Diversity of Lichen as A Bioindicator of Air Quality at The University of Jember

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Abstract: Lichen is an indicator plant that is sensitive to air pollution. This sensitivity is indicated by changes in state, body resistance, and reactions to environmental changes. This study aims to evaluate air quality in the University of Jember environment by using lichen as a bioindicator. The selection of the University of Jember as the research site was based on its unique environmental conditions, namely the presence of high motor vehicle activity, the presence of industry, and also the extent of green areas. Data were obtained through lichen sampling in 15 faculties and analyzed using the Air Quality Index of Atmospheric Purify (IAP). The results showed low average IAP values, indicating poor air quality in the campus environment. The Faculty of Computer Science and Faculty of Agriculture had the lowest IAP values, indicating the highest levels of pollution. Correlations between IAP values and the presence of green spaces and human activity showed that these factors significantly affected air quality. A decrease in lichen diversity indicates an increase in air pollutants, especially from vehicle exhaust. This study concludes that lichens can be an effective tool for monitoring air quality in urban environments, particularly in campus areas.

Keyword: Air Quality, Bioindicators, Lichen, Pollution

INTRODUCTION

Lichen is a low-level plant that belongs to the Thallophyta division. Lichen or crustal lichen is an organism resulting from a symbiotic association composed of millions of photosynthetic microorganisms (photobiont) united in a network of parasitic hyphae or so-called mycobiont (Campbell *et al.*, 2003). Algae (photobiont) acts as a carbohydrate provider because it has chlorophyll to carry out photosynthesis while parasites take minerals from the environment, while acting as a provider of structure and mass and protection. This relationship makes it possible for lichen to live in extreme environments (Ahmadjian, 1973). Lichen has 3 types, namely Crustose or brightly colored lichen, Foliose or lichen that has threads like roots and is attached to trees, and Fruticose or bush-like lichen (Rahayu and Roziaty, 2018). The distribution of lichen is also influenced by light, humidity, topography, rainfall, and temperature (Roziaty *et al.*, 2021).

Lichen is an indicator plant that is sensitive to air pollution. This sensitivity is indicated by changes in state, body resistance, and reactions to environmental changes. Lichen has an important role in ecosystem balance including as an oxygen supplier, succession agent, bioindicator of air pollution, and biomonitoring of air quality (Pratama and Trianto, 2020). Lichens have a wide geographical distribution (except in water areas), are abundant, sessile, perennial, have a relatively fixed morphological shape over a long period of time and do not have a cuticle layer, so they can absorb gases and pollutant

particles directly through their talus surface. The use of lichen as a bioindicator is considered more efficient than using indicator tools or machines whose operation requires large costs and special handling (Rahayu and Roziaty, 2018).

The University of Jember was chosen as the research location not only because of the high intensity of motorized vehicle activity and the presence of industry around the campus area that has the potential to reduce air quality, but also because the University of Jember area has a fairly large green space with the presence of shade trees. Based on the research of Qomah *et al* (2015), the University of Jember area has 43 types of plants with tree habitats on an area of 27.75 ha which functions as a green lung to help absorb air pollutants. The utilization of lichen as a natural indicator in the study can provide an accurate picture of the condition of air quality in the University of Jember environment, so that it can be known to what extent the air quality in this area is still maintained or has experienced pollution. More in-depth air quality mitigation and evaluation measures such as controlling vehicle emissions, and increasing green space are needed to buffer air quality. Therefore, it is necessary to conduct research in the University of Jember area to analyze lichen diversity as a bioindicator of air quality.

RESEARCH METHODS

This research was conducted during October 2024 with data collection conducted on October 5, 2024 in fifteen faculties at the University of Jember. Data analysis was conducted at the Biology Laboratory, Faculty of Mathematics and Natural Sciences, University of Jember. The following is a plan of the location of data collection conducted at the University of Jember (Fig. 1).

