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Research Article

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The diversity of Pteridophytes in pepe watershed Surakarta polluted by household waste

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ABSTRACT

Pepe River is one of the Bengawan Solo with a reasonably high level of water pollution due to the habit of the surroundings in throwing garbage into the river. Plants that can survive in polluted land conditions have a high tolerance level, called pioneer plants. One of them is ferns (*Pteridophyta*). This study aims to identify the type, abundance, Important Value Index (IVI), and index Diversity of *pteridophytes* plant diversity in the Pepe Watershed. The method used in this research is descriptive quantitative using the quadrat sampling technique method with a 1x1 meter plot. The sampling technique is using purposive sampling. Data analysis was conducted qualitatively and quantitatively. Analysis of diversity index data (H') by Shannon-Wiener. Based on the results of the study found eight species of ferns from 5 families. There are *Pteris vittata, Pteris biaurita* L., *Adiantum lunulatum* Burm.fil., *Adiantum latifolium* Lam., *Adiantum hispidulum* Sw, *Marsilea crenata* C. Presl, *Microlepia speluncae* (L.) T. Moore, *and Asplenium scandicinum* Kaulf. This diversity is included in the medium category with H'= 1.44. The fern with the highest abundance was *Pteris vittata* with 176 individuals, a density of 5.87 individuals/m2, a frequency of 0.53, and an IVI of 109.3%. Set side by set, the lowest abundance was *Microlepia speluncae* with eight individuals, a density of 0.27 individuals/m2, a frequency of 0.03, and IVI of 5.6%. Based on this, ferns can survive in polluted river areas. Information on the diversity of ferns found on critical land, especially rivers, is expected to provide initial information in overcoming other similar critical lands.

Keywords: Diversity; Pteridophytes; pepe river; household waste

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INTRODUCTION

River is one of the springs that have many roles and benefits for human life. This utilization has long been done especially for people who live near watersheds. River has a water reservoir area that will drain

into the river. It is called a watershed. The watershed is divided into three parts: upstream, midstream, and downstream. The function of the watershed is as a catchment area, water storage, and water distribution area (Halim, 2014). In general view, watersheds are the unity of ecosystems consisting of main elements such as natural resources of soil, water, vegetation and human resources as a subject of the utilization of natural resources (Maryani et al., 2018). Watersheds are also bounded by the height of land and provide a connected network of streams, lakes and wetlands, linking each stream to the other streams and watersheds it flows to and from. This connected network defines stream systems – stream tributaries flow from a stream headwater to a mouth located on either another stream or some other water body e.g., a lake or the ocean (Gray, 2012).

Nowadays, many rivers are found that have decreased water quality due to pollution. One of the rivers in Surakarta that has been polluted is the Pepe River (BBWSBS, 2019). Pepe River is one of the tributaries of Bengawan Solo that the people around the river use daily. This river flows along the residential area and upstream from the branch of Anyar River in the Tirtonadi Bus Station in Gilingan Village, Banjarsari, and divides in Surakarta to Demangan Water Gate Sangkrah Village, Pasar Kliwon. Pepe River becomes a river that flows in Solo City, which has about 7.4 Km with different widths, ranging from 2 to 5 Km (Wibawa & Qomarun, 2020).

Pepe Watershed is one of the rivers with a high water pollution level (BBWSBS, 2019). This problem is caused by people who ignored the conditions around the watershed. Moreover, the habit of throwing garbage in the form of solid or liquid waste into the river's body is still happening. Whereas the Solo Regional Government has issued various efforts to prevent this. Among them are river cleaning activities which have been carried out several times by the government and the Bengawan Solo BBWS together with the Water Resources Public Works Agency of Central Java Province, the Surakarta City Regional Disaster Management Agency, the Jebres District Police, and the Sibat River Care Community (BBWSBS, 2019). In addition, the government has also issued regulations that are the main guidelines in solving river problems, whether it is river water, riverbanks to the prohibition of throwing garbage in rivers (Wibawa & Qomarun, 2020). As in Regulation of the governor of Central Java number 98 Of 2018 article 16 paragraph 1 concerning water establishment and river water quality Management Pepe river in Central Java which contains *"Regency/City Governments monitor the implementation of water pollution control action programs and control environmental damage in Pepe Sub-watersheds in an integrated manner between the Central, Provincial and Regency/City governments"* (Pergub No 98 Tahun 2018). In addition, there are other regulations in the Solo Regional Regulation No. 10 of 2015 concerning environmental protection and management and the Solo Regional Regulation No. 2 of 2016 regarding the prevention and improvement of river quality for housing and slum settlements (Wibawa & Qomarun, 2020).

