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Research Article

ECOLOGICAL EFFECTS OF BELIK RIVER HYDRAULIC CHARACTERISTICS ON PERIPHYTON COMMUNITY AS WATER QUALITY BIOINDICATOR

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ARTICLE HIGLIGHTS

- Differences in river hydraulic characteristics affect ecological river health
- The influence of flooding on the dynamics of physical and chemical characteristics of river water
- Life strategy, adaptation of periphyton to environmental changes
- Development of green infrastructure for river conservation

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ABSTRACT

Belik River is one of urban rivers in the Special Region of Yogyakarta, which has hydrological problems both in quantity and quality. These problems triggered the construction of various types of channel modifications. This study aimed to identify water quality and the ecological effects of channel modifications based on the presence of periphyton communities as water quality bioindicators. Sampling was carried out in January 2021 and March 2021. Samples were taken from 4 sampling sites having different channel characteristics with 3 repetitions at each location. The physicochemical parameters measured included pH, detergent, nitrate, sulfate, total phosphate, TSS, TDS, DO, CO_2, water temperature, depth, transparency, discharge, current velocity, and yearly rainfall data. Ninety-one (91) periphyton species dominated by *Nitzschia improvisa*, *Nitzschia terricola*, and *Nitzschia philippinarum* were found in January 2021, higher than the 61 species of periphyton dominated by *Nitzschia improvisa* found in March 2021. Results of the Canonical Correlation Analysis (CCA) indicated that the distribution and abundance of periphyton in Belik River were influenced by CO_2, total phosphate, discharge, DO, nitrate, TSS, and depth. The Shannon-Wiener Diversity Index showed that water quality in January 2021 decreased compared to March 2021. Results of the cluster analysis showed differences in water quality and abundance of periphyton found in the four types of river channels. It can be concluded that differences in hydraulic characteristics affected water quality and the ecological health of Belik River.

Keywords: *canonical correlation analysis, cluster analysis, diversity index, Nitzschia, pennate diatom*

INTRODUCTION

Land use changes in the Belik watershed area were influenced by the increase in population growth (Utami & Suprayogi 2014). These changes include the increase in asphalt/cement buildings (7.11%) and the reduction of vegetated land (3.64%) (Mubarok & Suprayogi 2018). Environmental deterioration may arise from development practices that do not prioritize ecological sustainability. Surface runoff in the rainy season can occur because of development activities, so that rainwater cannot infiltrate the soil (Utami & Suprayogi 2014). Human activities also cause groundwater quality to decline around the Belik River (Suprayogi *et al.* 2019). In addition, the waste input in the upstream part of Kali Belik cannot be accommodated due to surface water pollution (Suprayogi *et al.* 2019; Tofani & Hadi 2020). Wisdom Park (*Taman Kearifan*), through which the Belik River flows, is one of the developed areas designed to deal with hydrological problems. The modification of the river channel in Wisdom Park accommodate rainwater to reduce flooding (Lumuan *et al.* 2017). Channel modification is done by changing the hydraulic characteristics of the water. The changes include rivers that are straightened, deepened, and widened (Franklin *et al.* 2009; Harisnor & Amalia 2016).

Many factors, including alteration in hydraulic characteristics, can lead to changes in the ecology of an aquatic ecosystem. In addition, the linkage between river channel and flood plain can be disturbed by the construction of embankments along the river, causing harm to biodiversity (Franklin *et al.* 2009; Lennox & Rasmussen 2016). Water organisms respond to changes in abiotic conditions of an aquatic ecosystem (Amoatey & Baawain 2019). Changes to the distribution and abundance of organisms in an ecosystem can also indicate water quality (Manickavasagam *et al.* 2019). Periphyton is one of aquatic organisms that can be used as a water quality bioindicator (Larned 2010; Rashid *et al.* 2013; Rier & Stevenson 2006). The combination of physical, chemical, and biological parameters provide comprehensive water quality analysis. Therefore, this research examined the effects of river channel modification on ecological conditions of periphytic community as water quality bioindicator.

MATERIALS AND METHODS

Study Area

The research was conducted in the upstream region of the Belik River in Sleman Regency, Yogyakarta Special Region. This study had 4 sampling sites in Belik River (BR1, BR2, BR3, BR4). Samples were collected in January 2021 (before the flood) and March 2021 (after the flood). The description of the research location is shown in Table 1 and Figure 1.

Periphyton Collections

Periphyton sample was collected by implementing scraping method using a soft brush based on the Periphyton Protocols literature (US Environmental Protection Agency 2012, 2012). At each sampling point, samples were taken from the stone masonry wall and the rocks in the river with a size of 5 cm x 5 cm. The west side of the river wall was used to take periphyton samples before the flood, while the east side wall was used to sample the periphyton after the flood. The periphyton was separated from the surface of the river wall with a soft brush, sprayed with distilled water, and collected on a tray.