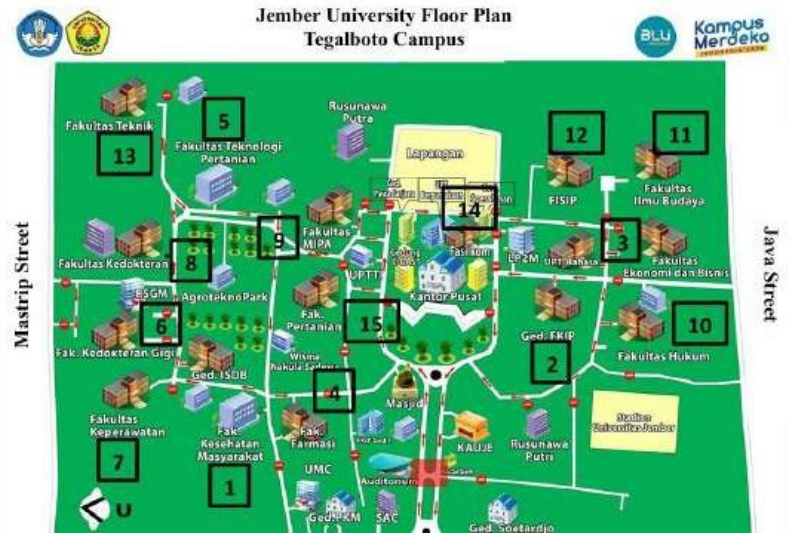

Figure 1. Maps of *Lichen* Sampling Location
(Source: https://unej.ac.id/peta-unej/)

The tools used in this research is plastic plots with the size of 10x10 cm/tree, microscope, ruler, and cutter. The materials used in this research is markers, ziplock plastic bags, labels, and paper.

Lichen samples were collected at 15 different sites with 7 trees observed at each site. Plots were placed horizontally on the tree trunk at a height of 1.3 meters from the ground, on four sides of the observed trees. Lichens found in the plots were shaded using markers, then counted and recorded the number of colonies, to calculate the area of cover. Lichen samples were taken by peeling the substrate to which *the* lichen was attached using a *cutter,* then placed in a *ziplock* plastic bag and labeled. The lichen samples were identified at the Biology Laboratory, Faculty of Mathematics and Natural Sciences, University of Jember.

The lichen samples were then identified microscopically. Microscopically identified lichen by observing the morphological characteristics of lichen, such as color, talus shape, and the presence and absence of additional organs, using a stereo microscope. Observation results were documented to facilitate the identification process. The identification of lichen samples was matched using the book Lichen in the Environment of Jember University by Wiku Purnama Wisesa (2016).

The data obtained in this study were analyzed using Microsoft Excel, starting from the calculation of the Atmospheric Purity Index (IAP) to the percentage of vegetation cover. IAP is an index used to determine the level of atmospheric purity using data on the number of moss colonies and their cover area. Data analysis began with calculating the percentage of moss cover at various sample points taken from the study site. The percentage was calculated based on visual observation of the area covered by moss at each point. Enter the data in excel form and then calculate the IAP value by comparing the measured concentrations of air pollutants at the study site with the applicable air quality standards using the following formula:

$$\mathbf{IAP} = \frac{\mathbf{1}}{\mathbf{100}} \sum_{\boldsymbol{I=i}}^{\boldsymbol{n}} (\boldsymbol{Q_i} \times \boldsymbol{f_i})$$

Description:

n = Total number of lichen

Q = Ecological index

f = Frequency of cover

Analyzing the correlation between the percentage of lichen cover and IAP value to see the relationship between lichen diversity and air quality in the area. The value obtained from the formula is then entered into the IAP criteria to determine the level of pollution, which is presented in the following table 1

Table 1. IAP Criteria

Pollution Level	Criteria	Description
Level A	$0 \leq IAP \leq 12.5$	Very high pollution
Level B	$12.5 < IAP \leq 25$	High pollution
Level C	$25 < IAP \leq 37.5$	Moderate pollution
Level D	$37.5 < IAP \leq 50$	Low pollution
Level E	$IAP > 50$	Very low pollution

(Fandani *et al*., 2019).

