Atmospheric Air Pollution and Roughness of Bark as Possible Factor in Increasing Density of Epiphytic Terrestrial Algae

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ABSTRACT--- ***Air pollution released to the atmosphere due to anthropogenic source particularly of motor vehicles creates emissions that significantly affect not living organisms. Epiphytic terrestrial algae were known to have a tendency towards atmospheric gases due to its high sorption capability. Besides the pollutant, the different texture of the bark of the trees also plays an important role for the colonization of the algae. This present work studies on two parameters that canaffect the number of algal cells per unit area (density); the increased pollutants and tree bark texture. Sampling stations which represent the polluted and relatively unpolluted environment hasbeen chosen. Quadrat sampling method was used to estimate the density of algae on 30 random trees inhabiting 15 x 15 cm quadrat. Results showed that both polluted and unpolluted sites were dominated by the same algal species, the Coccomyxa confluens (Kützing) Fott. The polluted environment significantly support higher number ofepiphyticalgaeat 202 ± 37 x 10^4 cells/cm^{2}compared to the unpolluted area at 63 ± 12 x 10^4cells/m^2. Similarly, trees with rough textures was found to sustain higher number of algal cell at 228 ± 52 x 10^4 cells/cm^{2}compared to trees with smooth textures (187 ± 41 x 10^4cells/cm^2). Higher concentration of carbon dioxide and/or carbon monoxide and nitrogenous gases in polluted area possibly enhanced the growth of epiphytic terrestrial algae.In conclusion, polluted environment and rough bark textures was found to positively support higher algal density.***

Keywords--- algae, air pollution, density, dominant species, bark

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1. INTRODUCTION

Air pollution is defined as the presence of foreign substances in the air or excessive amounts of certain impurities. Emissions from motor vehicles are the single most significant source of air pollution in many Malaysian urban areas (Waleed *et al*., 2013). As for the past years, motor vehicles remain the major contributor of air pollution especially in urban areas. In 2010, the number of registered car passengers increased by 7.16%, motorcycles by 5.61%, buses by 3.86%, goods vehicles by 3.20% and taxis by 6.96% compared to 2009 (Waleed *et al*., 2013). Up to end of 2011, there were 21,401,269 vehicles registered in Malaysia (Briggs, 2007). Significant quantities of pollutants such as carbon dioxide, carbon monoxide, sulfur oxides, nitrogen oxides, ammonia, particulate matter, volatile organic compounds and toxic metals such as leads are generated from great number of transportation.Air pollution from vehicles is split into primary and secondary pollution. Primary pollution is emitted directly into the atmosphere and become as precursors of secondary air pollutants. Meanwhile the secondary pollution results from chemical reactions between pollutants in the atmosphere. The combustion of fossil fuels is the most common source of air pollution (Afroz *et al*., 2003). Emissions from cars increase the levels of carbon dioxide (CO_2) and other greenhouse gases in the atmosphere. Malaysia produced 5.4 metric ton of CO_2 for the year 2000 exceeding the global average production of 3.9 metric ton per capita, and Asian average production of 2.2 metric ton per capita.

Air pollutants particularly the nitrogen containing ones are known to affect vegetation indirectly either via chemical reactions in the atmosphere, or directly after being deposited on vegetation, soil or water (Frank, 2000). Therefore, vehicle exhaust emissions are a dominant feature causing detrimental effects on plants (Honour *et al*., 2009). Presence of anthropogenic pollutants and non-point source pollutants in the air caused air pollution which indirectly contributed towards the degradation of environment. The air pollutants especially those emitted by the vehicles, give negative impacts towards the population of epiphytic terrestrial algae. Since algae has been known as one of the bio-indicator for air pollution, the increasing or reducing number of algal population indicates the status of air pollution within the area. Several studies has put forward some evidence that traffic density and levels of primary pollutants in urban areas or close to roads are positively correlated (Kuhler *et al*., 1994).

Algae are lower plants without structures such as leaves, roots and stems. Algal species inhabiting tree barks are known as "aero-terrestrial" (Ettl and Gartner, 1995) or epiphytic terrestrial algae. Most terrestrial algae are of green algae where it contains photosynthetic eukaryotes composing double membrane bound plastids containing chlorophyll a and b, accessory pigments such as beta carotene and xanthophylls with a unique stellate structure (Pröschold and Leliaert, 2007).About 800 species of green microalgae are known to occur in terrestrial environments. However, the range of habitats occupied by these organisms is extremely wide and includes natural rocks, biotic crusts in deserts (Lewis, 2007), concrete walls (Rindi and Guiry, 2004), tree bark, leaves and fruits (Lopez-Bautista *et al*., 2002).Algae that grow on surfaces that lie above the surface level of soil, water, snow, and ice, where they are exposed to the air, are considered to be subaerial (Neustupa and Skaloud, 2010). Subaerial algae also grow as epiphytic communities on plant surfaces such as on bark of tree, wood, and leave (Neustupa and Skaloud, 2010).All photosynthetic microalgae use chlorophyll *a* as their primary photosynthetic pigment, with a secondary photosynthetic pigment (Graham and Wilcox, 2000).