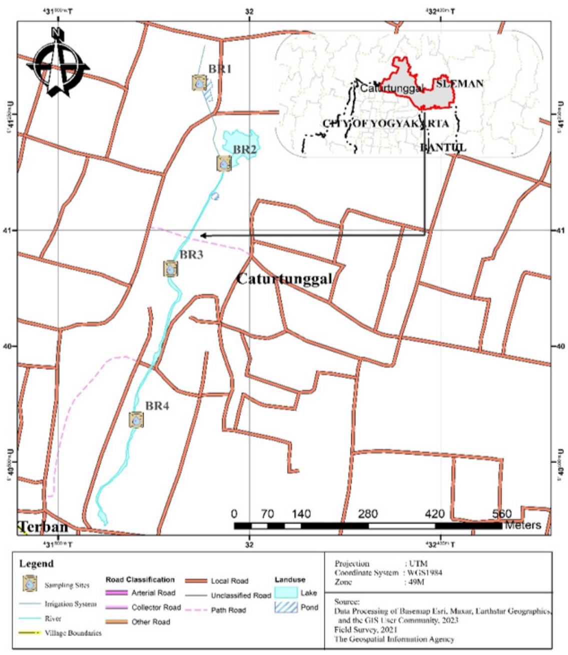

Figure 1 Map of sampling sites at Belik River in Sleman Regency, Special Region of Yogyakarta

Table 1 Sampling site and their characteristics

Sampling site	Code	GPS (Lat-Long)	Altitude (masl)	Hydraulic characteristics
Belik River	BR1	7°46'03.5" S 110°22'56.3" E	1,135.38	natural bottom, straightened furrow, and stone masonry shorelines
	BR2	7°46'08.9" S 110°22'57.7" E	1,152.75	modified bottom, straightened furrow, and stone masonry shorelines
	BR3	7°46'14.2" S 110°22'53.0" E	1,135.69	modified bottom, straightened furrow, and gabions shorelines
	BR4	7°46'27.9" S 110°22'52.1" E	1,125.32	natural bottom, furrow, and shorelines

The water sample on the tray was put into a 10 mL vial bottle. After that, fixation was carried out by giving 3 drops of 4% formaldehyde in each vial bottle. Vial bottles were then wrapped in plastic, tied with rubber bands, and labeled. For each research station, periphyton samples were collected with 3 replications (the right side of the river, the middle side of the river, and the left side of the river) in order to increase the level of data accuracy and represent the heterogeneous condition of the waters in the river flow on each side. Water volume taken for each periphyton sampling was 10 mL. Therefore, with 3 replications, the total water sample volume at each sampling point was 30 mL. Periphyton samples that had been preserved were inserted into the Sedgewick Rafter Counting Chamber (SRCC) and observed under a microscope with a magnification of 10 x 10. The periphyton samples that had been obtained were then identified based on "The Freshwater Algae of The United States" (Smith 1950), "Plankton of South Vietnam" (Shirota 1966), and "How to Know Freshwater Algae" (Prescott 1981) literatures.

Water Quality Collections

Water samples for water physicochemical parameters measurement were taken based on the guidelines of APHA literature (1998). Physical and chemical parameters measured directly in the field include DO, CO_2, pH, water temperature, depth, current velocity, discharge, and transparency. The floating method measured current velocity, and the discharge was calculated using the slope area method. Meanwhile, water samples for parameter measurement, including TDS, TSS, total phosphate, nitrate, sulfate, and detergent, were collected and taken to the laboratory for analysis.

Data Analysis

The calculation of periphyton on the SRCC was carried out using the total strip counting method. The periphyton identification results were counted using a hand counter and analyzed in Microsoft Office Excel 2007 to determine the density of the species (D). Furthermore, the Shannon-Wiener Diversity Index was calculated using a formula as follows (Kent & Paddy 1992):

$$H' = \sum_{i=1}^{S} [pi \ln pi]$$

$$\text{pi} = \frac{\text{ni}}{\text{N}}$$

where:

H' = index of species diversity

ni = number of individuals of an I species

N = number of individuals of all species

pi = proportion of the number of individuals of the I species to the number of individuals of all species.

The data were analyzed using Canonical Correlation Analysis (CCA) with Paleontological Statistic (PAST) software version 3 to determine the relationship between periphyton and physico-chemical parameters (Venkateswarlu *et al.* 2020). Then, cluster analysis was carried out to classify and determine differences in the characteristics of the sampling sites (Hossain *et al*. 2013).

