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Revealing Diversity of Bacillariophyceae in Brantas River through Project Based Learning

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Abstract : Bacillariophyceae is a group of microscopic, unicellular or colonial algae, enclosed within a cell wall made of silica called frustule. Students of the Department of Biology of Universitas Negeri Malang study Bacillariophyceae on the course subject of Thallophyta through the project-based learning method. On project-based learning, students are given a project to identify the Bacillariophyceae found in five streamside observation stations of Brantas River, Malang, Indonesia. The students were grouped into five groups. Eachteam observed the Bacillariophyceae in a different observation station. This article presents the identification results of Bacillariophyceae found along the Brantas River. There were 84 species of Bacillariophyceae altogether. The number of species found differed in each station, namely 43 species in the 1st station, 70 species in the 2ndstation, 34 species in the 3rd station, 53 species in the 4th station, and 41 species in the 5thstation. The factors contributing to the different number of species found at each stationare still unknown and shall be an interesting field of further research.
Keywords : project-based learning, identify, *Bacillariophyceae.*

Introduction

Bacillariophyceae is a single-celled or colonial organism. Bacillariophyceae lives in various aquatic environments with sufficient sunlight which can supply the photosynthesis activities to supply marine oxygen concentration[1]. Bacillariophyceae is characterized with silica-made cell wall typically made up of two valves which overlap one another like petri dish[2]. The upper valve is called as *epitheca* while the below valve is called *hypotheca*[2-4].

The class of Bacillariophyceae is classified as belonging to Chrysophyta division by Smith and Papenfus[3]. The members of class Bacillariophyceae are known as diatoms. Bacillariophyceae is classified into two orders, i.e. Pennales or Bacillariales and Centrales or Biddulphiales[2-4].Pennales order consists of four sub-orders[5] including Araphidineae, Raphidiodineae, Monoraphidineae, and Biraphidineae. Centrales order includes three sub-orders[6-7], namely Coscinoidiceneae, Rhizosoleniineae, and Biddulphiineae.

Bacillariophyceaeplays an essential role in marine ecosystem since it is a producer in a food chain which produces organic material for invertebrate[8-9] and it also has a role in the biogeochemical cycle of carbon, nitrogen, phosphor, and silicon, with a significant impact on global climate[10]. It also acts as a good indicator to assess the ecological quality of waters for the last fifty years[11] since it has a high sensitivity of the physicochemical changes of waters[12].

Bacillariophyceaeis one of the topics studied on Thallophyta course subject in Department of Biology, Universitas Negeri Malang. The course goal is, among others, for students to have the skills of taxonomy concerned with collecting, describing, identifying, and classifying specimens. Such skills can be enabled through project-based learning strategy.

Project-based learning is defined as a learning method which encourages students' active participation, either individual or group in a certain period to achieve specific products or outcomes relating to real situations in a period of time to cultivate students' responsibility, discipline, and independence[13-15]. Project-based learning develops a mastery of 21st Century essential learning since it engages students in designing projects, developing their knowledge, problem solving problem, and their reasoning and communication abilities[16].The main goal of project-based learning is to assist students to be responsible in their learning process so that they can understand the lesson independently and can produce a specific project either autonomously or collaboratively[17-18].

Method

The samples for this research were gathered by the students of the Universitas Negeri Malang who took the Thallophyta course subject with project-based learning strategy. Project-based learning includes three stages, namely project planning (planning), project implementation (creating), and project evaluation (processing)[19].

1. Planning

a. Selection of research area

Brantas River selected as the research area flows over 43,000 meters across Malang, Indonesia. The research area is divided into the following 5 observation stations. The 1st station located 1250 meter above sea level in Junggo village, Bumiaji District. The 2nd station located 575 meters above sea level in Sengkaling village, Dau District. The 3rd station located 450 meters above sea level in the center of Malang. The 4th station situated approximately 420 meters above sea level in Bumiayu village, Kedung Kandang District. The 5th station located 360 meters above sea level in the downstream area (Figure 1).

Figure 1. Map of Five Observation Stations at Brantas River, Indonesia

b. Class preparation

The course participants were 30 students, divided into five groups. Each group consisted of 6 students with various academic abilities. Each group held a discussion to determine the goal of the project, to look at the logistics for the project implementation, to study the literature on gathering and washing Bacillariophyceae for easier observation. Subsequently, the groups designed the project to observe the Bacillariophyceae in different stations.