Based on the observations that have on July 2021, on the right and left sides of the river, there are the most densely populated housing and buildings that are quite high. The colour of the water is not clear. The water appears green to dark, turbid has a pungent smell, and contains solid pollutants such as plastic waste, diapers, household waste, and others. It happens because the entire flow of household waste treatment derived from residential areas flows through the river's waterways and mixes into one. The impact of this river pollution will cause damage to the ecosystems and environmental pollution if just left in these conditions. The condition of pepe river polluted by household waste can be seen in Figure 1 and household water lines from the residential area can be seen in Figure 2.

Figure 1. The Condition of Pepe River Polluted by Household Waste (Source: Personal Documentation, 2021)

Figure 2. Household Water Lines from the Residential Area (Source: Personal Documentation, 2021)

The latest data obtained from the Great Hall of the River Region Bengawan Solo shows that household waste plays a significant role in polluting the waters of the Pepe River (Bengawan Solo, 2020). Terrible water conditions can be seen from the value of BOD_5 on June-December 2020 has an average of 19.8 mg / L, which is far above the quality standard, 12 mg / L. The high value of BOD_5 is a cause of household and industrial waste disposal that has a pungent odour, the water turns black, turbid, has foam, and some piles of garbage on the banks of the river. The high result of BOD_5 values found in the Pepe watershed can

decrease DO levels in this area. For example, in October 2020, as a result of BOD_5 26.7 mg / L, it causes DO levels of 0.4 mg / L. Then, in December 2020, the BOD_5 value is 7 mg / L and has a DO level of 0.8 mg / L (Happy et al., 2012). It happens because of the poor river environment, over organic and non-organic waste in the river. Turbidity in water does not necessarily indicate a high content of BOD_5 and COD. However, it can be caused by deposits or suspension particles such as clay, mud, dissolved organics, bacteria, plankton and other organisms (Pujiastuti et al., 2013).

Since Pepe river is one of the city rivers, most river banks are walled and fenced. However, on the riverbank found several kinds of plants. The plants that can survive in polluted land conditions, such as in the Pepe River, have a high tolerance level. The plant is known as a vascular plant. One of the plants that include vascular plants is *pteridophyte* (Laely et al., 2020). The results of research that has been carried out by Wahyuna (2014) on polluted land namely former PETI mining, it can be found *pteridophyte* s that live there. The impacts of mining activities include: destruction of vegetation, changes in the composition of plants that constitute mining, decreased productivity, disturbance of flora and fauna, and changes in micro-climate vegetation damage is the most obvious impact in an ex-mining area. This makes plants need a long time to grow on the former PETI land. However, in the land around Blue Lake, many species of *pteridophyte* are found. This shows that Pteridophyta are plants that have a high tolerance level.