RESULTS AND DISCUSSION

Periphyton species found in Belik River were classified into 96 species and grouped into 6 functional groups, namely filamentous algae, pennate diatoms, unicellular algae, colony algae, centric diatoms, and dinoflagellates. The species composition in January 2021 differed from the periphyton composition in March 2021 (Table 2). Several periphyton species were only found in January 2021, such as *Mougeotia* sp., *Spyrogyra* sp., *Melosira granulata*, *Malleochloris sessilis*, *Spondylosium planum*, *Desmidium baileyi*, *Sphaeroplea annulina*, *Nitzschia* sp., *Nitzschia acicularis*, *Nitzschia vermicularis*, *Navicirula* sp., *Navicirella elegans*, *Pinnularia giba*, *Tabellaria fenestrata, Diatoma vulgaris, Cocconeis* sp., *Anomoeneis* sp., *Frustulia rhomboides, Gyrosigma attenuatum, Pleurosigma* sp., *Straurastrum notula, Cosmarium reniforme, Pleurotaenium* sp., *Chroococcus turgiderius* sp., *Palmella miniata, Protococcus viridis, Peridinium gatunense, Gonyaulax* sp., *Prorocentrum* sp., and *Dinobryon* sp. In contrast, several species of *Spirulina major, Fragilaria crotonensis, Epithemia turgida, Stauroneis* sp., and *Cosmarium turpinii* were only found in March 2021.

Table 2 List of Belik River periphyton species found in January 2021 and March 2021

No.	No.	Periphyton species	Presence	
			January	March
Filamentous Algae				
1	1	*Lyngbya birgei*	+	+
2	2	*Oscillatoria* sp.	+	+
3	3	Mougeotia viridis	+	+
4	4	*Mougeotia* sp.	+	-
5	5	*Spyrogyra* sp.	+	-
6	6	*Spirulina major*	-	+
7	7	*Hyalotheca dissiliens*	+	+
8	8	*Hyalotheca mucosa*	+	+
9	9	*Hyalotheca* sp.	+	+
10	10	*Melosira varians*	+	+
11	11	*Melosira islandica*	+	+
12	12	*Melosira granulata*	+	-
13	13	*Plectonema tomasiniana*	+	+
14	14	*Zygnemopsis* sp.	+	+
15	15	*Schizogonium murale*	+	+
16	16	*Malleochloris sessilis*	+	-
17	17	*Spondylosium planum*	+	-
18	18	*Desmidium baileyi*	+	-
19	19	*Sphaeroplea annulina*	+	-
Pennate Diatom				
20	1	*Nitzschia improvisa*	+	+
21	2	*Nitzschia acicularis*	+	-
22	3	*Nitzschia terricola*	+	+
23	4	*Nitzschia filiformis*	+	+
24	5	*Nitzschia* sp.	+	-
25	6	*Nitzschia sigmoidea*	+	+
26	7	*Nitzschia philippinarum*	+	+
27	8	*Nitzschia ligowskii*	+	+
28	9	*Nitzschia hassall*	+	+
29	10	*Nitzschia vermicularis*	+	-
30	11	*Navicula* sp.	+	-
31	12	*Navicula cryptocephala*	+	+
32	13	*Navicula gregaria*	+	-
33	14	*Navicula gastrum*	+	+
34	15	*Synedra acus*	+	+
35	16	*Synedra ulna*	+	+
36	17	*Synedra* sp.	+	+
37	18	*Surirella robusta*	+	+
38	19	*Surirella terera*	+	-
39	20	*Surirella elegans*	+	-
40	21	*Pinnularia giba*	+	-
41	22	*Pinnularia* sp.	+	+
42	23	*Pinnularia viridis*	+	+
43	24	*Denticula elegans*	+	+
44	25	*Tabellaria fenestrata*	+	-
45	26	*Neidium affine*	+	+
46	27	*Fragilaria crotonensis*	-	+
47	28	*Diatoma vulgaris*	+	-
48	29	*Diatomella balfouriana*	+	+
49	30	*Diatoma* sp.	+	+
50	31	*Diatoma elongatum*	+	+
51	32	*Epithemia turgida*	-	+
52	33	*Gomphonema micropus*	+	+
53	34	*Gomphonema* sp.	+	+
54	35	*Odontidium mesodon*	+	+
55	36	*Cocconeis* sp.	+	-
56	37	*Anomoeneis* sp.	+	-
57	38	*Frustulia rhomboides*	+	-
58	39	*Brachysira microcephala*	+	+
59	40	*Amphora ovalis*	+	+
60	41	*Gyrosigma attenuatum*	+	-
61	42	*Licmophora* sp.	+	+
62	43	*Pleurosigma* sp.	+	-
Unicellular Algae				
63	1	*Closterium littorale*	+	+
64	2	*Closterium lunula*	+	+
65	3	*Closterium* sp.	+	+
66	4	*Straurastrum notula*	+	-
67	5	*Stauroneis* sp.	-	+