2. Creating

a. Field collection of Bacillariophyceae

Students collected the *Bacillariophyceae* from 5 observation stations located in Brantas River. Each group was responsible for collectingBacillariophyceae from various observation stations. Students performed such collection for five times by using synthetic substrates made from flat glass. The flat glass with the size of 15 x 10 x 0.5 cm3 was used and exposed for 14 days. Bacillariophyceaewas collected by scraping both sides of the glass to be then rinsed off by using 30 ml distilled water. Then, the collected Bacillariophyceaewas saved in a sample bottle. Next, five drops of 40 % formalin were dropped into the bottle as the preservative. The following processes were performed in the Laboratory of Biology of theUniversitas Negeri Malang.

b. Laboratory preparation of Bacillariophyceae

In the laboratory, students rinsed the collected Bacillariophyceae by adding potassium permanganate($KMnO_4$) until it turned to purple in color and then added by concentrated sulfuric acid (H_2SO_4) until it turned into clear[20-22]. Next, the liquid was centrifuged at the speed of 2000 rpm for 10 minutes. The rinse aimed to remove dirt from the frustule so that the specimen would be easy to describe. The supernatant was removed by using a pipette so that it would not contaminate the deposit. After that, the tube was filled with distilled water and centrifuged for one more time. The process was repeated for three times. The deposit was then moved to the sample bottle and 10 ml distilled water was added. Then, such deposit was observed through a light microscope with 400-time zoom. Lastly, the students identified the species of *Bacillariophyceae*[23-29].

3. Processing

a. Sharing: in this stage, students presented the findings of the project, i.e. the Bacillariophyceae species found in each station.
b. Reflection and evaluation: students reflected and evaluated the project-based learning process in groups and individually.

Results and Discussion

1. Species Diversity of Bacillariophyceae Class

Figure 2.*Bacillariophyceae*species found in Brantas River

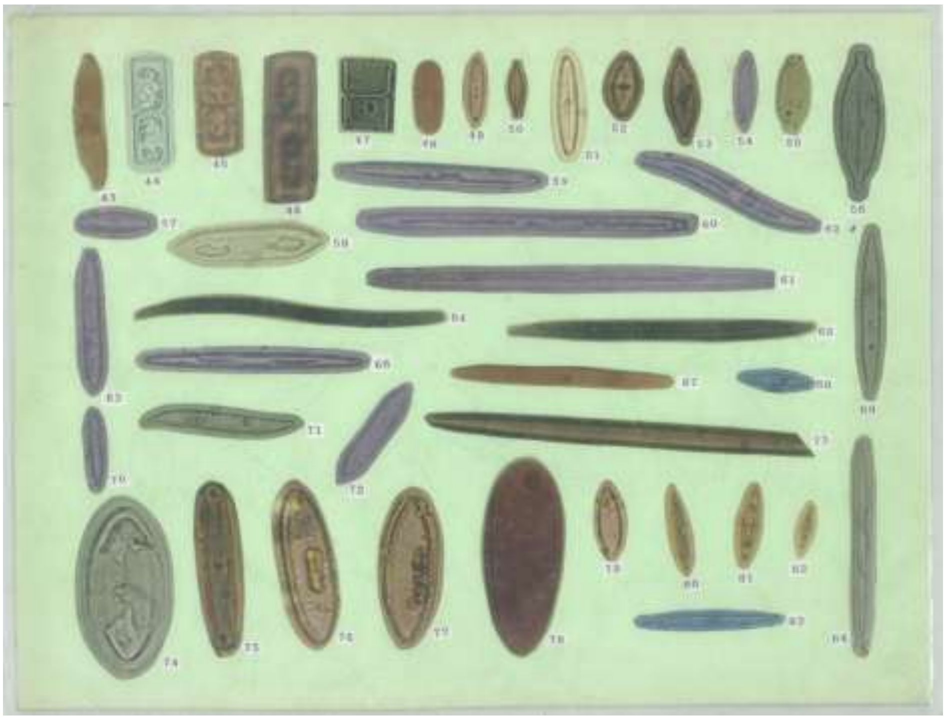

Figure 3.*Bacillariophyceae* species found in Brantas River

The Bacillariophyceae communities found by five student groups through the project through 5-time collection in each station are presented in Figure 2 and 3 and Table 1