Besides air pollutants, the density of epiphytic terrestrial algae is also affected by the roughness of the bark of the trees. Different textures of bark offers different environment for the algae in term of moisture, pH and essential elements for their growth (Edward and Lewis, 2012).It is believed that rough barks are more likely to be the first choice for algae as Ellis *et al.* (2007) reported that the colonization of epiphytic terrestrial algae are often observed to be more on the rough and porous bark surface compared to the smoother bark.However, the scenario is yet to be observed in Malaysia.

The objective of the study was to compare the number of green algal cells,*Coccomyxa confluens* (Kützing) Fott between polluted and unpolluted environments. Other objective was to assess the effect of texture of tree bark (roughness of bark) to algal density.

2. RESEARCH METHODOLOGY

Algal sample was collected using quadrat sampling method. A 15 x 15 cm rectangular shaped flexible plastic was placed on 30 trees within the two sampling sites. Sites chosen were Kuala Lumpur City Centre which represents the polluted environment and the relatively cleaner air was represented by a site in Banting (**Fig.1**). Means of comparison are based on the Air Pollution Index.
KLCC is a transit-oriented development and a well-developed area. These study areas cover the perceived deposition gradients for the pollutants of interest. It is also a bus hub the largest public transport operator in Kula Lumpur. The other sampling site, Banting is located 65 km away from the Kuala Lumpur City Centre. It is considered as a low to medium populated area. Therefore, less pollution was to be expected within this setting.

Fig. 1: Map showing sampling stations in KLCC (polluted site) and Banting (unpolluted site). Sampling sites shown in red circles ( ).

To explore the diversity of the green algae, the trees chosen were based on different texture of tree barks. The algal sample was taken from both types of tree bark textures which were smooth and rough bark. Algal collection was done by scrapping off the microbiotic layers of terrestrial algae on the bark of tree using wetted cotton wool (**Fig. 2**). It was then steeped into 100 mL specimen tube containing 20 mL distilled water. After that, the procedure was followed by pipetting 10 µL of algal sample into the well of haemacytometer. Number of algal cell in the haemacytometer was observed and counted under the light microscope. The algal samples were observed by using the light microscope (Brunel, UK). Observed criteria of the samples were referred to the standard taxonomic books and the world's algal database.All data obtained were expressed as value ± standard error means (SEM) and analyzed using independent t-test (SPSS 19th edition).

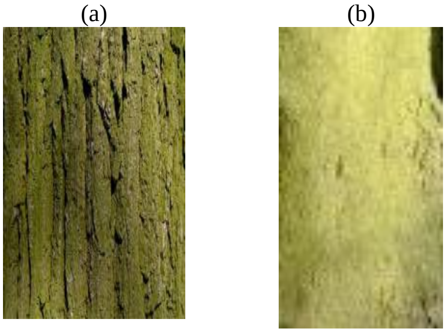

Fig. 2 (a): Algae on the rough bark **(b)** algae on the smooth bark

3. RESULTS AND DISCUSSION

3.1 Number of Algae in Polluted and Unpolluted Environments

Results from the current study (**Fig. 2**) showed that the number of algal cells per quadrat is higher in the polluted area (202 ± 37 x 10^4) as opposed to unpolluted environment (63 ± 12 X 10^4). The independent t-test showed a significant different ($p < 0.05$) between numbers of algal cell on two different sampling sites. This might probably due to higher concentration of carbon dioxide and nitrogen in the polluted area (Kauppi *et al.*, 1992).