No.	No.	Periphyton species	Presence	
			January	March
68	6	*Cosmarium reniforme*	+	-
69	7	*Cosmarium turpinii*	-	+
70	8	*Pleurotaenium* sp.	+	-
71	9	*Chroococcus turgidus*	+	-
72	10	*Chlorococcum* sp.	+	+
73	11	*Ankistrodesmus densus*	+	+
74	12	*Oocystis borgei*	+	-
75	13	*Cylindrocystis gracilis*	+	+
76	14	*Cylindrocystis* sp.	+	+
77	15	*Colacium vesiculosum*	+	+
Colony Algae				
78	1	*Pediastrum biradiatum*	+	+
79	2	*Scenedesmus dimorphus*	+	+
80	3	*Scenedesmus quadricauda*	+	+
81	4	*Anabaena circinalis*	+	+
82	5	*Merismopedia tenuissima*	+	+
83	6	*Pandorina morum*	+	+
84	7	*Sphaerocystis schroeteri*	+	-
85	8	*Gloeocapsa gelatinosa*	+	+
86	9	*Coelosphaerium* sp.	+	-
87	10	*Palmella miniata*	+	-
88	11	*Protococcus viridis*	+	-
Centric Diatom				
89	1	*Biddulphia* sp.	+	+
90	2	*Cyclotella meneghiniana*	+	+
Dinoflagellate				
91	1	*Peridinium gatunense*	+	-
92	2	*Peridinium umbonatum*	+	+
93	3	*Peridinium* sp.	+	+
94	4	*Gonyaulax* sp.	+	-
95	5	*Prorocentrum* sp.	+	-
96	6	*Dinobryon* sp.	+	-

Table 2 data shows that in March 2021, 35 periphyton species were missing, and 5 periphyton species were present as new species in Belik River. The reduction of periphyton species number in March 2021 occurred in almost all sampling sites compared to that in January 2021 (Fig. 1). This can be caused by several flood events in February 2021. The average amount of rainfall has increased significantly in 2020 and 2021 (Table 3). Floods in March 2021 could be caused by an accumulation of rainfall during January - March 2021 (the peak of heavy rains at the research location). Flood is one of the disturbances for periphyton because these creatures live by sticking to the substrate (benthic). The flood caused the current velocity and discharge to increase, thus periphyton, especially the immobile periphyton, were swept away by the water. In addition, periphyton density was influenced by the presence of nutrient content and sediment from floods (Wang *et al.* 2018; Whorley & Wehr 2016).

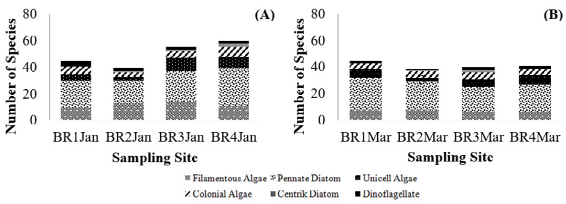

Figure 2 Number of periphyton species found in Belik River in (A) January 2021 and (B) March 2021

TDS average in January 2021 (97.5 mg/L) increased to 208.5 mg/L in March 2021. Likewise, TSS increased in March 2021 from an average of 90.15 mg/L to 217.5 mg/L. Transparency decreased from 0.12 m to 0.06 m (Table 4). Transparency less than 20 cm indicates that the water was very turbid (Pal *et al.* 2015), which is the very turbid water ecosystem category. In a very turbid water ecosystem, photosynthetic process can be disrupted because turbidity reduces light penetration into the water (Bahri & Maliga 2018; Butler & Ford 2018; Rashid *et al.* 2013; Singh *et al.* 2017).