RESULTS AND DISCUSSION

Air quality can be seen through several aspects, one of which is the biological aspect (Kaswinarni *et al.*, 2023). Samudera *et al* (2022), stated that one of the efforts to prevent and control air pollution is to monitor air quality using bioindicators. Lichen are

biological aspects that can be used as bioindicators of air quality (Ramadhani *et al*., 2022). Lichen are very sensitive to the environment in which they live. If there is air pollution in its habitat, it will disrupt its process of growing or even unable to grow. Lichen are able to live in harsh and extreme environments, but are also very sensitive to air pollution. Most species of Lichen are particularly sensitive to sulphur gas (SO2) and other exhaust gases from motor vehicles or industrial areas. The use of Lichen as bioindicators of air quality can be seen from the damage and accumulation of pollutants in their thallus (Kaswinarni *et al.*, 2023; Ardiansyah *et al.,* 2024).

Table 2. **IAP Measurement Results from each faculty at the University of Jember**

Faculty	IAP
Faculty of Public Health (FKM)	0.15
Faculty of Education (FKIP)	0.12
Faculty of Economics and Business (FEB)	0.16
Faculty of Pharmacy (FARMASI)	0.10
Faculty of Technology and Agriculture (FTP)	0.25
Faculty of Dentistry (FKG)	0.24
Faculty of Nursing (FKEP)	0.28
Faculty of Medicine (FK)	0.22
Faculty of Mathematics and Natural Sciences (FMIPA)	0.16
Faculty of Law (FH)	0.16
Faculty of Humanities (FIB)	0.13
Faculty of Social and Political Sciences (FISIP)	0.65
Faculty of Engineering (FT)	0.28
Faculty of Computer Science (FASILKOM)	0.01
Faculty of Agriculture (FAPERTA)	0.01
Total	**2.92**

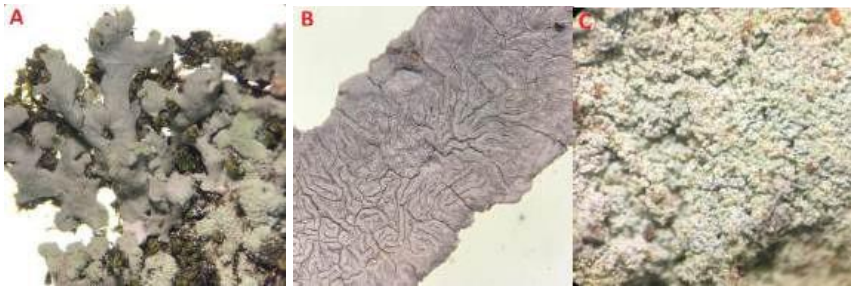

Figure 2. A. *Flavoparmelia* cf. *caperata,* B. *Graphis* cf. *araceae,* C. *Lecanora* sp.

Based on the results of IAP measurements from each faculty at the University of Jember, the vehicle frequency distribution of the lowest IAP value comes from the Faculty of Computer Science (FASILKOM) and the Faculty of Agriculture (FAPERTA) with an IAP value of 0.01. The value obtained indicates air quality with very high pollution levels. This is because the environment of the faculty of Computer Science (FASILKOM) does not have many plants or trees that can condition pollution from motorized vehicles which are quite a lot while in the environment of the Faculty of Agriculture (FAPERTA) there are many plants or trees but the total number of motorized vehicles in the faculty has a very large number. This statement is supported by Diener's research (2021), namely that a small amount of plant vegetation can reduce the absorption of CO_2 *(carbon dioxide)* levels so that the concentration of CO_2 *(carbon dioxide)* in the

air increases and dust particulates will float more freely in the air. Based on research conducted by Ramadhani *et al* (2022), the more motorized vehicles, the exhaust gas which is a source of air pollution will also increase. This causes the level of air pollution to almost exceed air quality standards so that pollution is categorized as very high.

Vehicle frequency distribution data at the University of Jember, Faculty of Social and Political Sciences (FISIP) shows values that indicate air quality with low levels of pollution. This is relevant to the IAP recorded in the faculty, which is 0.65 the highest value compared to other faculties. This statement is supported by Nugroho and Muhammad's research (2021), namely the frequency distribution level of motorized vehicles in the social science faculty, one of which is in the faculty of social science and political science, the percentage is lower than the science faculty. The use of motorized vehicles is one of the main factors causing air pollution, so the low use of motorized vehicles in the Faculty of Social Sciences has the potential to have a positive impact on air quality around the faculty. Another underlying factor is having more plants or green open spaces around campus. Research conducted by Khiron and Moelyaningrum (2022), states that plants can absorb air pollutants, such as carbon dioxide (CO_2) and fine particles, and produce oxygen that helps improve overall air quality. This is a very important factor in creating an environment with high IAP.