Table 1.BacillariophyceaeSpecies found in five observation stations of Brantas River

No	Species	Station				
		1	2	3	4	5
1	*Achnanthes crenulata*Grun.	√	√	-	√	-
2	*Achnanthes hongarica* Grun	√	√	-	√	√
3	*Achnanthes lanceolata*(Breb.) Grun.	√	√	-	√	-
4	*Achnanthes minutissima*Kutz.	√	-	-	√	√
5	*Amphora acutiuscula* Kutz	√	√	-	√	√
6	*Amphora bitumida* Prowse.	-	√	√	-	-
7	*Amphora bullatoides*Hohn & Hellerman	-	√	-	-	-
8	*Amphora delphinea*Bailey	√	√	√	√	√
9	*Amphora holsatica* Hustedt	-	√	-	√	√
10	*Amphora normannii* Robenhurst	-	√	-	√	√
11	*Amphora ovalis*Kutz	√	√	-	√	√
12	*Amphora proteus* Gregory	-	√	-	-	-
13	*Amphora strigosa*Hustedt	-	√	-	-	-
14	*Bidulphialeavis*Ehr.	√	√	-	√	-
15	*Caloneis bacillum* (Grun.) Cleve	-	√	-	√	√
16	*Caloneis silicula* Ehr.	-	√	-	√	-
17	*Cocconeis pediculus* Ehr.	√	√	-	-	-
18	*Cocconeis placentula*Ehr.	√	√	√	-	-
19	*Cocsinodiscus argus* Ehr.	√	√	√	-	-
20	*Cymbella kolbei*Hustedt.	√	-	√	-	-
21	*Cymbella microcephala* Grun.	√	-	-	-	-
22	*Cymbella tumida* (Breb.)van Heurck.	-	√	-	-	-
23	*Cymbella turgida* Gregory	-	√	-	-	-
24	*Cymbella turgidulla*Grun.	√	√	-	-	-

25	*Cymbella ventricosa*Kutz.	√	√	-	-	-
26	*Diploneis subovalis*Cleve	√	-	√	√	-
27	*Eutoniafaba*Ehr.	√	-	√	√	-
28	*Eutonia monodon* Ehr.	√	-	-	√	√
29	*Flagilaria construens*(Ehr.) Grun.	√	√	-	-	-
30	*Flagilaria crotonensis*Kitton	√	√	-	√	√
31	*Flagilaria vaucherias*Kutz.	√	√	-	√	-
32	*Frustulia rhomboides* Ehr.	√	√	√	√	√
33	*Frustulia saxonica*Rabenhorst	√	√	-	√	√
34	*Frustulia vulgaris* (Thwaites)	√	√	√	-	-
35	*Gomphonema cleveі*Fricke	√	√	-	√	-
36	*Gomphonema christenseni*Lowe & Kociolek	√	√	-	-	√
37	*Gomphonema gracile* Ehr.	√	-	√	√	√
38	*Gomphonema lanceolatum*Ehr.	√	√	-	√	√
39	*Gomphonema parvulum*Kutz.	√	√	√	√	√
40	*Gomphonema vibrio* Ehr.	√	√	-	√	√
41	*Gyrosigma scalproides* (Rabh.) Cleve	-	√	-	-	√
42	*Gyrosigma spenceri* (W. Smith) Cleve	-	√	-	√	√
43	*Hanzchia amphioxys* (Ehr.) Grun	√	√	√	-	-
44	*Melosira granulata* (Ehr.) Ralfs.	-	√	-	√	-
45	*Melosira italika* (Ehr.) Kutz	-	√	-	-	-
46	*Melosira solida*Eulenstein	-	√	-	-	-
47	*Melosira varians* C. A. Agardh	-	√	-	√	-
48	*Navicula bacillum* Ehr.	√	√	√	√	-
49	*Navicula cincta* Grun	-	-	-	√	-
50	*Navicula cryptocephala* Kutz	√	√	√	√	-
51	*Navicula cryptotenella* Lang, B.	√	√	-	√	√
52	*Navicula confervacea* Kutz	-	√	√	√	-
53	*Navicula cuspidata* Kutz.	-	-	-	√	√
54	*Navicula feverborni*Hust.	-	-	√	-	-
55	*Navicula pupula* Kutz.	√	√	√	√	√
56	*Navicula rhyncocephala* Hust.	-	√	√	√	√
57	*Neidium iridis* (Ehr.) Cleve	-	√	-	√	√
58	*Nitzschia amphibia* Grun.	-	√	√	√	√
59	*Nitzschia filiformis* (W.Sm.) V.H.	√	-	√	√	-
60	*Nitzschia gandersheimiensis* Krasski.	√	√	-	√	-
61	*Nitzschia gracilis*Hantzsch	-	√	-	-	√
62	*Nitzschia ignorata*Krasski.	-	-	-	√	-
63	*Nitzschia microcephala*Grun.	-	√	√	√	-
64	*Nitzschia obtusa* W. Smith	-	√	√	√	√
65	*Nitzschia philipinarum* Hust.	√	√	-	√	√
66	*Nitzschia palea* (Kg.) W. Smith	-	√	√	√	√
67	*Nitzschia paradoxa* (Gmelin) Grun.	√	√	√	-	√
68	*Nitzschia ponticula* Grun.	-	-	-	√	-
69	*Nitzschia subtilis*Hust.	-	√	√	√	-
70	*Nitzschia parvula* Lewis	-	√	-	√	√
71	*Nitzschia sigma* (Kulz). W Smith	-	√	-	√	-
72	*Nitzschia stagnorum* (Rabh.) Grun.	√	√	-	-	-
73	*Nitzschia tenuis*W. Smith	-	√	√	√	√
74	*Nitzschia tryblionella* Hantzch	√	√	-	√	√
75	*Pinnularia microstauron* (Ehr.) Cleve	√	√	√	-	√
76	*Surirella angusta* Kutz.	-	√	-	-	√
77	*Surirella linearis*W. Smith	-	√	√	-	√
78	*Surirella robusta* Ehr.	-	√	-	√	-