Table 3 Yearly rainfall data (last 5 years) in the study area

Month	Rainfall (mm3/day)				
	2017	2018	2019	2020	2021
January	384.16	533.61	216.78	1,005	1,182
February	258.18	329.07	453	1,089	811.5
March	277.16	305.12	1,326	1,963.5	1,038
April	294.4	19.16	672	955.5	226.5
May	135.56	19.10	16.5	736.5	189
June	51.73	12.15	1.5	4.5	595.5
July	21.08	74.48	1.5	3	154.5
August	4.78	0.78	6	66	72
September	85.26	104.27	139.55	124.5	379.5
November	124.54	95.52	28.5	715.5	589.5
December	761.13	215.99	114	394.5	849
Total	362.60	186.2	1,360.5	621	247.5
Average	2,760.57	1,895.47	4,335.83	7,678.5	6,334.5
Maximum	230.05	157.96	361.32	639.88	527.88

Table 4 Physicochemical characteristics of Belik River in January and March 2021

Physicochemical parameters	BR1 Jan	BR2 Jan	BR3 Jan	BR4 Jan	BR1 Mar	BR2 Mar	BR3 Mar	BR4 Mar
DO (ppm)	7.33	7.90	7.87	6.17	5.40	6.13	5.43	4.93
CO_2	5.33	2.00	2.00	2.67	4.25	2.92	4.75	3.25
pH	7.30	6.93	7.03	7.00	6.90	7.10	7.13	7.00
Water temperature (°C)	28.67	27.00	27.17	27.00	27.33	26.33	27.00	26.00
Depth (m)	0.16	0.20	0.18	0.22	0.17	0.27	0.24	0.18
Current velocity (m/s)	0.72	0.54	0.67	0.20	0.84	0.52	0.43	0.34
Discharge (m^3/s)	0.32	0.28	0.60	0.98	0.50	0.31	0.35	0.28
Transparency (m)	0.08	0.12	0.13	0.13	0.05	0.05	0.06	0.08
TDS (mg/L)	112	120	70	88	296	218	144	176
TSS (mg/L)	48.6	152	90.8	69.2	216	125	123	406
Total phosphate as PO_4 (mg/L)	0.24	0.27	0.28	0.24	0.81	0.32	0.33	0.29
Nitrate as NO_3-N (mg/L)	4.19	4.83	3.81	3.46	1.45	1.38	1.12	1.63
Sulfate as SO_4 (mg/L)	18.34	16.20	21.66	25.23	9.40	7.50	12.70	4.82
Detergent as $C_{18}H_{29}NaO_3S$ (µg/L)	< 2	< 2	< 2	< 2	198	21	< 2	21

The number of periphyton species in BR2 January 2021 and BR2 March 2021 was the lowest number of species compared to that in other sampling points (Fig. 2). BR2 is a canalized river channel with a pavement-modified riverbed. The sediment transport rate was accelerated by the pavement of the river channel so that sediment tends to be deposited in the downstream area of the river. Sediment was used by mobile periphyton as a shelter during the flood, while immobile periphyton will be immediately carried away by the current (Hoyle *et al.* 2016). BR1, BR3, and BR4 had the natural characteristics of riverbed, formed by soil and mud. In addition, in BR4, the periphyton was protected by water plants when the current velocity and discharge increased. The release of nutrients plants can also be used by periphyton for their growth. Aquatic plants also had an important role as agents in the phytoremediation process of water (Kemalasari & Choesin 2011; Kukuryk & Mieczan 2012; Swanson *et al.* 2017; Ummi *et al.* 2019). Therefore, the BR2 channel was unsuitable for periphyton to live because of the absence of sediments and aquatic plants .

The Shannon Wiener Diversity Index showed that water quality in BR1, BR2, and BR3 in January 2021 and March 2021 was lightly polluted. Meanwhile, water quality of BR4 in January 2021 was very lightly polluted. Subsequently, water quality changed to medium pollution in March 2021 (Table 4), in which that carbon dioxide, total phosphate, and detergent levels increased. Meanwhile, DO has decreased below class II water quality threshold. Nitrate levels in BR4 were the highest compared to that in other sampling points (Table 4). This drastic change can be caused by the flow of water from the upstream area, especially BR2, on a canalized river. The water flow brought sediment when it flooded in February 2021, which was deposited in BR4. According to Walalite *et al.* (2016), canalized channels do not have floodplains and substrates to filter nutrients and sediment in water when the flood occurs.

The periphyton genus most commonly found in this study was *Nitzchia*. The most abundant species in January 2021 were *Nitzschia improvisa* (BR1, BR2), *Nitzschia philippinarum* (BR3), and *Nitzschia terricola* (BR4). Meanwhile, the most abundant species in March 2021 was *Nitzschia improvisa* at all sampling points (Fig. 3). *Nitzschia* is part of the pennate diatom, a functional group with the highest number of species (Fig. 2). Diatoms have an important role in the silica cycle. Silica is one of the compositions for making detergent, so the high detergent content in waters can be indicated by the presence of diatom pennate (Biranje *et al.* 2015; Singh & Parikh 2020). This finding is consistent with the condition of BR1 in March 2021, which experienced a significant detergent increase (Table 4). The river flow at the BR1 sampling point was in the middle of a community settlement dominated by economic activities, such as student boarding houses and laundry facilities, which disposed washing waste into the river body. The presence of *Nitzschia, Navicula,* and *Synedra* indicates that the river waters are turbid and contain excessive organic matter.