The existence of *pteridophyte* is one of the components of the ecosystem that can indicate whether the environment can support the life of the organism or not because it has a reciprocal relationship and interdependence with the environment (Wahyuna, 2014). In general, *pteridophyte* plants grow in sheltered and moist places (Dayat, 2020). However, *pteridophyte* can also be found in the open place. One of the damp and open places in the watershed of Pepe River in Surakarta. The research on *pteridophyte* plants in the watershed has been studied by Nofri (2015). The result is the discovery of 16 species *pteridophyte* in the cold water trunk of Lubuk Minturun, Koto Tangah Padang. Another research by Amin & Jumisah (2019) found two species of *pteridophyte*, namely *Diplazium accendens blume* and *Orthioptheris* sp in Terutung Kute, Darul Hasanah, Southeast Aceh. However, the diversity of *pteridophyte* plant species found in rivers with polluted conditions of household waste has never been studied before. The types of *pteridophyte* located in the watershed of Pepe River has not been explored yet. Therefore the researchers are interested in identifying nail *Pteridophyte* water conditions contaminated with household waste.

This study aims to identify the type, abundance, Important Value Index (IVI), and index Diversity of nail *pteridophyte* diversity in the Pepe Watershed. The differences of *pteridophyte* that can survive in the Pepe Watershed are essential information that needs to be known to provide an overview of the land communities that have been damaged. The known diversity of *pteridophyte* on critical land, especially rivers, is expected to provide preliminary information addressing other similar critical lands. In addition, the data regarding the types of *pteridophyte* are essential data as a database of biodiversity or as a material for the manufacture of learning media and others that certainly play a role in education.

RESEARCH METHODS

This research was conducted along the Pepe Watershed, starting from the Anyer River in the Tirtonadi Bus Station area, Gilingan Village, Banjarsari District, into the Demangan Water Gate Sangkrah Village, Pasar Kliwon for a length of 7.4 KM. The research activity uses a descriptive quantitative method with the sampling method using the quadratic method. While the sampling technique used purposive sampling, one of the non-random sampling techniques in which the researcher determines the sampling by setting special characteristics following the research objectives so that it is expected to answer research problems (Asrianny

et al., 2010). Map of pepe watershed can be seen in Figure 3 and research location (pepe watershed) can be seen in Figure 4.

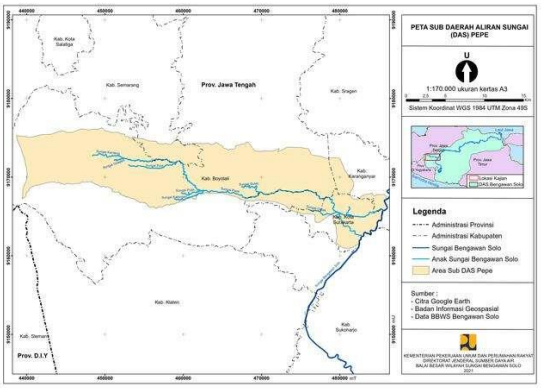

Figure 3. Map of Pepe Watershed
(Source: BBWS Bengawan Solo, 2021)

Figure 4. Research location (Pepe Watershed)
(Source: Google maps, 2021)

This research was conducted in July-August 2021. The tools and materials used are stationery, camera, 1x1 meter plot, hygrometer, soil tester, lux meter, plastic bag, cutter, identification book, 70% alcohol, sack and newspaper. The steps of this research are field surveys, sampling, species identification, herbarium preparation, and report preparation. The sampling step was carried out at three main stations. Station 1 is located upstream of the Pepe River (West side of Brayat Solo Hospital); station two is located in the midstream of the Pepe River (Keprabon Park), and station three is located downstream of the Pepe River (Demangan Watergate). It was done with the aim that the ferns obtained can represent each of the river areas. Sampling location can be seen in Figure 5.

