

NICHE Journal of Tropical Biology

Available online: <https://ejournal2.undip.ac.id/index.php/niche>

Plant diversity based on pollen and spores morphology from sediment lake of Kedung Ombo Purwodadi

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ABSTRACT

Kedung Ombo Lake was an artificial lake that has formed since 26 years ago. Environmental has changed from the terrestrial environment into the aquatic environment, because of that the diversity of flora around the Lake Kedung Ombo was changed. The diversity of flora can be learned through the morphology of pollen and spores. Aimed of this study was to determine the diversity of plants based on the morphology pollen and spores that found in the Lake Kedung Ombo sediment. Sampling took by coring clay soil sediment in depth of 1 m, located near the outlet of Lake Kedung Ombo. Data were analyzed by making the morphology of pollen and spores description. The result showed that morphology of pollen and spores are found in the Lake Kedung Ombo sediment has a variety of shapes and sizes. The plant's diversity obtained are 25 taxa plants that were categorized into 3 taxa of arboreal pollen (AP), 9 taxa of non-arboreal pollen (NAP) and 13 taxa of spores. The dominance of taxa NAP is *Celtis* sp. (45,12%), this suggested that shrubs or not plant trees were more developed in Lake Kedung Ombo environment. The study concluded that the value of diversity index categorized as low and the value of similarity index categorized as high, it means that plant diversity was quite similar and there is no significant changes of diversity with their presence were quite stable.

Keywords: Kedung Ombo, morphology, pollen, spore, diversity

I. INTRODUCTION

Kedung Ombo was located in Purwodadi, Jawa Tengah, Indonesia. Lake Kedung Ombo was an artificial lake that has formed since 26 years ago (Nuroniah, 1994). Since 1989 there were vegetation changes with the environment changes from the terrestrial environment into the aquatic environment. The presence of pollen and spores were found in sediment was a source of palynological data which can used for environment detection from the past because the presence was abundant, countable, and resistant in sediment.

Pollen is the male reproductive organs contained in plants (Arizona, 2000), and the spores are cryptogamae's reproductive organ such as algae, mosses, and ferns (Tjitrosoepomo, 1986). Pollen from and spores can be learned through Palynology. Palynology also studied the structure, form, and preservation of pollen or spores on certain conditions (Moore & Webb, 1978; Morley, 1990). Morley (1990) and Flenley (1979) states that knowing the type of pollen and spores based on morphology, it is known as the taxon of flora. Through morphological identification of pollen and spores can also be shown habitus and habitat of plants. That information can reveal the historical development of flora in the past in an environment.

Research on paleontology is widely used to reveal changes in vegetation and climate of the past as done by Vincens *et al.* (2005) in the lakes region of Africa Middle East, and Wang *et al.* (2013) in Lake Aibi China. The same

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Recently Lake Kedung Ombo get some environmental issues such as silting or sedimentation is too high, so that during the dry season was drought and flooded during the rainy season. Therefore, it is necessary to do research on the identification of vegetation through Palynology studies in Lake Kedung Ombo, Purwodadi. This study concluded that to determine the diversity of plants that grow in the area Kedung Ombo Lake temporally from morphological identification of pollen or spores were found. Through this research is expected data obtained can be used as a reference for reconstructing the past environmental conditions so it can be used as a basis for understanding the environmental changes that occur at this time. With the advanced research results of this study can be used as a reference in conservation or environmental protection of Lake Kedung Ombo Purwodadi. According Raharjo *et al.* (1998) Palynology of data can be a reference to determine past climate change and can be used as a basis for reconstructing the environment vegetation, climate, flora history, conservation, and natural disaster prevention.

II. MATERIAL AND METHODS

The research has two stages of field research which includes sampling sediment in the lake area Kedung Ombo, Purwodadi, and laboratory studies which includes preparation of sediment to make preparations preparations microscopic at the Laboratory of Palynology paleobotany, Geological Engineering University of Jendral Sudirman Purwokerto, observation, identification and data analysis conducted at the Laboratory of Basic Biology, Department of Biology, Faculty of Science and Mathematics, University of Diponegoro in Semarang. The experiment was conducted in February - June 2015.