Meanwhile, the existence of a genus that has tolerance for pollutants, such as *Cyclotella, Amphora, Melosira,* and *Surirella* showed that the waters contain anthropogenic waste (Singh & Parikh 2020). This statement can be proven by high levels of total phosphate in BR1, BR2, BR3, and BR4 in March and January 2021, which exceeded class II water quality (Table 3). Phosphate in waters can be caused by domestic waste (54%), agriculture (38%), and industry (8%). High phosphate content indicated the presence of high household waste. One of the wastes that can cause high phosphate content in waters is domestic waste from community settlements, especially related to washing waste because detergent also contains phosphate (Mekonnen & Hoekstra 2018; Puijenbroek *et al.* 2018). The upper reaches of settlements of Belik River, which tend to be congested and are very close to the river, can be one of the causes of river pollution. In this study, cluster analysis was carried out to classify the conditions of the sampling locations based on their characteristics. Canonical Correlation Analysis (CCA) was also carried out to find out the water quality parameters that contributed most impacts to periphyton community. Results of cluster analysis showed that the environmental conditions at the 4 sampling sites were divided into 2 clusters. In January 2021, the first cluster consisted of BR3, BR4, and BR1, while the second cluster consisted of BR2 (Fig. 4). In March 2021, the first cluster consisted of BR4, while the second cluster consisted of BR2, BR3, and BR1 (Fig. 5). Based on these data, it can be concluded that there have been changes in the dynamics of physical, chemical, and biological conditions at different sampling times resulting in cluster shifts. In January 2021, BR3 had a close relationship with BR4, but changed to be closer to BR2 in March 2021.

Table 5 Water quality based on Shannon-Wiener Diversity Index (H')

H' and Water Quality	BR1 Jan	BR2 Jan	BR3 Jan	BR4 Jan	BR1 Mar	BR2 Mar	BR3 Mar	BR4 Mar
Shannon-Wiener Diversity Index	2.40	2.79	2.90	3.14	2.75	2.32	2.45	1.99
Water quality	Lightly polluted	Lightly polluted	Lightly polluted	Very lightly polluted	Lightly polluted	Lightly polluted	Lightly polluted	Medium polluted

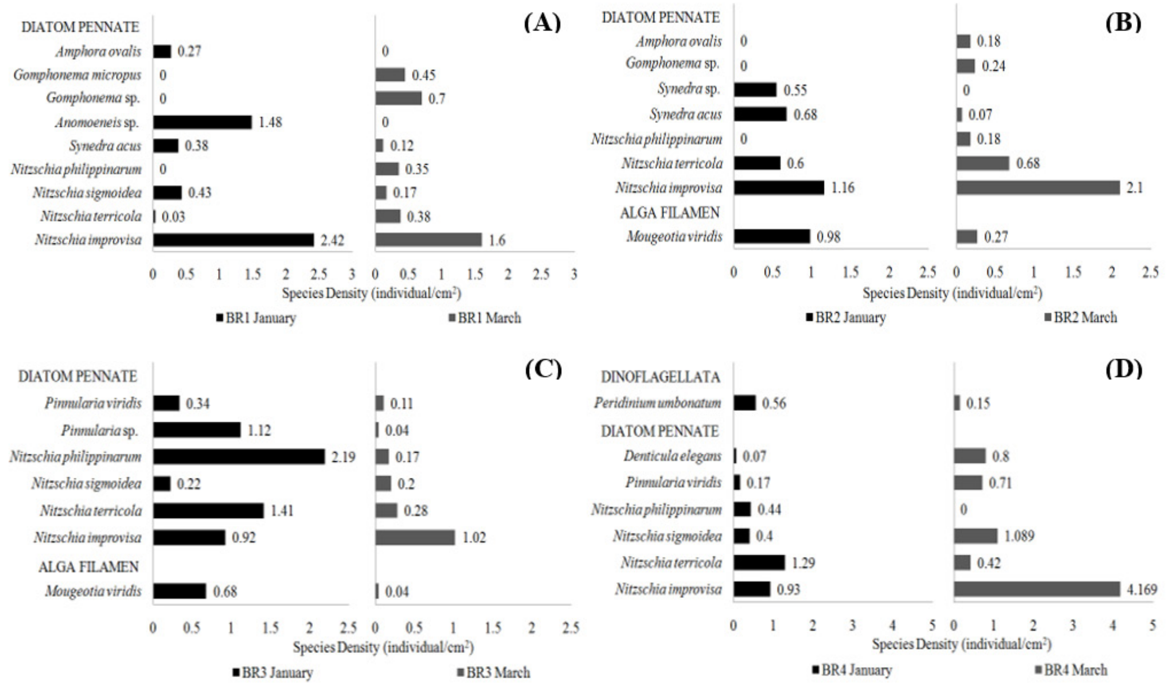

Figure 3 The 5 highest Belik River periphyton species in (A) sampling site 1 (BR1), (B) sampling site 2 (BR2), (C) sampling site 3 (BR3), and (D) sampling site 4 (BR4)