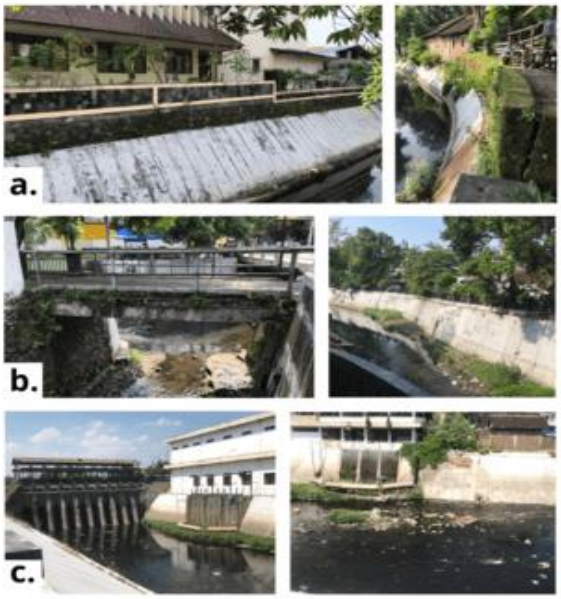

Figure 5. Sampling location: a) Upstream of the Pepe River (West side of Brayat Solo Hospital). b) Midstream of the Pepe River (Keprabon Park). c) Downstream of the Pepe River (Demangan Watergate).
(Source: Personal Documentation, 2021)

The population in this study is the entire *pteridophyte* vegetation in the Pepe watershed area in Surakarta City. While the research sample is *pteridophyte* plants contained in sample plots measuring 1x1 meter. Plant sampling is divided into two parts, the left and right sides of the river. Plots were placed at each

observation station, which consisted of 10 plots: 5 plots placed on the left side and five plots on the right side with a size of 1x1 meter each. The distance from one plot to another is 1 meter. *Pteridophytes* found in each plot were recorded with the names given by taxonomists, counted the number of species, and captured. Then, samples of plants of unknown species were taken, put in the plastic, and preserved using 70% alcohol. Sample identification was conducted at the Biology Education Laboratory, Teacher Training and Education Faculty, Sebelas Maret University, Surakarta, to determine the type of *pteridophyta* using an identification book.

Data analysis was conducted qualitatively and quantitatively. Descriptive qualitative data analysis is presented in a table containing the names of species, families, and habitats. Then, the morphological data from the *pteridophytes* were analyzed through a qualitative approach viewed from environmental aspects (temperature, humidity, light intensity, and soil pH). Meanwhile, quantitative analysis about the abundance of ferns found in the Pepe River watershed can be measured based on the value of Density (D), Relative Density (RD), Frequency (F), Relative Frequency (RF), and Important Value Index (IVI). The abundance of ferns can be seen from the Important Value Index (IVI), where this important value can be determined by the Relative Density (RD) and Relative Frequency (RF). The diversity index (H') can be calculated using the formula by Shannon-Wiener (Handayani, 2012):

$$H' = \sum_{i=1}^{s} \text{pi In pi}$$

Notes :
H': Index of Diversity by Shannon-Wiener
Pi: ni/N
ni: Total individual of a kind
N: Total individuals
S: Total types
Points of the Species Diversity Index, according to Shannon Wiener based on the following:

- The value of H' > 3 indicates that the species diversity on a transect is high.
- The value of H' 1 H' 3 indicates that the species diversity on a transect is of moderate diversity.
- The value of H' < 1 indicates that the species diversity on a transect is small or low.

FINDING AND DISCUSSION

The types of ferns found in the Pepe Watershed consist of 5 families and eight species from every point of observation stations. The types of ferns in the Pepe Watershed in Surakarta on Table 1.

Table 1. Types of Ferns in the Pepe Watershed, Surakarta

No	Family	Species	Habitat	Total
1	Pteridaceae	*Pteris vittata*	Terestrial	176
2		*Pteris biaurita* L.	Terrestrial	21
3	Adiantaceae	*Adiantum lunulatum* Burm.fil.	Terestrial	42
4		*Adiantum latifolium* Lam.	Terestrial	7
5		*Adiantum hispidulum* Sw	Terrestrial	13
6	Marsileaceae	*Marsilea crenata* C. Presl	Terestrial	32
7	Dennstaedtiaceae	*Microlepia speluncae* (L.) T. Moore	Terrestrial	8
8	Aspleniaceae	*Asplenium scandicinum* Kaulf.	Terrestrial	11
		Total		310

Based on Table 1, the types of pteridophyte *s* found in the Pepe Watershed contaminated with household waste consist of several families. The most dominating family composition is from the