Sediment samples were taken in the area of the shores of Lake Kedung Ombo in the area around PLTA at Bulak Rejo village, Purwodadi, Sragen. Sampling was performed at only one location because this study was conducted temporally or by age layers. Samples were taken using a drill diameter of 1 dm (\pm 4 cm) with a depth of 75 cm, then put in a plastic gutter. Sampling sites located near the outlet of water from Lake Kedung Ombo because the area near the outlet is an area that allows for pollen and spores from plants located around the lake more sedimented in that area. Sediment samples were coded Kedung Ombo (KO), then marked the bottom layer is a layer of old age, and the uppermost layer is a layer of young age.

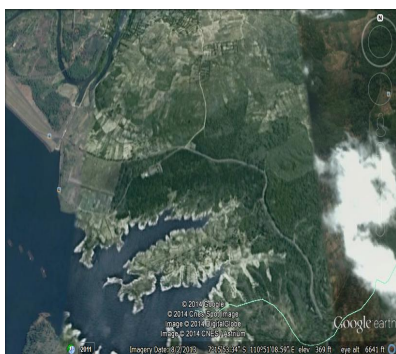


Figure 1. Map of sampling site at elevation 7°15'53.34" S, 110°51'08.59" E

Preparation of pollen and spores is using Moore *et al.* methods (1991) which has been modified by Suedy and Setijadi (2009):

- a. Five grams of sediment samples in beaker glass treated with a solution of HCl 33%, let stand for 3 hours and neutralize with aquadest much as 4-5 times.
- b. Sediment samples were given 40% HF solution, let stand for 24 hours and neutralize with aquadest much as 4-6 times.
- c. Sediment samples treated with a solution of HCl 33%, heat for 2 hours and neutralized with aquadest much as 4-5 times.

- d. The stratified sample is filtered using a 10 µm filter and five µm. Samples treated with a solution of HNO₃ and heat for 10 minutes. Samples are neutralized with aquadest and filtered with a filter size of 5 µm.
- e. Samples were given a 5% KOH solution and simmer for 5 minutes. Neutralize the sample with aquadest and put into a vial bottle.
- f. Samples of 200 µL drop on glass objects, dried on a hotplate, dropped with entelan and covered with a cover glass.

Pollen and spores are observed under a microscope with a magnification of 400x-1000x to see the morphology, include shape, polarity, symmetry, the type and number of aperture, as well as ornamentation exin. The number of individuals of each sample was observed the minimum of around 100 individuals. Identification of pollen and spores carried by reference: Erdtman (1952), Huang (1972), Morley (1990), Halbritter (2007), Hesse (2009) the reference collection of the Smithsonian Tropical Research Institute (on www.striweb.si.edu/roubik) and a collection of PalDat

Pollen and spores that have been identified further grouped based its habitus include Arboreal pollen (AP) which is derived from plant pollen of trees, Non-Arboreal Pollen (NAP) is pollen derived from a shrub or shrub, and group Pteridophyta. Pollen and spores calculation amount using the Shannon-Wiener diversity index analysis and similarity of species Sorensen index. Data analysis and data percentage use PAST program and Sigmaplot ver.12.

III. RESULTS AND DISCUSSION

Based on the results obtained by microscopy, pollen and spores have a variety of shapes and sizes. After the observation, identification is then performed with reference of various reference books. Results of identification will be known plant of the producing pollen or spores. Results of pollen and spore identification successfully identified to the species level reached eight types: *Podocarpus polystachyus*, *Actinostachys digitata*, *Stenochlaena palustris*, *Lycopodium fargesii*, *Lycopodium cernuum*, *Lycopodium juniperoideum*, *Lygodium scandens*, and *Ophioderma pendula*. Pollen and spores were identified to the genus level reaches 11 types including *Acacia* sp., *Pinus* sp., *Celtis* sp., *Croton* sp., *Polygonum* sp., *Ipomoea* sp., *Umbelliferae* sp., *Pteris* sp., *Adiantum* sp., *Gleichenia* sp., *Selaginella* sp., and identified to the family level, there are 6 types: Gramineae, Asteraceae, Liliaceae, Leguminosae, Cyatheaceae, Polypodiaceae. Type of pollen and spores are then carried pollen grouping based habitus is Arboreal Pollen (AP), Non-Arboreal Pollen (NAP), and spores are grouped separately. According to Prebble et al. (2005) AP composed by pollen from woody plants such as trees making forest vegetation, while the NAP is composed by pollen from non-woody vegetation consisting of shrubs and herbs. Type of pollen and spores are found in the sediments of Lake Kedung Ombo as many as 25 types consist of 3 types Arboreal Pollen (AP), nine types of Non-Arboreal Pollen (NAP), and 13 types of spores (Pteridophyta). The type that was found is dominated by NAP group of species *Celtis* sp. ulmaceae family.