79	*Surirella tenuisima* Hust	-	√	√	-	√
80	*Stauroneis anceps* Ehr.	√	√	√	-	-
81	*Stauroneis phonicenteron* (Nitz) Ehr	-	√	√	-	√
82	*Stauroneis pusila* A. Cleve	√	√	√	-	√
83	*Synedra rumpens*Kutz.	-	-	√	√	√
84	*Synedra ulna* (Nitz.) Ehr	-	√	√	√	√
	Total	**43**	**70**	**34**	**53**	**41**

Based on Table 1, there were 84 species of Bacillariophyceaefound in Brantas River. There were different numbers of varieties and species found in every station. There were 43 species found in the 1st station, 70 species found in the 2nd station, 34 species found in the 3rd station, 53 species found in the 4th station, and 41 species found in the 5th station. The factors contributing to the diversities and different numbers of Bacillariophyceae are still unknown since the course subject only aimed to improve students' skills in collecting, describing, identifying, and classifying specimen. Such differences possibly resulted from physico-chemical factors, such as flow speed, temperature, dissolved oxygen, BOD, etc. on each different station. It becomes an interesting field of further research.

2. Taxonomy and descriptions of Class Bacillariophyceae species

This subsection presents the morphology characteristic descriptions of the species found in the five observation stations of Brantas River. The identification of each species was made based on the references which explained about each species written after the names in taxonomy. The followings are several abbreviations related to taxonomic descriptions.

L: shell length
W: shell width
D: shell diameter
S:striae number in 10 µm.
P: punctae in 10 µm

Ordo: Centrales
Sub Ordo: Coscinoidiceneae
Family: Coscinodiscaceae
Genus: *Coscinodiscus*

1. *Cocsinodiscus argus* Ehr[24].
   D. 70-100 µm

Genus:*Melosira*

2. *Melosira granulata* (Ehr.) Ralfs. [24,26].
   L.16-28 µm, D. 5-10; S. 8-11 in 10 µm
3. *Melosira italika* (Ehr.) Kutz.[24-25,29] .
   L. 16-28 µm, D. -10 µm, , S 10-20 in 10 µm
4. *Melosira* solidaEulenstein[25-27].
   D. 9 µm,
5. *Melosira varians* C. A. Agardh[29].
   L. 13-16 µm , D. 8-35 µ*m*