Pteridaceae and Adiantaceae family. There are 8 species of ferns identified, there are: *Pteris vittata, Pteris biaurita* L., *Adiantum lunulatum* Burm.fil., *Adiantum latifolium* Lam., *Adiantum hispidulum* Sw*, Marsilea crenata* C. Presl, *Microlepia speluncae* (L.) T. Moore, and *Asplenium scandicinum* Kaulf. All pteridophyta species found have terrestrial habitats, mainly on riverbanks. Based on the observations, the species that dominates the Pepe watershed is *Pteris vittata*, with 176 individuals from the Pteridaceae family. This following research by Abotsi et al. (2015) which showed that the *Pteridaceae* group, especially *Pteris vittata* has excellent adaptability and is cosmopolitan, meaning that it can be found in habitats both in the air and in the air. This species can act as a phytoremediator, able to live in contaminated areas. This type includes epilithic nails which have high durability to environmental influences, likes sunlight and alkaline environment (Mumpuni, 2016). *P. vittata* has distinctive morphological characteristics compared to other types of the P*teridaceae*, namely having monomorphic leaves. Leaf shape is elongated/oblong, leaf type is compound, leaf tip is tapered, leaf base is lanceolate, leaf surface is bald/slick/glabrous, young leaves are green, dark green leaves are dark green, sori at the edges of the leaves with an elongated sorus arrangement on the leaf edges, indusium is absent (Yusna et al., 2016). Based on the *principal component analysis* (PCA) there is an influence between morphological characters and environmental factors such as soil fertility and climate, altitude, or biological factors such as reproduction and genetics (Mumpuni, 2016).

The species with the smallest number was *Adiantum latifolium* Lam. from the family of Adiantaceae, which only found seven species. This species does not show any special conditions that can be suspected as a determining factor for the existence of *Adiantum latifolium*. If a species has a small tolerance to all environmental factors, it has a narrow distribution area (Rizkiani, 2019). The morphology of this plant is in the form of a long spreading rhizome with brown scales. The fronds are pinnate and branched, the leaflets are trapezoidal in shape with serrated edges, forging venation. The slender stalk is black, the underside of the stalk near the root is brown scales. Linear sorus slightly curved, located at the edge of the leaf (Agatha et al., 2019). In addition, *Adiantum latifolium* lives in terrestrial habitats, namely on flat land and shaded conditions (Rizkiani, 2019). Based on this, the environmental conditions observed in this study were in the range of poor tolerance for growth and development of ferns in the area. Pteridophytes found in the Pepe River can be seen in Figure 6.

