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RESEARCH PAPER

Bark pH as a factor affecting the density of epiphytic terrestrial algae in Taman Wetland Putrajaya, Malaysia

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Abstract—Epiphytic terrestrial green algae are normally favoured by an environment with higher pH level. Air pollution in the atmosphere contributes to altering the bark pH and provides a better medium for algal growth. High absorption capacity of the microalgae makes it easy to accumulate atmospheric pollutants in their cells immediately. Habitats of epiphytic terrestrial algae are mostly characterized by aridity, and/or levels of temperature and light intensity. Bark pH of tree surfaces has been considered as one of the most important factors affecting the community structure of corticolousbiocells. The present work was designed to assess the effect of bark pH on the number of algal cells inhabiting 15 standing trees from the sampling station located in the Central Region of Peninsular Malaysia, Putrajaya. Several methods were used including field sampling, algal quantification, algal identification and measurement of bark pH. The study revealed that the density of epiphytic terrestrial algae was found to be significant with the bark pH (p-value= 0.001). This positive correlation (r-value= 0.762) showed that bark pH does play an important role in the health of algal cells. The algae are believed to be able to tolerate higher bark pH. The alkaline bark pH altered the microalgal composition because it was found to be positively affecting the density of epiphytic microalgae. Therefore, higher bark pH significantly contributes to the enrichment of algal density

I. INTRODUCTION

Terrestrial algae play important roles in every ecosystem. They contribute to the fertility and stability of soils everywhere, through fixation of carbon and nitrogen, release of organic compounds, and binding together with oil particles to reduce soil erosion. Algae are abundant on many substrates. It is an important colonizer of isolated land areas [1] and water bodies [2]. To establish an active population at a particular site, successful dispersal of viable algae is important. The dispersal of algae is through passive means such as by water, air, and other organisms, including humans [3]. Algae not only inhabit marine and freshwater ecosystem but they also occur in a wide variety of terrestrial environments [4]. The algae that inhabit terrestrial environments can be defined by different terms such as micro-biotic crusts, cryptogrammic crusts, subaerial algae, aerophytic algae and terrestrial algae. Many of them are freely used as synonyms. Terrestrial

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algae need water to complete their reproductive stages [5].

Terrestrial algae received less attention from phycologists than marine and freshwater algae, so their diversity and community structure is still very poorly known [6]. Tropical subaerial algae is usually dominated by filamentous Trentepohliales, whereas bark habitats in temperate ecosystems are more typically dominated by coccoid green algae mostly belonging to the Trebouxiophyceae [7]. Terrestrial algae have simple structures. They are called terrestrial algae because they are not dependent on liquid water [8]. It can efficiently accumulate it from the atmosphere. This accumulation makes the algae a good biological indicator. The pH of the bark surfaces has been considered as one of the most important factors affecting the community structure of corticolous organisms [9].

The aim of this study is to investigate the effect of bark pH on algal density inhabiting the surface of bark on trees in Taman Wetland, Putrajaya. Despite being an artificial lake system, Taman Wetland is considered as a significant ecological resource within the region. It has viable fresh water ecosystem with a high level of biodiversity, reflecting both natural and introduced components. The landform of the Putrajaya site is characterized by undulating hills with topography ranging between 20m and 80m elevation and the three main river valleys of Sungai Chuau, Sungai Bisa and Sungai Limau Manis. This area places high value on a natural setting created by an integrated system of parks, water bodies, wetlands, forest and open spaces.

II. LITERATURE REVIEW

A. Bark pH Affects the Growth of Algae

The pH of the bark surface has been considered as one of the most important factors affecting the community structure of corticolous organisms. The relationship between pH and community structure is well known for epiphytic lichens and bryophytes [10], [11] and myxomycetes [12]. Tree bark is recommended as a sensitive and simple indicator of air pollution [13]. According to [14] pollutant concentrations especially NH3 are believed to play important role in determining bark pH. Nitrogen sources cause the alteration of bark pH. Nitrogen has been determined as a nutrient for algal growth [15].

The host tree species is often taken as a proxy for the bark pH, but several studies have shown that the actual pH of bark samples may vary considerably between different individuals of the same tree species [16], [17]. [18]reported that the host tree species may be more closely correlated with the community structure of corticolous epiphytic lichens than the actual pH of the bark samples.

B. Taxonomy and Morphology of Terrestrial Algae

Terrestrial algae has very lucid and uniform habit that usually refers to a unicellular, uniseriate filamentous, sarcinoid colony and displays few useful characters for taxonomic and systematic purposes [6] Algae species that grow on tree barks are known as aero-terrestrial. Coccoid and filamentous algae such as Desmococcus, Chlorella, Klebsormidium and Trentepohlia are common on tree barks in temperate and tropical ecosystems [19]. For single cells, the examples are Chlorella sp., Chlococcum sp., Stichococcus sp., and Trebouxia sp. For sarcinoid habit, the example are Coccomyxa sp., Apatococcus sp., Desmococcus sp., Chlorosarcina sp., and Chlorokybus sp. They are in packet-like colonies formed by a limited number of cells. For uniseriate filaments, they could be in branched and unbranched forms.