Sub Ordo: Biddulphineae
Family: Biddulphiaceae
Genus:*Fragillaria*

6. *Bidulphialeavis*Ehr.[24]
   D. 65-120 µm

Order:Pennales
Sub Order: Araphidinneae
Family: Fragillariaceae
Genus:*Fragillaria*

7. *Fragilaria construens*(Ehr.) Grun[26-29]

L. 4-35 µm, W. 2-12µm, S. 12-20 in10 µm

8. *Fragilaria crotonensis*Kitton[25,27,29]
L.40-170, W. 2-4(5) µm, S. 11- 15 in 10 µm
9. *Fragilaria vaucherias*Kutz. [24-25] .
L.50-90 µm, W. 3-6 µm, S. 9-12 in 10 µm

Genus:*Synedra*

10. *Synedra* rumpensKutz.[25-28]
L. 54 µm, W. 3 µm, S. 16 in 10 µm
11. *Synedra ulna* (Nitz.) Ehr.[24,25,27,28]
L. 150-250 µ*m*, W. 5-7 µm, S. 8-10 in 10 µm

Sub Order: Raphidiodineae

Famili Eunotiaceae

Genus: *Eunotia*

12. *Eutoniafaba*Ehr.[24]
L. 13-15 µm, W. 3-4 µm, S. 19-20 in 10 µm
13. *Eutonia monodon* Ehr.[28]
L. 65-70 µm, W. 10-15 µm, S. 10-12 in 10 µm

Sub Order: Monoraphidinae

Family: Achnantaceae

Genus:*Achnanthes*

14. *Achnanthes crenulata*Grun[30]
L. 30-87µm, W. 13-22µm, S. 8-9 in 10 µm
15. *Achnanthes hongarica* Grun[23]
L. 16-18µ m, W. 4,5-7,5 µm. S. 18-24 in 10µm
16. *Achantheslanceolata (Breb)* Grun.[23]
L. 12-31 µm, W. 4,5-8 µm, S. 11-14 in10 µm.
17. *Achnanthes minutisima* Kutz.[27]
L. 5-25 µm, W. 2.5-4 µm (mostly 3-3.5 µm), S. 30-32 in 10 µm.

Genus: *Cocconeis*

18. *Cocconeis pediculus* Ehr.[25,27,29]
L. 5-25 µm, W. 8-40µm, S. 27-32 in 10 µm
19. *Cocconeis placentula*Ehr.[25-29]
L. 7.5-98 µm, W. 8-40 µm, S. 24-26 in 10 µm

Sub Order: Biraphidineae

Family: Naviculaceae

Genus:*Caloneis*

20. *Caloneis bacillum*(Grun.) Cleve[25,27,29]
L.15-40 µm, W. 4-9 µm, S. 22-28 in 10 µm
21. *Caloneis silicula* Ehr.[23-29]
L. 25-120 µm, W. 6-24 µm, S. 16-20 in 10 µm

Genus: *Diploneis*

22. *Diploneis ovalis* Cleve[24].
L.20-25 µm, W. 12-15 µm, P. 18-22 in 10 µm

Genus: *Frustulia*

23. *Frustulia rhomboides*Ehr.[24,29]
L. 30-55 µ*m*, W. 8-12,5 µm, S. 30-35 in 10 µ*m*
24. *Frustulia saxonica*Rabenhorst.[24,29]
L. 30-40µm , W. 8-10 µm , S. 29-32 in 10µm
25. *Frustulia vulgaris*(Thwaites)[25,29]
L. 40-60 µm, W. 8-12 µm, S. 27-32 in 10 µm

Genus:*Gyrosigma*

26. *Gyrosigma scalproides*(Rabh.Cleve Hust)
L. 40-70 µm, W. 7-11 µm. S. 20-24 in 10 µm
27. *Gyrosigma spenceri*(W. Smith) Clteve.[27]