The total and percentage of pollen and spores found in the sediment of Lake Kedung Ombo Purwodadi can be seen in Table 1. Overall the type of flora found in the sediment of Lake Kedung Ombo dominated by Non-Arboreal Pollen (NAP) or groups of shrubs or herbaceous plants. Because shrubs are easy to grow on the environmental conditions in the Lake Kedung Ombo is an open environment with enough light intensity is not obstructed by the canopy of trees and close to the river flow. In accordance with the opinion of Gusmaylina (1983) that are generally shrubs or herbaceous plant are a pioneer and a variety of shrubs and herbaceous species strongly influenced by environmental factors such as light, humidity and canopy cover of trees around it. Taxa flora of the NAP group is a group that is more dominating *Celtis* sp. *Celtis* sp dominates the group because it is a pioneer plant or capable and easy plant to rapidly grow and develop in an environment of Lake Kedung Ombo. In accordance with the opinion (Orwa et al., 2009) that *Celtis* sp is a synonym of *Trema orientalis* which is a pioneer plant that spread is very broad.

The diversity of taxa flora found in Lake Kedung Ombo Purwodadi is in low category of diversity with the average value of the diversity index of 1.277. The highest diversity index values found in the sample amounted to 2.05 KO.28 the number of taxa is 13 and the number of individuals as much as 111. The index value is the lowest diversity found in the sample amounted to 0.356 KO.50 the number of taxa by 4, and the number of individuals amounted to 326 individuals.

Table 1. Total and percentage of pollen and spores were found in the Sediment of Lake Kedung Ombo Purwodadi (total grain/400 µl)

No	Name of Taxa	Total	Percentage (%)
Kelompok Arboreal Pollen (AP)			
1	<i>Acasia</i> sp.	640	7,95
2	<i>Podocarpus polystachyus</i>	86	1,07
3	<i>Pinus</i> sp.	26	0,32
Kelompok Non Arboreal Pollen (NAP)			
4	<i>Celtis</i> sp.	3634	45,12
5	Gramineae	531	6,59
6	Asteraceae	1681	20,87
7	<i>Croton</i> sp.	166	2,06
8	<i>Polygonum</i> sp.	708	8,79
9	Liliaceae	8	0,10
10	<i>Ipomoea</i> sp.	89	1,11
11	Leguminosae	55	0,68
12	<i>Umbelliferae</i> sp.	28	0,35
Spora (Pteridophyta)			
13	<i>Actinostachys digitata</i>	54	0,67
14	<i>Pteris</i> sp.	27	0,34
15	Cyatheaceae	133	1,65
16	Polypodiaceae	71	0,88
17	<i>Adiantum</i> sp.	72	0,89
18	<i>Gleichenia</i> sp.	11	0,14
19	<i>Lygodium scandens</i>	2	0,02
20	<i>Stenochlaena palustris</i>	5	0,06
21	<i>Lycopodium fargesii</i>	3	0,04
22	<i>Lycopodium cernuum</i>	4	0,05
23	<i>Ophioderma pendula</i>	4	0,05
24	<i>Lycopodium juniperoideum</i>	6	0,07
25	<i>Selaginella</i> sp.	10	0,12
	Total pollen AP	752	9,34
	Total pollen NAP	6900	85,67
	Total spore	402	4,99
	Total Palinomorf	8054	