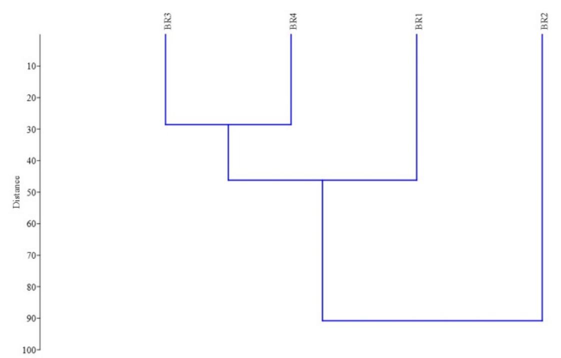

Figure 4 Dendrogram of the 4 sampling sites in January 2021 (based on the results of Cluster Analysis)

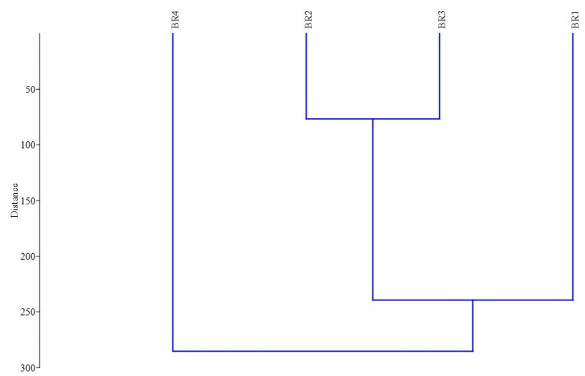

Figure 5 Dendrogram of the 4 sampling sites in March 2021 (based on the results of Cluster Analysis)

That change was caused by the floods happened in February 2021, which brought the nutrients present in BR2, which had a modified riverbed and were retained in BR3, which had a natural riverbed. In addition, BR2 and BR4, separated into different clusters, indicated a significant difference in conditions between the modified and natural river. According to Kennedy & Turner (2011), the canalization in BR2 hinders connectivity in the riparian zone that connects aquatic and terrestrial ecosystems. The existence of riparian zone changes affected the water dynamics physically and chemically (nutrients), thus affecting periphyton dynamics. Meanwhile, BR4 has a riparian zone which is more natural to support the organisms' life.

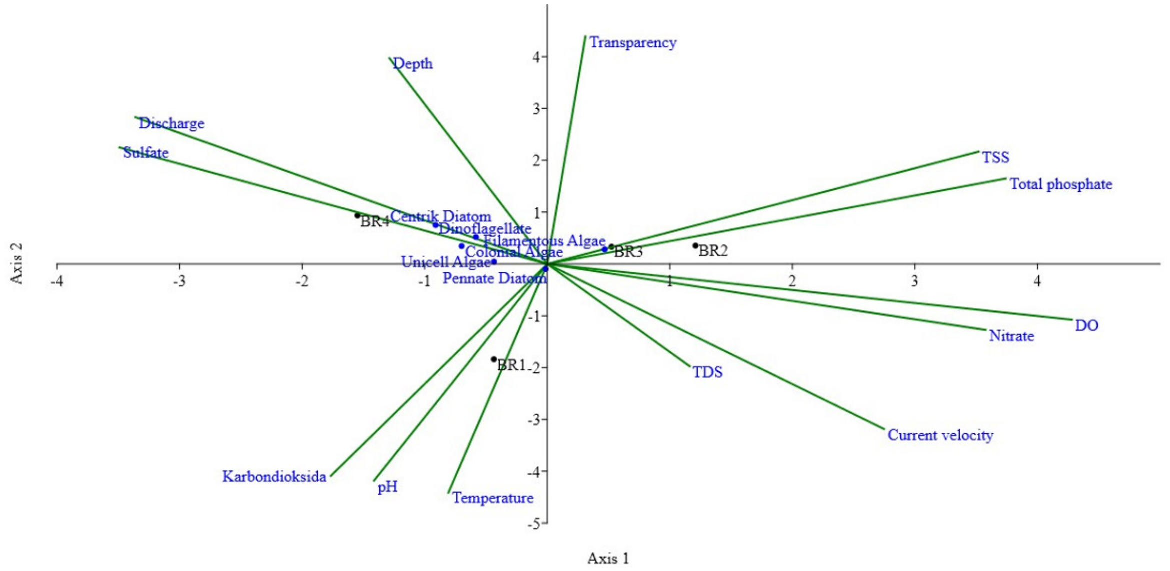

Figure 6 Canonical Correlation Analysis ordination diagram of Belik River physicochemical and the presence of periphyton in January 2021