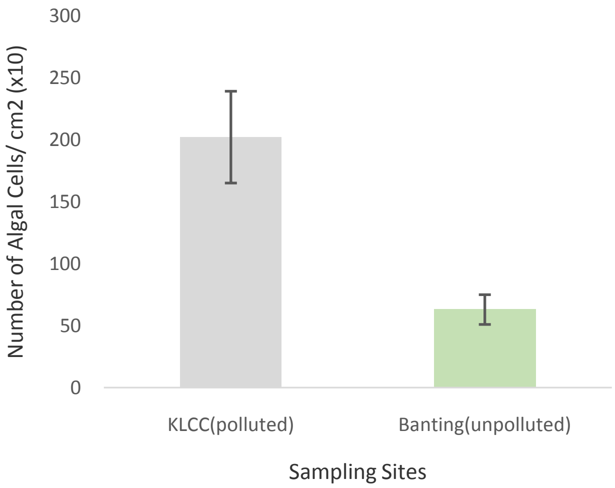

Fig. 2 : Number of algal cells in polluted and unpolluted environment

Based on Sims and Reynolds (1999), terrestrial epiphytic algae are able to absorb atmospheric pollutants. Algal has been known to be able to absorb high carbon dioxide which helps in their cell growth (Packer, 2009). Therefore higher carbon dioxide at the polluted area potentially increased the productivity of plant and stimulates the algal growth. Higher carbon availability in atmosphere also indicates higher carbon-to-nutrient ratio (Schoo *et al.*, 2013).Meanwhile, nitrogen constitutes in general 1-2 % of total dry weight of plant. Human activity has led to a significant increase in nitrogen (N) emissions and deposition (Galloway *et al.*, 2004). Nitrogen emissions from fossil fuel combustion are almost two-thirds of the rate of use of synthetic nitrogen fertilizer (Howarth and Rielinger, 2003). Increase in the nitrate level increases algal growth because nitrate significantly affected algal growth.

This is supported by Steffii *et al.*, (2003), which stated that nitrate levels have a significant effect on algal growth. This means that given ample sunlight, the major nutrient that regulates plant growth rates is nitrogen. If the supply of nitrogen increases, some algae can take up the nitrogen and grow faster.

3.2 Relationship between Texture of Bark and Algal Density

The texture of tree barks consists of rough and smooth bark. Both play important role in determining the distribution of alga growth. Algal is usually found in damp places because algal lacks vascular tissues. A study by Kraemer (1901) found that bark moisture which is higher for the rough bark as opposed to smooth bark was the chief factor in alga distribution. Kobendza and Motyka (1929) showed that even the distribution of lichen which is also consider as the lower plant such as alga preferred the position of the tree bark that has the greatest amount of moisture.

This study showed higher number of algal cells on the rough bark compared to smooth bark in both polluted and unpolluted sites, $228 \pm 52 \times 10^4$ and $187 \pm 41 \times 10^4$ respectively(**Fig. 3**).

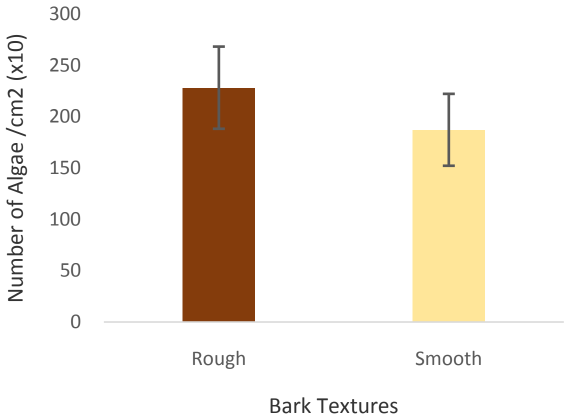

Fig. 3: Mean number of algae collected from the rough and smooth barks for both sites

Therefore, the algal growth is not limited to the desiccation as compared to smooth bark. However, the data for the mean differences of algal cells between rough and smooth bark trees for each sampling sites do not show significant different. The result is $p > 0.05$ due to only slight differences in means from the number of algal cell on rough and smooth bark. Based on the result, it has clearly shown that roughness of tree bark do affect the algal growth.

Rough bark surfaces are porous and can store more water from the rain than the smooth bark which then retains the moisture (Ihsan *et al.*, 2015). Since the terrestrial algae can only become metabolically active when there is enough water to support the activity to survive in temperate environment, they will chose habitats that are moist and damp as an adaptation (Linda, 2009).

Besides water, Poikolainen (2004) stated that the bark crevices also trap air pollutants such as carbon dioxide and nitrogen. Algae are unique as they have the ability to absorb air pollutants directly from the surrounding as they are fully exposed without having protective cuticle wax covering them (Malinska and Zabochnicka-Swiatek, 2010). This makes the rough bark more favorable for their growth as the essential components for their growth are easier to be obtained.

However, since the data from both sampling sites do not show significant different, it could possibly mean that the most important factor for algal growth is air pollution. This is because the larger mean differences from both sampling sites support the evidence that the air pollutants are affecting the algal growth.

It is recommended to conduct further investigation to verify some possibilities that may affect the number of algal cell such as the effect of bark pH, air moisture content and relative humidity. Molecular taxonomy will help to support the morphological approach in species identification of algae.

4. CONCLUSION

In conclusion, polluted environment which has higher concentration of carbon dioxide and nitrogen possibly enhances the growth of epiphytic terrestrial algae, *Cocomyxa confluens*. Diffusion and dispersion of atmospheric pollutants particularly of carbon dioxide, carbon monoxide and nitrogenous gases coupled with rough bark in trees,provide a suitable environment for epiphytic terrestrial algae.

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