The species such as Klebsormidium sp., Printzina sp., and Trentepohlia sp., exhibit this kind of habit [20]. All these habits offer characters useful for taxonomic and systematic purposes [21]. Taxonomic criteria at the species level are mainly based on shape and size (length and width) of vegetative cells, presence of hair-like cells (setae), branching pattern, position, and morphology of reproductive structures. Based on [22] some of the features used for taxonomic purpose are unstable and can vary in relation to ecological conditions.

C. Habitat

Algae are mainly known to be from marine and freshwater habitats. But, they also occur in a wide variety of terrestrial environments [4]. About 800 species of algae are known to occur in terrestrial environments.

They show conspicuous growth in several surface types, including rocks, urban walls, metals, tree barks, leaves and animal hair [23]. Algal species living on tree barks are known as aero-terrestrial algae. Besides that, they also occur in the most extreme habitats, such as walls of urban buildings [6], biotic crusts in hot deserts [24].

Antartic snow [25] and air at 2,000 m height [26]. Terrestrial algae can be described due to their habitat and substratum which is epiphylic (on leaves), epizoic (on animals), epiphytic (on plants), epipsammic (on sand), epipelic (on silt) and epilithic (on rocks). On anthropogenic substrates, such as walls, fences and rooftiles, biofilms have already been recognized in thebeginning of the nineteenth century [8].

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III. MATERIALS AND METHOD

D. Study Sites

Algal samples were collected from Taman Wetland, Putrajaya (geographical coordinates N 02□ 55.915 and E101□ 40.909). The mean annual rainfall recorded at Putrajaya is about 2,000 mm. The rainfall pattern reflects the annual monsoon cycles. The northeast monsoon occurs from December to March with the highest rainfall recorded around November/December. The southwest monsoon occurs from June to September. The period of lowest rainfall is around June/July. The mean annual air temperature is approximately 27 C with monthly mean air temperatures ranging from around 26 C in December to 28 C in May. The mean monthly minimum and maximum air temperatures range from about 20 C to 36 C in February, to about 22 C to 35 C in May.

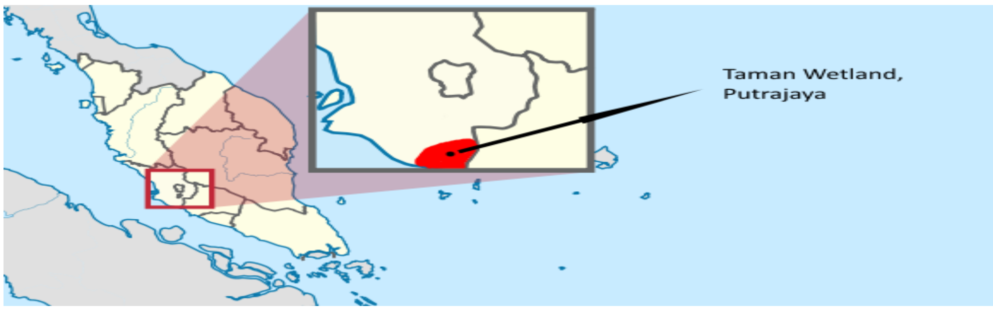

Fig. 1. Map location of the sampling site in Putrajaya.

Samples collection, quantification and identification

Algae within each quadrat were collected by scraping the bark surface with wetted cotton wool and then placed in a sterile specimen tube containing 30ml deionized water. The tube specimens were shaken vigorously to loosen the algae from the wetted cotton wool. All samples were stored in a refrigerator at 1-4ºC to prevent post-sampling growth. This study encompassed a collection of 45 tubes of algae (15 trees × 3 quadrats). Algal samples on wetted cotton wool were squeezed to ensure all algal samples were transferred into sterile specimen tube. Algal samples were then shaken vigorously to dissociate clumped algae and to separate filamentous algae intofragments. For quantification process, the haemocytometer chamber was used as a counting chamber of algal cells. 1 ml of algal samples wasp petted into the well of haemocytometer and counted under light microscope. Species of algae was observed under light microscope and the morphological characters were noted to aid in species identification. The species were identified using a taxonomic book "The Freshwater Algal Floral of the British Isle" and also referring to the established algal database "www.algaebase.org". Bark pH was measured in situ at 1m above ground level by using a Jenway 350 pH meter with a flathead electrode.