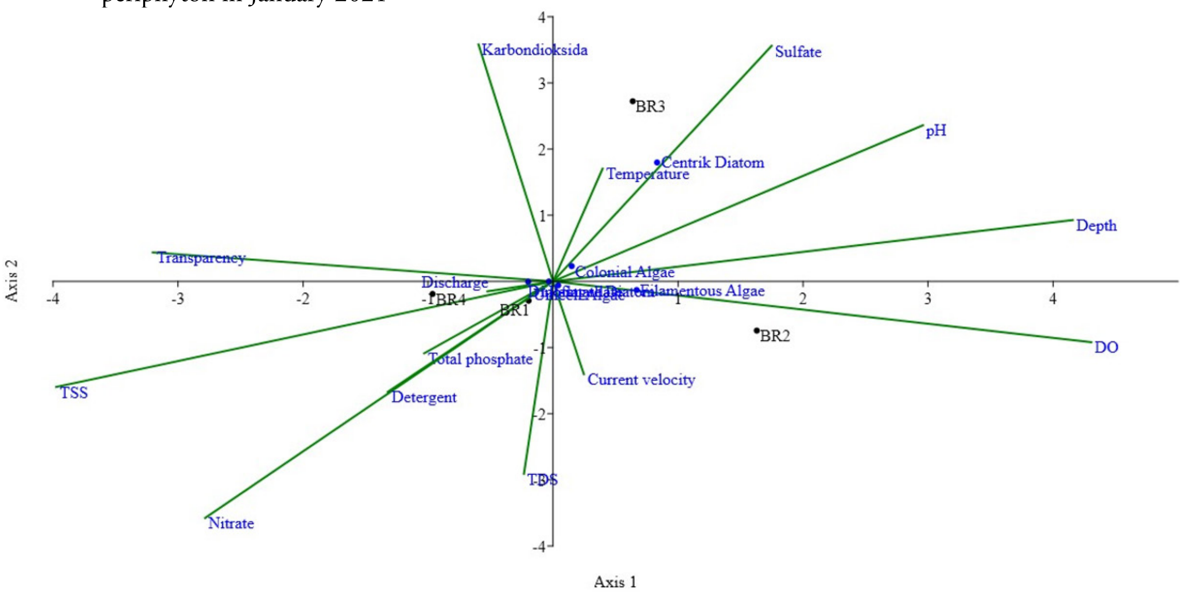

Figure 7 Canonical Correlation Analysis ordination diagram of Belik River physicochemical and the presence of periphyton in March 2021

The Canonical Correlation Analysis indicated that, in general, the distribution and abundance of periphyton in Belik River were influenced by CO_2, total phosphate, discharge, DO, nitrate, TSS, and depth (Figs. 6 & 7). Specifically, in January 2021 periphyton had the highest diversity in BR4, influenced by discharge and sulfate parameters (Axis 1), and depth (Axis 2). Meanwhile, in March 2021, there was no big difference in periphyton diversity at the 4 sampling sites. However, BR3 had the highest diversity of centric diatoms, influenced by depth (Axis 1) and sulfate (Axis 2). This occurrence was consistent with the condition of BR3 in March 2021, having the highest sulfate levels compared to other sampling points. According to Olszynski & Wieczorek (2018), it is known that centric diatoms have a wide tolerance range so that they can live in waters containing extreme sulfates.

CONCLUSION

Belik River water had been very lightly to medium polluted. Water quality changes temporally mainly due to flooding. The type of hydraulic characteristics of the river channel influences the distribution and diversity of periphyton. The presence of pennate diatoms as periphyton with the highest species number indicates that the levels of organic pollutants in the water are quite high. Human activities, especially household activities in the upper reaches of the Belik River, greatly affect the quality of river water. This is indicated by the high levels of detergent, TDS and TSS in BR1 and BR 2. Further research that can be developed is a study related to detailed hydraulic characteristics that examines the type of vegetation around river channels. This can illustrate the influence of the characteristics of each vegetation species which may affect the water quality in a river.

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