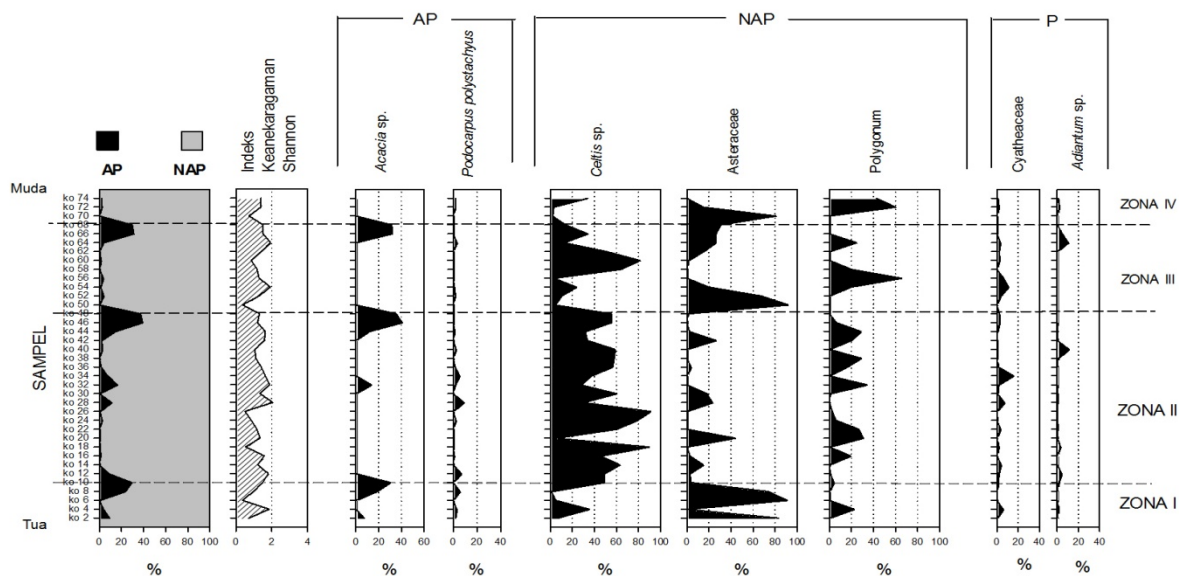


Figure 2. Diagrams of flora diversity dynamics were found in the sediment of Kedung Ombo Lake

Based on the curve temporally seen a change in the number type of flora has fluctuated up and down from a layer of sediment that old age until the age of youth, although with a lower value of diversity but dynamic and balanced. It was indicated the presence of pollen and spores was followed the pattern of dynamic sedimentation and repeated on multiple layers.

The increase in the value of diversity index caused by the imbalance of the number of taxa and number of individuals who attend or are found in the sediments of Lake Kedung Ombo. When the value of diversity index Shannon-Wiener was up, it indicates a high number of taxa of flora which present in the layer with the number of individuals that a balanced and stable. Up and down fluctuation of the diversity of flora is also influenced by environmental conditions and climate change that could affect the development of a flora. When the value of the Shannon diversity index was up, suggests that there is high stability of plant development or more plants that can survive in the environment and climate conditions Kedung Ombo Lake at the time.

Based on the value of Sorensen similarity index, the value of similarity between samples ranged from 0.14 to 0.88 (14% -88%), which the highest similarity index score of 0.88 (88%) were found between the samples KO.30 with KO.12 and KO.64 with KO.12 indicated similarity types of pollen and spores that are present in all three samples was very high at 88%. It also showed that the diversity of flora in the Lake Kedung Ombo Purwodadi inclined dynamically balanced because of the temporal presence of pollen and spores on each layer quite same. With Sorensen Similarity Index mean value of 0.56 (56%) showed high similarity between samples of species, and indicates that the layers have the same similarities at one time or condition, although there has been a change in the environment because the formation of the lake did not change drastically of taxa diversity flora in the environment, with a high similarity index values showed high diversity of flora around the Lake Kedung Ombo, including low or, can be quite uniform.

The presence of flora found in the sediment of Lake Kedung Ombo besides the pollen comes from the environment of the lake Kedung Ombo, which is an environment of freshwater but also pollen carried from the surrounding environment near the lake but it also forms of lowland areas and pollen that comes away from the mountain areas. While it can be ascertained Pteridophyta presence because according to Tjitrosoepomo (1986) Pteridophyta is cosmopolitan or it was able to live throughout habitat and one group of plants to indicate habitat condition is more wet or damp.