IV. RESULTS

E. The Relationship Between Algal Density and Bark pH

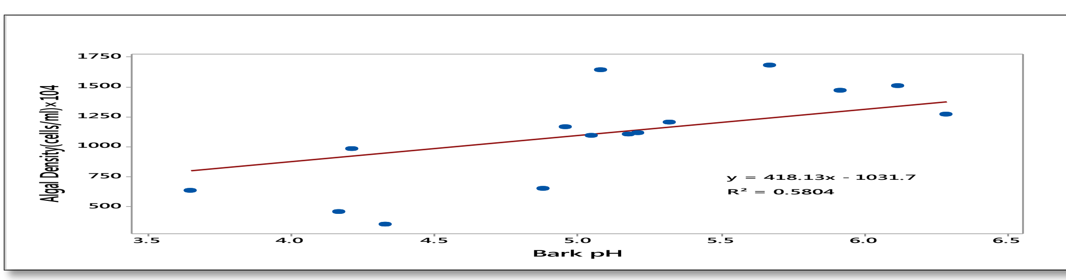

Fig. 2. Correlation between algal density and bark pH.

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The present study showed that the pH of tree bark in Putrajaya Wetland is 4.21, 3.65, 4.17, 4.33, 5.18, 5.21, 4.88, 5.08, 4.96, 5.67, 5.32, 6.29, 5.05, 6.12 and 5.92 respectively. Based on Figure 2, the result of Pearson correlation analysis between bark pH and algal density showed the r-value of 0.762 while the p-value was equal to 0.001. Since the r-value of 0.762 was nearest to 1, it showed that there was a positive correlation between bark pH and algal density. The p-value of 0.001 is lower than the significance level of 0.05 and shows that the bark pH was influencing density of algae found at Putrajaya. The highest algal density was recorded at 5.67 of bark pH with 1680 × 104 cells/ml and the lowest algal density was recorded at 4.33 of bark pH with 351 × 104 cells/ml.

F. *Algal Species Identification*

There were two species of algae observed in this study. There were Apatococcussp (Figure 3) and Printzinasp (Figure 4). In this study, the most dominant algae were Apatococcus sp. This species was found to be growing abundantly on the bark of trees and are known to be able to grow well in higher bark pH. Besides that, this study also recorded another algal species that belongs to Printzina sp. However, the number of Printzinasp was relatively small. Printzina sp. was considered as an irrelevant species in this study.

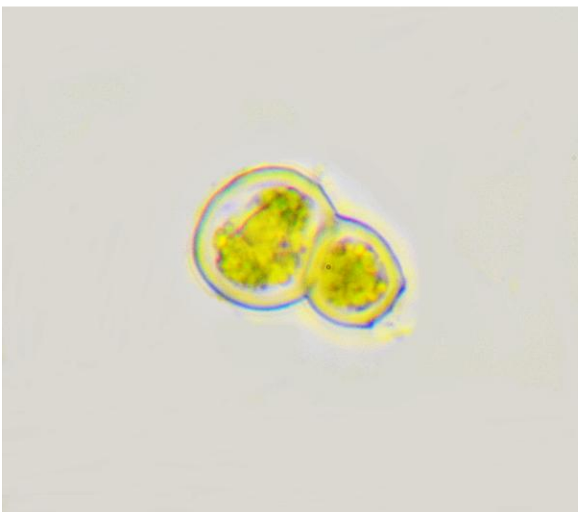

Fig. 3. Apatococcus sp.

Fig. 4: Printzina sp.

V. DISCUSSION

The correlation analysis shown in Figure 2 indicates a positive correlation between algal density and bark pH. The highest algal density was recorded at bark pH of 5.67 with 1680 cells/ml and the lowest algal density at the pH of 4.33. The bark is permanently diffused by stemflow during rainfall, which often is acid in polluted areas. Bark of the species with high pH value may be acidified with time, because of buffer capacity loss caused by gradual cation leaching by acid rain [27].

The study sites were exposed to the use of productions. Major increase in nitrophytes appears to be associated with an increase in bark pH due to NH3 [14]. The pH of bark is a sensitive factor responding to relatively small changes in the habitat acidification [28]. N deposition alters bark pH which is known to influence epiphytic communities [29], [30]. The relationship between lower plant frequency and bark pH confirmed that pH was an important driver for the distribution of lichens and bryophytes [30]. As the ammonia alters the bark pH, this process provides a better surrounding for algal growth. Green algae as compared to other algal groups normally grow better at a higher pH. Abundance of Cyanobacteria was also strongly related to increasing bark pH [9]. Due to the alkaline properties of NH3, the pH increased and ultimately helped in shifting the algal composition [13]. NH3 is also known to promote nitrophilous species of lichens [13].

Similarly, in Netherlands, an increased bark pH appeared to be the primary cause of the enormous abundance of nitrophytic species [13]. The nitrophytic species preferred a less acidic bark and was most abundant where bark pH was high, but it was less abundant in sites with the highest bark pH [30].

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VI. CONCLUSION

This study follows the pattern of many other studies carried out in assessing the effect of bark pH on the algal density. Bark pH plays an important role in enhancing algal density approved by the results presented from the current work.

The data in this study suggest that attention should be paid to controlling the pollutant which significantly affects the algal density.

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