

well as 56.7% in Sajmole. Cymbella affinis Kützing agg. was typically found in 120% of samples from Sajmole and 70% in Tre Urat. Gomphonema olivaceum var. minutissimum Hustedt was found in approximately 70% of samples from Dragot Station. It is worth noting that other species were also observed during this sampling period, but their frequency was less than 15%. During the dry period of July 2023, 131 species were identified in the Mifoli station, including Gomphonema minutum (Ag.), Agardh f. minutum, and Gomphonema pumilum. During the dry period of July 2023, 131 species were identified in the Mifoli station, including Gomphonema minutum (Ag.), Agardh f. minutum, and Gomphonema pumilum. However, most of these species were found with a low frequency, with a maximum of 20%. Brachysira neoexilis Lange-Bertalot was an exception, with a frequency of approximately 24%. During September, almost the same situation was observed, with the identification of approximately 125 species. However, their frequency remained under 20%, except for Cocconeis pediculus Ehrenberg, which had a frequency of 22.5% at the Aragosta (Klos) station, and Cocconeis placentula var. lineata (Ehrenberg) Van Heurck, which had a frequency of approximately 34% at the same station.

In a separate study carried out by [5] in the Vjosa River, 110 taxa were identified, with an additional 50 taxa found at the Mifoli station. The most prevalent taxa included Diatoma vulgaris, Diatoma moniliformis, Achannthes minutissima, and Gomphonema olivaceum. Furthermore, Miho et al. (2018) discovered the presence of the filamentous algae Chladophora glomerata in the Vjose River, which was also observed in previous studies conducted by [5],[18]. It is imperative to mention that our study found the presence of Chladophora glomerata at several stations of the Vjosa River, for example, Sajmola, Memaliaj, and Kelcyra, which were widespread findings during the July expedition at Tre Urat. This situation is due to arid atmospheric conditions and inadequate precipitation, resulting in reduced water flow and diminished plant life within the aquatic environment.

The Vjosa River seems to be present with rare and little-known species as: Gyrosigma wansbeckii (Donkin) Cleve, Navicula tuscula Ehrenberg, Rhopalodia gibba (Ehr.) O. Muller var.gibba, Nitzschia diversa Hustedt, Nitzschia diversa Hustedt etc.

Table 1. The frequency of species distribution at all sampling stations and during all sampling periods as: (+) low, (++) middle, (+++) high, (++++) very high density

		Species name						
Sampling periods	**Sampling sites**	*Cyclotella ocellata Pantocsek*	*Achnanthes exilis Kützing*	*Cocconeis pediculus Ehrenberg*	*Cocconeis placentula var. lineata*	*Cymbella affinis Kützing agg.*	*Gomphonema olivaceum var .olivaceolacuum*	*Brachysira neoexilis Lange-Bertalot*
		Dominance of species						
May-22	Poçem	+	+	+	+	+	+	+
	Mifol	+	+	+	+++	+	+	+
	Memaliaj	+	+	+	++	+	+	+
	Sajmola	+	+	+	+++	++++	++++	+
	Tre Urat	+	++++	+	++++	+++	++	+

Jul-22	Poçem	+	+	+	+	+	+	+
	Mifol	+	+	+	+	+	+	++
	Memaliaj	+	+	+	+	+	+	+
	Sajmola	+	+	+	+	+	+	+
	Tre Urat	+	+	+	+	+	+	+
22-Sep	Poçem	+	+	++	+	+	++	+
	Mifol	+	+	+	+	+	+	++
	Memaliaj	+	+	+	+	+	+	+
	Sajmola	+	+	+	+	+	+	+
	Tre Urat	+	+	+	+	+	+	+

Ecological Assessment

To conduct an ecological assessment of the Vjosa river waters, we used the pollution index (IPS) as an evaluation tool. Abbreviations will be explained when they are used for the first time. Kupe came up with the trophic index (for inorganic water pollutants) and the saprobic index (for organic water pollutants) to figure out the state of Vjosa in 2006 [17] and [18].Our investigation is focused on the IPS index. In contrast to TI_{DIA} and SI, IPS offers a comprehensive overview of pollutants present in water basins, including organic and inorganic pollutants, poisons, salinity, and other substances. This approach enabled us to obtain a more complete understanding of the ecological state of the river Vjosa. Based on the IPS calculation standard developed by Coste in Cemagref in 1982, the French and Belgian standards determine that water quality is very good when IPS is between 17 ≤ IPS ≤ 20 17.5. Good water quality is indicated when IPS ranges from 13 ≤ IPS ≤ 17. Conversely, poor water quality is a result of IPS between 9 ≤ IPS ≤ 13, while IPS values is Less than 5, indicate bad water quality.

Table 2. Data on IPS values in several stations of the Vjosa River during different seasons throughout one year

Sampling periods	Sampling sites	Number of species, N:	Margalef Index, d (Margalef, 1958)	Specific Pollution Sensitivity Index (IPS; Coste in Cemagref, 1982)	Classes of Specific Pollution Sensitivity Index (IPS; Coste in Cemagref, 1982)
May '22	Mifol	33	6.6	16.1	Good
	Pocem	8	1.2	15.2	Good
	Memaliaj	10	1.8	16.0	Good
	Sajmole	31	4.2	17.9	Very good
	Tre Urat	18	2.8	15.8	Good
July '22	Mifol	23	3.1	16.3	Good
	Pocem	22	3.4	15.9	Good
	Memaliaj	22	3.3	14.9	Good

	Sajmole	21	3.1	16.3	Good
	Tre Urat	29	4.0	16.5	Good
September '22	Mifol	22	3.1	15.7	Good
	Pocem	26	3.8	17.3	Very good
	Memaliaj	18	2.7	18.4	Very good
	Sajmole	21	3.9	19.4	Very good
	Tre Urat	30	4.3	17.2	Very good

From Table 2, it is evident that IPS values consistently vary between good and very good water quality. Notably, all water sampling stations recorded very good quality during September 2022. The high IPS values, which indicate good or very good water conditions (Table 1), are linked to the scarce presence of species such as Melosira varians, Navicula capitata, Fragilaria capucina, Cymbella tumida, Synedra ulna, Cyclotella meneghiniana, and Cocconeis placentula, which occupy a small percentage in all sampling stations and seasons [19]. The low values of phosphates and ammoniums are a result of pristine areas with minimal human habitation and without the impact of urban or rural pollution.

CONCLUSION

In this research, a total of 131 diatom species were identified, comprising Achnanthes neoexilis, Diatoma moniliformis, Brachisyra neoexilis, Achnanthes minutissima KŸtz. var.affinis, Gomphonema clavatum Ehr., and others. Among these species, 129 were pennate and 2 were centric diatoms. The study has identified the presence of *Chladophora glomerata* at various stations along the Vjosa River, including Sajmola, Memaliaj, and Kelcyra. These findings were prevalent during the July expedition at Tre Urat. The IPS values indicate consistently good to very good water quality. Remarkably, all water sampling stations recorded very good quality in September 2022.

Albania is striving to adhere to the EU's environmental criteria, and the ecological status of surface waters is monitored in accordance with the European Water Framework Directive (WFD, 2000) [20]. To aid in the development of future plans for conservation and management, experts should consider using these techniques. This is particularly important in light of the upcoming expansion of dams and the unsustainable development of hydropower plants.

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CONFLICT OF INTERESTS

The authors confirm that there is no conflict of interests associated with this publication.

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