L. 95-140 µm, W. 13-15 µm, S. 18-24 in 10 µm

Genus:*Navicula*

28. *Navicula bacillum* Ehr.[25]
L.30-80 µm, W. 10-20 µm, S. 12-14 in µm
29. *Navicula cincta* Grun(Ehrenberg) Ralfs[29]
L. 14-45 µm, W. 5,5-8 µm, *S.* 8-12 in 10 µ*m*
30. *Navicula cryptocephala* Kutz[23, 25,27-29]
L. 24-42 µ*m*, W. 5-7 µ*m, S. 15-16* in 10 µ*m*
31. *Navicula cryptotenella* Lang, B.[25,27-29]
L. 12-40 µm, W. 5-7 µm, S. 14-16 in 10 µm
32. *Navicula confervacea* Kutz[24-25,27-29]
L. 18-25 µm, W. 7-9 µm, S. 18-20 in 10 µ*m*
33. *Navicula cuspidata* Kutz.[23,24-29]
L. 95-100 µ*m*, W. 25-30 µ*m, W.* 17-35 µ*m*, S. 17-18 in 10 µ*m*
34. *Navicula feverborni*Hust.[23-24]
L. 40-48 µ*m*, W. 6-8 µm, S. 10-12 in 10 µm.
35. *Navicula pupula* Kutz.[23-25,27]
L.10-90 µ*m* , W. 13-15µ*m* ; S.18-19 in 10 µ*m.*
36. *Navicula rhyncocephala* Hust.[25,27]
L. 27-30 µ*m*; W. 8,5-10 µm; S. 10-12 in 10 µ*m.*

Genus:*Neidium*

37. *Neidium iridis* (Ehr.) Cleve.[23-24]
L. 35-40 µm, W, 10-20 µm, S. 16-18 µm

Genus:*Pinnularia*

38. *Pinnularia microstauron* (Ehr.)[24,28]
L.50-70µm, W. 10-14µm, S. 10-13 in 10µm

Genus:*Stauroneis*

39. *Stauroneis anceps* Ehr.[23]
L. 47-48µ*m* , W. 11-12 µ*m*, S. 16-18 in 10 µ*m* .
40. *Stauroneis phonicenteron* (Nitz) Ehr.[23,28]
L. 49-56 µm, W.7-11 µm, S. 12-20 in 10 µm
41. *Stauroneis pusila* A. Cleve[24]
L. 30-45 µm, W. 7-11 µm, S. 30 in 10 µm

Genus:*Gomphonema*

42. *Gomphonema clevei*Fricke.[25,28]
L. 12-50 µm, W. 4-9 µm, S. 10-18 in 10 µm
43. *Gomphonema christenseni*Lowe & Kociolek[25]
L.46-73 µm, W. 8,5-10 µm, S. 11-13,5 in 10 µm
44. *Gomphonema gracile* Ehr.[23-24]
L. 40-50 µm , W. 8-10 µm, S.12-15 in 10 µm
45. *Gomphonema lanceolatum* Ehr[24]
L. 20-70 µm, W. 7-10 µm, S. 8-10 in 10 µm
46. *Gomphonema parvulum* Kutz[25-26,29]
L. 10-36 µm, W. 4-8 µm, S. 7-20 in10 µm
47. *Gomphonema vibrio* Ehr.[25-26]
L. 20-37 µm, W. 4-5 µm, S. 10-14 in 10 µm

Family: Cymbellasceae

Genus:*Amphora*

48. *Amphora acutiuscula*Kutz[24,29]
L. 30-60 µm, W. 6-8 µm, S. 18-20 in 10 µm.
49. *Amphora bitumida*Prowse.[24]
L. 18-23 µm, W. 11-12 µm, S. 17-18 in 10 µm
50. *Amphora bullatoides*Hohn& Hellerman[31]
L. 17-30 µm, W. 4-6 µm, S. 16-18 in 10 µm
51. *Amphora delphinea*Bailey[23]

L. 16 µm, W. 4 µm

52. *Amphora holsatica*Hustedt.[24]
    L. 40-45 µm, W. 7-9 µm, S. 12-13 in 10 µm
53. *Amphora normannii*Robenhurst.[24]
    L. 30-40µm, W. 9-14 µm, S. 16-20 in 10µm
54. *Amphora ovalis*Kutz.[23,25,27]
    L. 32-95 µm, W. 8-10 µm, S**.** 17 in 10 µm
55. *Amphora proteus* Gregory.[24]
    L. 40-60µm, W. 7-10, S. 10-13 in 10 µm
56. *Amphora strigosa*Hustedt[24,29,32]
    L. 17,7-30 µm, W. 3,5-6,2 µm, S. 16-20 in 10 µm