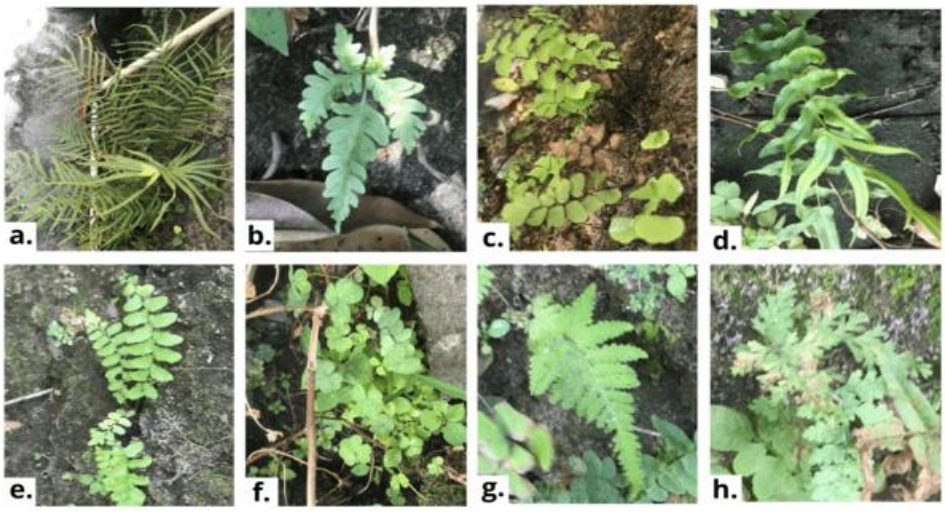

Figure 6. Pteridophytes found in the Pepe River a) *Pteris vittata,* b) *Pteris biaurita* L., c) *Adiantum lunulatum* Burm.fil., d) *Adiantum latifolium* Lam., e) *Adiantum hispidulum* Sw, f) *Marsilea crenata* C. Presl, g) *Microlepia speluncae* (L.) T. Moore, h) *Asplenium scandicinum* Kaulf. (Source: Personal Documentation, 2021)

The *pteridophyte* that found in the Pepe River area are fewer species than (Yassir et al., 2020) in the waters of the Lawe River Deleng Pokhisen District, Southeast Aceh Regency. In the research conducted, there were 12 species with 589, while in the Pepe River area, about 310 plants. The waters of the Lawe Harum River have both abiotic and biotic environmental conditions that support the existence of ferns, but Pepe River was not. The environment around the river is overgrown with densely growing trees that support plant life (Yassir et al., 2020). Meanwhile, the environment around the Pepe River is densely populated with residents. Calculation of the abundance of ferns in the pepe watershed, Surakarta can be seen in Table 2.

Table 2. Calculation of the abundance of ferns in the Pepe Watershed, Surakarta

No	Family	Species	Total	D	RD	F	RF	IVI
1	Pteridaceae	*Pteris vittata*	176	5,87	56,8%	0,53	52,5%	109,3%
2	Pteridaceae	*Pteris biaurita* L.	21	0,7	6,8%	0,07	6,9%	13,7%
3	Adiantaceae	*Adiantum lunulatum* Burm.fil.	42	1,4	13,5%	0,1	9,9%	23,4%
4	Adiantaceae	*Adiantum latifolium* Lam.	7	0,23	2,2%	0,07	6,9%	9,1%
5	Adiantaceae	*Adiantum hispidulum* Sw	13	0,43	4,1%	0,07	6,9%	11%
6	Marsileaceae	*Marsilea crenata* C. Presl	32	1,07	10,3%	0,07	6,9%	17,2%
7	Dennstaedtiaceae	*Microlepia speluncae* (L.) T. Moore	8	0,27	2,6%	0,03	3%	5,6%
8	Aspleniaceae	*Asplenium scandicinum* Kaulf.	11	0,37	3,6%	0,07	6,9%	10,5%
		Total	310	10,34	99,9%	1,01	99,9%	199,8%

Important Value Index (IVI) indicates the species' role in the community or research location. The greater the important value index, the more a plant species has a high role (Solikhatun et al., 2019). The presence of a plant species in an area shows the ability to adapt to the habitat and wide tolerance to environmental conditions. Plants that have the highest IVI value among the same vegetation are called dominant. It shows the ability of this species to adapt to the surrounding environment and compete with other species (Khamalia et al., 2018).

The results of data analysis on ferns seen from the IVI show that ferns have a higher index value than other species and differ in the same area. Based on Table 2, the density, frequency, and index values of ferns in all stations obtained the highest IVI, *Pteris vittata* with a density value of 592 individuals/m^2, a frequency of 0.653 and an IVI of 109.3%. This species has more frequency of presence than other species, so it has the highest abundance. The abundance of this plant is influenced by various factors, including the ability to adapt and compete with other plants (Sari & Bayu, 2019). If an IVI is highest and dominates at a point of observation, it can indicate that the species has a tolerance to its habitat. This fern type of *Pteris vittata* has fairly good adaptability and breeds in unfavourable conditions, such as the Pepe River polluted by household waste.