Overall from the oldest sediment layers up to the age of the youngest, the presence of taxa of flora NAP was more abundant than the number of taxa AP and Pteridophyta. This shows that the group of shrubs was able to grow around the Lake Kedung Ombo than the group of plants with tree habitus. It also shows that the environmental conditions around Lake Kedung Ombo Purwodadi has a climate tends to be cold and dry. According to Rahardjo et al. (1999)

when the percentage of AP increases, the climate will tend to be hot and wet (humid), otherwise, if NAP increases, changes in the climate became cooler and dry.

The dynamics of the diversity of flora that is found in the sediment of Lake Kedung Ombo Purwodadi temporally from the age of the oldest sedimentary layer to layer a young age is divided into 4 zones. This zoning is based on fluctuations in the percentage of the presence of flora found in the sediment. The overall diversity of flora vegetation around the lake tend to be dynamically stable in the dominance of the group flora NAP up to 90%, and the average is dominated by a group *Celtis* sp. with characteristic morphology with an aperture spherical pollen triporate and habitat in the lowlands. Diversity types of flora in the zone I or zone to the age of the oldest sediment layers dominated by Asteraceae, then in zone II group *Celtis* sp. more dominating, and the third zone changes in environmental conditions of terrestrial into the aquatic environment characterized by declining attendance *Celtis* sp groups which has a lowland habitat and then an increasing number of groups of Asteraceae, and *Polygonum* sp. which has a freshwater habitat. In zone IV which is the youngest sediment layers and groups Asteraceae *Polygonum* sp. also dominate. Pteridophyta presence in the sediments of Lake Kedung Ombo has a very low percentage of the highest only about 10% shows the environmental conditions around the lake tends to dry.

Lake Kedung Ombo which is an artificial lake which was built about 26 years ago, it did not provide a very significant change to the diversity of taxa of flora in the environment of the lake from the past to the present, but did decrease the number of taxa until a point is very low, reaching 0.356 (KO.50) in zone III then the number of taxa at the layer above it increased back and the next layer becomes more dynamic. Currently, the lowest point of the number of taxa that the possibility of changes in the environment of the terrestrial environment into the aquatic environment as a result of the formation of the lake.

The overall diversity of flora found in the sediment of Lake Kedung Ombo dominated by non-arboreal pollen (NAP) or groups of shrubs or herbaceous plants. This is because a shrub is easy to grow on the environmental conditions in the Lake Kedung Ombo is an open environment with enough light intensity is not obstructed by the canopy of trees and close to the river flow. In accordance with the opinion of Gusmaylina (1983) that are generally shrubs or herbaceous plant are a pioneer and a variety of shrubs and herbaceous species strongly influenced by environmental factors such as light, humidity and canopy cover of trees around it. Taxa flora of the NAP group is a group that is more dominating *Celtis* sp and Asteraceae.



Figure 3. Habitus of *Celtis* sp. (Anonim,2015)

Celtis sp was dominance because it is a pioneer plant or pilot plant capable and easy to rapidly grow and develop in an environment of Lake Kedung Ombo. In accordance with the opinion, Orwa et al., (2009) that *Celtis* sp is the synonym of *Trema orientalis* which is a pioneer plant that spread is very broad. The presence of Asteraceae groups also dominates as seen from habitat which is fresh water or a group of plants that live near freshwater flow into the reason these groups also dominate the environment of Lake Kedung Ombo which is a freshwater environment. Morphology of pollen and spores found in the sediment of Lake Kedung Ombo Purwodadi have variations in shape, size, symmetry, polarity, type aperture, and ornamentation exin. Type of pollen and spores are found in the sediments of Lake Kedung Ombo Purwodadi consists of 25 types and identified up to the level of the family as much as six types, as many as 11 types genus level, and as many as eight species type. Type of pollen and spores found in the sediment of Lake Kedung Ombo split of arboreal pollen (AP) which shows the plant in the form of trees as much as 3 types, non-arboreal pollen (NAP) shows the shrub and

herbaceous as many as 9 types, and spores indicate plants Pteridophyta as many as 13 types, NAP is dominated by a group of species *Celtis* sp.

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