Genus:*Cymbella*

57. *Cymbella kolbei*Hustedt[24,29]
    L. 25-30 µm, W. 9-11 µm, S. 11-12 in 10 µm
58. *Cymbella microcephala*Grun.[27-29]
    L. 10-23 µm, W. 3.5-4.2 µm, S. 23-25 in 10µm
59. *Cymbella tumida*(Breb.)van Heurck[25,27-29]
    L. 35-95 µm, W. 16-24 µm, S. 8-13 in10 µm
60. *Cymbella turgida*Gregory[23]
    L. 31-52µm, W. 10-14µm, S. 11-12 in10 µm
61. *Cymbella turgidulla*Grun.[23-25,29]
    L.30-50 µm, W. 11-14 µm, S. 8-14 in 10 µm
62. *Cymbella* ventricosaKutz.[24,29]
    L. 21- 29 µm, W. 5-7 µm, S.14-19 in 10

Family:Nitzchiaceae

Genus:*Hantzchia*

63. *Hanzchia amphioxys* (Ehr.) Grun[26,29]
    L. 30-100 µm, W. 5-10 µm, S. 13-20 ini10 µm

Genus:*Nitzchia*

64. *Nitzschia amphibia* Grun.[25,27-28]
    L. 18-20 µm, W 4,6-5,0 µm, S. 16-17 in 10 µm.
65. *Nitzschia filiformis* (W.Sm.) V.H.[25,27]
    L. 40-100 µ*m*, W. 4-6 µ*m*, S. 27-36 in 10 µ*m*
66. *Nitzschia gandersheimiensis* Krasski.[24,27]
    L. 90-100, W. 4 µm, S. >30 in 10 µm
67. *Nitzschia* gracilisHantzsch[27-28]
    L.45-110 µm. W. 2.5-4 µm. S. 38-42 in 10 µm
68. *Nitzschia ignorata* Krasski.[24]
    L. 40-60 µm, W. 4 µm, S. >30 in 10 µm
69. *Nitzschia microcephala*Grun.[24]
    L. 10-19 µm. W. 2,3-4 µm. S 30-41 in 10 2,3-4 µm
70. *Nitzschia obtusa* W. Smith.[24-25,27]
    L. 25-80 µm , W. 4-5 µm, S. 28-30 in10 µm
71. *Nitzschia philipinarum* Hust[28]
    L.65-70 µm, W. 3.5-4.5 µm, S. 32 in 10 µm
72. *Nitzchia palea* (Kg.) W. Smith.[23,25,27,28]
    L. 15-70 µ*m*, W. 2,5-5 µm, S. 28-40 *in* 10µm.
73. *Nitzschia paradoxa* (Gmelin) Grun.[24]
    L. 60- 90 µm, W. 5-8 µm, S. 20-24 in 10 µm
74. *Nitzschia ponticula* Grun.[24]
    L. 12-15 µm, W.2-4 µm, S. 28-30 in 10µm
75. *Nitzschia subtilis* Hust.[24]
    L. 90-130 µm, W. 3-5 µm, S. 28-32 in 10µm
76. *Nitzschia parvula* Lewis.[24]
    L 30-40, W. 4-5µm, S. 29-30 in 10µm.
77. *Nitzschia sigma* (Kulz). W Smith[24]

L. 35-100 µ*m*, W. 4-5 µm, S. 22-30 in 10µm

78. *Nitzschia stagnorum*(Rabh.) Grun.[24]

L.30-60µm, W. 6-10 µm, S.26 in 10µm

79. *Nitzschia* tenuisW. Smith[27]

L 146 µm, W. 5 µm, S. 25 in 10 µm

80. *Nitzschia tryblionella*[23,27]

L. 60-180 µm, *W.* 16-35 µm, S. 30-35 in 10 µm

Family: Surilellaceae

Genus: *Surirella*

81. *Surirella angusta* Kutz.[27]

L. 30-50 µm, *W. 9-10*µm, S. 22-28 in 10 µm

82. *Surirella* linearisW. Smith[24,28]