This is following research conducted by Abotsi et al., (2015) which shows that the *Pteridaceae* group, especially *Pteris vittata*, has excellent adaptability and is cosmopolitan, meaning that it can be found in various habitats both on land and in the air. *Pteris vittata* is a liar fern that is spread in the tropics and subtropics. This species has a wide tolerance range from lowlands to highlands (± 2000 m asl), spreads in primary and secondary forests, lives in open areas with dry or humid environmental conditions, grows attached to rocks at the edge of the forest, roads, and gaps in building walls (Mumpuni et al., 2015). This species can act as phytoremediator, able to live in areas contaminated by chemicals that contain Arsenic and other substances containing elements of other heavy metals such as Cadmium, Copper, Iron,

Manganese, Lead, and Zinc which are commonly found in areas polluting and mining areas (Morajkar et al., 2015).

Meanwhile, the lowest IVI *Microlepia speluncae* have a density value of 0.27 individuals/m2, frequency of 0.03, and an IVI of 5.6%. This type of fern has a less frequent presence than other types. It is because these ferns are commonly found in lowland areas with humid environmental conditions. The lowest IVI is the fern species that are less able to grow and adapt to the environmental conditions of the Pepe River, which is polluted by household waste. According to the research conducted by Astuti et al. (2018) showed that *Microlepia speluncae* was found on the edges of ravines, river banks, and the edges of wet or damp bushes. If observed from the characteristics of its species according to Yudhayana (2013), *Microlepia speluncae* is a terrestrial plant that is able to live in environmental conditions in a shade that is not too close to normal soil pH conditions ranging from lowlands to high at a certain altitude, so only a few grow in the Pepe River because of the unshaded and polluted condition of the Pepe River. *Microlepia speluncae* in the Pepe River was only found under the shade of trees with not too dense conditions so that sunlight could still penetrate at that location. Calculation of fern diversity in the pepe watershed, Surakarta can be seen in Table 3.

Table 3. Calculation of Fern Diversity in the Pepe Watershed, Surakarta

No	Species	∑individual	Pi(ni/N)	ln Pi	Pi ln Pi
1	*Pteris vittata*	176	0,57	-0,57	0,32
2	*Pteris biaurita* L.	21	0,07	-2,69	0,18
3	*Adiantum lunulatum* Burm.fil.	42	0,14	-2,00	0,27
4	*Adiantum latifolium* Lam.	7	0,02	-3,79	0,09
5	*Adiantum hispidulum* Sw	13	0,04	-3,17	0,13
6	*Marsilea crenata* C. Presl	32	0,10	-2,27	0,23
7	*Microlepia speluncae* (L.) T. Moore	8	0,03	-3,66	0,09
8	*Asplenium scandicinum* Kaulf.	11	0,04	-3,34	0,12
	Total	310	1,00	-21,49	H' = 1,44

Based on Table 3, the results of the calculation of the Shanon-Wiener species diversity index of the fern species in the Pepe Watershed, Surakarta, show a diversity value of H' = 1,44. H'>3 value indicates high species diversity. H'1≤H≤3 value indicates diversity a species is at a moderate level, and the value of H'<1 indicates that the level of diversity of a species is at a low level (Handayani, 2012). It shows that the fern community in the Pepe Watershed Surakarta has a moderate diversity index value due to H'1≤H≤3.

The diversity of ferns in the area is moderate because of the eight species of ferns found. There is one that dominates the forest location, namely the *Pteris vittata* species. This type of *Pteris vittata* is widely distributed in the research area, found in 16 of the 30 observation plots. Following Leksono (2017), species diversity can be used to determine community structure. The more species with the same or close to the same number of individuals, the higher the heterogeneity level.

Conversely, if the number of species decreases, and there are considerable differences in the number of individuals between species, the lower the heterogeneity of a community itself (Leksono, 2017). Many individuals of the *Pteris vittata* species inhibit the growth of other ferns in competing for space, nutrients, and light. The diversity of ferns in the Pepe Watershed area of Surakarta is influenced by environmental factors, shown in Table 4.