Based on the results of the IAP measurements in 15 faculties at the University of Jember, an IAP value of 2.92 was obtained, indicating air quality with very high pollution levels in the University of Jember campus environment. University of Jember is one of the major universities in East Java with an area of 97.449 hectares and a student population of 39.677 in the 2022/2023 academic year. Dense activities on the campus of the University of Jember, especially the use of motorized vehicles by the academic community on campus, contribute significantly to high CO_2 emissions and other pollutants that ultimately worsen air quality (Damayanti *et al*., 2024).

University of Jember has a high diversity of plant species, which contributes to improving air quality in the campus area. Existing plants, especially street shade trees and ornamental plants, have an important role in filtering pollutants and producing cleaner air. University of Jember has 43 tree species that help reduce the concentration of pollutant particles from vehicle fumes, dust, and other pollutants. The existence of this vegetation has a positive impact by creating a healthier, safer, and more comfortable environment for the entire academic community (Qomah *et al*., 2017).

Although plant type vegetation on the University of Jember an important role in improving air quality by absorbing pollutants and producing oxygen, the high intensity of motorized vehicle activity in the University of Jember environment remains a major factor that negatively affects air quality. The high volume of vehicles from the academic community at the University of Jember will produce CO_2 gas emissions and other pollutants that cause air quality with very high pollution levels in the University of Jember environment.

The results of this study using lichen as a bioindicator of air quality show that the University of Jember area has air quality with a very high level of pollution, as evidenced by the analysis of the IAP value of 2.92. This result is not in line with research conducted by Nisa *et al* (2022), showing an IAP value of 81.28, which indicates that the level of pollution is very low. The research that has been done this time is also inversely proportional to the research conducted by Ramadhani *et al* (2022), in the Sebelas Maret

University campus area which has a very low level of air pollution. The frequency of lichen species in Ramadhani *et al* (2022), research in the University of Sebelas Maret has a greater number than the research that has been done this time in the University of Jember. This statement is in accordance with the literature of Yuliani *et al* (2021), that the decline in air quality causes a reduction in lichen diversity in an area. The high and low frequency of lichen is influenced by several factors, including traffic density and environmental factors such as temperature, humidity, and light intensity (Ramadhani *et al.*, 2022).

According to Marianingsih *et al* (2017), lichen can grow optimally at temperatures between 10^0C-28^0C, with air humidity of 40%-69%, and light intensity of 16-27 mol $m^{-2}s^{-1}$. The light is utilized by algae components (photobiont) to carry out the process of photosynthesis. Photosynthetic products in the form of carbohydrates are then used by fungai components (mycobiont) as a source of energy and carbon for lichen growth and development (Gasulla *et al*., 2012). The volume of vehicles passing through the University of Sebelas Maret is relatively small compared to the University of Jember area. The implementation of the green campus program at University of Sebelas Maret, which aims to create a sustainable and pollution-free environment, is one aspect of reducing traffic density in the area. Traffic density in the University of Jember area will increase the concentration of pollutants and have an impact on lichen growth and development. Environmental pollution causes severe damage to lichen talus. The process of plasmolysis, granulation, and cell discoloration are indicators of cellular damage that disrupt the photosynthesis process and inhibit lichen growth (Chandra, 2015). The presence of shady trees is also a factor in the growth and development of lichen, because its function is to produce oxygen so that the environmental temperature becomes lower, normal air humidity, and sufficient light intensity (Marianingsih *et al*., 2017).

CONCLUSIONS

Based on the analysis of lichen diversity as a bioindicator of air quality in the University of Jember area, it can be concluded that the air quality in this area is classified as highly polluted, with an IAP value of 2.92. The highest IAP value was found in the Faculty of Social and Political Sciences (FISIP) with 0.65, indicating better air quality compared to other faculties, while the Faculty of Computer Science (FASILKOM) and the Faculty of Agriculture (FAPERTA) showed the lowest IAP value, which was 0.01.

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