L. 40-100 µm, W.12-20 µm, S. 23 in 10 µm

83. *Surirella robusta* Ehr.[23]

L. 48-72 µm, W. 28-34 µm, S. 44-60 in 10 µ*m*

84. *Surirella tenuisima* Hust

L. 17-38 µm, W. 6-11 µm

The Bacillariophyceae communities in Brantas River found by the students were then classified based on the genera, families, sub orders and orders. From such classification, they found 22 genera, 10 families, six sub orders and two orders, namely Pennales and Centrales. The main diversities between the order Pennales and Centrales are valve structures and ornamentation. The Centrales valve is round, ellipse, polygonal and irregular between radial or concentric ornamentations, while the Pennales valve is anellipse with bilateral symmetrical ornamentation[4,33-34].

The Pennales order presents various valve areas. There is a gap called *raphe* found across the entire or a part of thecell wall in Pennales order. There are also Pennales members with rudimentary raphe located on the edge of the cell wall creating *pseudoraphe*[5]. According to the structures, Pennales order consists of four sub orders[5]. The first is Araphidineae which have a pseudoraphe, such as *Asterionella, Diatom, Fragilaria*, and *Synedra.* The second is Raphidiodineae which have rudimentary rapheat the edges of thecell, for example,*Actinella* and *Eutonia.* The third is Monoraphidineae which have a raphe in one valve and a pseudoraphe in another valve, such as *Achnanthes*and *Cocconei*s. The last is Biraphidineae which have *raphes*on both valves, e.g. *Amphora, Cymbella, Gomphonema, Navicula, Nitzschia, Pinnularia* and *Surirella.*

There is not a *raphe* in the Centrales order valves. The frustules of centrales order are discoid, cylindrical or irregular[4,24].TheCentrales Order includes three sub orders[6-7]. The first is Coscinoidiceneae with the cylindrical cell, round valves, radial striae structures such as *Cyclotella* and *Melosira*. The second is Rhizosoleniineae with elongated, cylindrical or sub cylindrical cell, a complex girdle with several bands such as *Rhizosolenia.* The third is Biddulphiineae with the square cell, two or more popping valves like animal horns, such as *Biddulphia* and *Triceratium.*

The most abundant Bacillariophyceae communities in Brantas River were from the order Pennales of 79 species (94%),while there were only five species (6%)identified from order Centrales. The order Pennales were dominantly identified in freshwater since it is its typical environmental niche[34] and they live as periphyton[29]. Many Pennales were found attaching to the flat glass since they are more adhesive than the species included in the order Centrales. The order Pennales has crystalloid organelle and fibrils which produce mucous (mucilage) or chitin organelle to attach[35], such as the genus *Cocconeis, Achnanthes,*and *Synedra*[37]. Such organelles are not found in the orders of Centrales. Therefore, most of Centrales are planktonic[24,29,38]. Some species from the genus *Cyclotella* and genus *Melosira*live as periphyton temporarily.

In this research, the students could identify the Bacillariophyceae specimens found in each station collaboratively in groups. In performing the project, students did brainstorming, respected others' opinions, and worked in ateam to produce ideas. They negotiated to solve problems collectively and finally did self-evaluation. The project-based learning seemspromotes social skills such as negotiating, communicating, collaborating, being creative, and problem solving[15,39].

Each group has determined the purpose of the project and designed a real scientific investigation to implement the project. The project-based learning can improve the students' ability to conduct research[40-41]. There are several essential aspects of project-based instruction for the success of projects, namely, among others, the harmony between the learning purpose and the implemented project and real-world investigation skill[42]. The collection of Bacillariophyceae was followed by the process of description and identification in a fragment of Brantas River related to the real daily lives of the students. The projects have to relate to the real world situation. Thus, students can understand what they learn and why they learn it[40].

Conclusion

The project-based learning method utilized in Thallophyta course subject has given students the opportunity to get experiences in collecting, describing, identifying, and clarifying the Bacillariophyceae they found from Brantas River.They Found 43 species in the 1st station, 70 species in the 2nd station, 34 species in the 3rd station, 53 species in the 4th station, and 41 species in the 5th station. The different number of species found at each stations seems interesting for further research to find outthe reason that contribute to those factors.

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