Table 4. Measurement Results of Abiotic Components at the Research Location

No	Time and Location	Abiotic Factors of The Environment			
		Air Temperature	Humidity	Light intensity	Soil temperature
1	Morning (Pepe River)	28,6 °C	67 %	49,2 lux	30 °C
2	Afternoon (DAS River)	32,8 °C	53 %	63 lux	30 °C
3	Evening (DAS River)	27,6 °C	60 %	42,2 lux	30 °C
	Average	29,7 °C	60 %	51,5 lux	30 °C

The antibiotic environmental conditions also influence the diversity of pteridophytes plants. The structure and composition of vegetation is influenced by one of the places where it grows or habitat (Abotsi et al., 2015). Based on Table 4, the environmental factors that affect research activities include the average air temperature, 29,7 °C, 60% air humidity, light intensity of 51,5 lux, and 30°C soil temperature. The factors affect the diversity and number of *pteridophytes* plants in the Pepe Watershed. Based on the results of these environmental conditions, therefore the *pteridophyte* plants that had the highest number were *Pteris vittata*. This is in accordance with the theory which shows that *Pteris vittata* live at a soil pH of 7.08, a soil moisture of 7.8 which means acid, and an air temperature of 28-32°C (Riastuti et al., 2018).

According to Handayani & Sugiarti (2012), air temperature is a factor controlling the distribution of a vegetation. The difference in temperature will affect the vegetation on earth, thus it will also affect the types of *pteridophytes*. Generally, *pteridophytes* are land plants that are found in humid or somewhat sheltered areas. *Pteridophytes* are usually found under dense tree canopy cover with low air temperatures and generally grow in the air temperature range of 21 – 27°C. Soil temperature is no less important for the growth of ferns. Soil is the main medium, especially for vegetation growth. The optimum soil temperature in the tropics for ferns ranges from 22 C-37°C. In addition to air temperature and soil temperature, air humidity, soil moisture, and soil pH also directly affect the life of ferns. The ideal soil moisture for the growth of ferns is with humidity between 50% - 80% (Wahyuningsih et al., 2019).

In addition, pollution also affects the growth of *pteridophyta*. If it increases, it will affect the number of species because only a few species or certain species can survive, and there are dominant species. According to Wahyuna (2014), pioneer plants such as *pteridophyta* can accumulate heavy metals, improving land quality. For example, ferns are a pioneer species. Each has anatomical and morphological characteristics that allow some of their species to survive in polluted river conditions.

CONCLUSION

Based on the study results, eight species of ferns from 5 families in the Pepe Watershed in Surakarta were polluted with household waste. There are *Pteris vittata, Pteris biaurita* L., *Adiantum lunulatum* Burm.fil., *Adiantum latifolium* Lam., *Adiantum hispidulum* Sw, *Marsilea crenata* C. Presl, *Microlepia speluncae* (L.) T. Moore, and *Asplenium scandicinum* Kaulf. *Pteridophyta* species were found to have terrestrial habitats, primarily on riverbanks.

The diversity of ferns in the Pepe Watershed area is included in the medium category with a Diversity Index (H') of 1.44. The fern with the highest abundance was *Pteris vittata* with 176 individuals, a density of 5.87 individuals/m2, a frequency of 0.53, and an IVI of 109.3%. In comparison, the lowest abundance was Microlepia speluncae with a total of 8 individuals, a density of 0.27 individuals. /m2, a frequency of 0.03, and an IVI of 5.6%. Based on this, ferns can survive in polluted river areas. *Pteridophyta* plants have anatomical and morphological characteristics that make some species of them survive in polluted river conditions. Like a *Pteris vittata* which has excellent adaptability and is

cosmopolitan, meaning that it can be found in habitats both in the air and in the air. This species can act as a phytoremediator, able to live in contaminated areas. This type includes epilithic nails which have high durability to environmental influences, likes sunlight and alkaline environment. *P. vittata* has distinctive morphological characteristics compared to other types of the Pteridaceae, namely having monomorphic leaves.

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