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Elevated CO_2 Effects on Lichen Frequencies and Diversity Distributions in Free-Air CO_2 Enrichment (FACE) Station

A. Abas[1,2*], M. S. Nizam[1,2], A. W. Aqif[2]

[1]School of Environmental & Natural Resource Sciences, Faculty of Science & Technology, Universiti Kebangsaan Malaysia (UKM), Bangi, Malaysia
[2]Institute of Climate Change, Universiti Kebangsaan Malaysia (UKM), Bangi, Malaysia
Email: *azlanabas@ukm.edu.my

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Abstract

Carbon dioxides (CO_2) concentration has become much higher every year and this has already become the global issue. Lichen is a symbiotic organism that is best known as the air pollution indicator. Based on its frequency and diversity distribution, the level of pollution that has been made can be determined. This research was conducted in UKM Fernarium Free Air Carbon Dioxides Enrichment Station (FACE Station) with lichen frequencies and diversities observed and analyzed statistically and graphically. Seven species of lichens were found at the sampling locations. Findings showed that there was significant relationship in lichen frequency and diversity distribution under elevated CO_2 inside FACE Station with its surrounding.

Keywords

Carbon Dioxides, Lichens, Air Pollution, FACE Station

1. Introduction

Lichens, the product of a symbiotic relationship between a fungus (mycobiont) and at least one photosynthetic algae or cyanobacterium (photobiont), are widely used as bio-indicators of air pollution and environmental change, both at cellular and the population or community level [1]. Due to the unique biology and their sensitivity to pollutants, lichens respond to variations in atmospheric composition and may be a useful measure for monitoring environmental quality. Lichens are responding to global warming and some long-term monitoring programmes

*Corresponding author.

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have proved their sensitivity, mainly through a community approach, while only few studies investigated eco-physiological responses to climatic change [2].

In Malaysia, a limited number of studies have used lichens as indicators of air pollution, especially to evaluate lichens response on elevation of CO_2 levels [3]. The negative effects of warming on the carbon balance of lichens may be at least partly counteracted by increases in atmospheric CO_2 levels. In lichens, the inability to regulate water loss limits the possible responses to CO_2 as compared to those of vascular plants, although the trade-offs related to, for instance, nitrogen allocation occur here just as much. This could also be the case for those epiphytes that grow closely attached to canopy soil or directly on living branches. For such species, increased respiration of the substrate due to higher temperatures may provide more extra CO_2 than the increased atmospheric levels. The objectives of this research were to compare the lichen diversity inside and outside Free-Air CO_2 Enrichments Station (FACE) and to analyze the distribution of identified lichen species [4] [5].

2. Experimental Design

2.1. Study Area

Research was conducted in the FACE Station located in UKM Fernarium, The National University of Malaysia (02˚55'20.3"N 101˚46'59.4"E). FACE Station in UKM Fernarium was programmed automatically to release CO_2 into the surroundings at fluctuated concentration. A computer-control system uses the wind speed and CO_2 concentration information to adjust the CO_2 flow rates to maintain the desired CO_2 concentration at the centre of the FACE ring. The system uses the wind direction information to turn on only those pipes upwind of the plots, so that CO_2-enriched air flows across the plots, no matter which way the wind blows. When wind speeds are low (<0.4 m/s) and direction is difficult to detect, the CO_2-enriched air is released from every other vertical pipe around the ring. The CO_2 flow rate is updated every second, and the choice of which vertical pipes to release from is updated every 4 seconds. Three different distances (20 m, 50 m and 80 m approximately) were selected to depict the effects of CO_2 on lichen distribution (**Figure 1**).

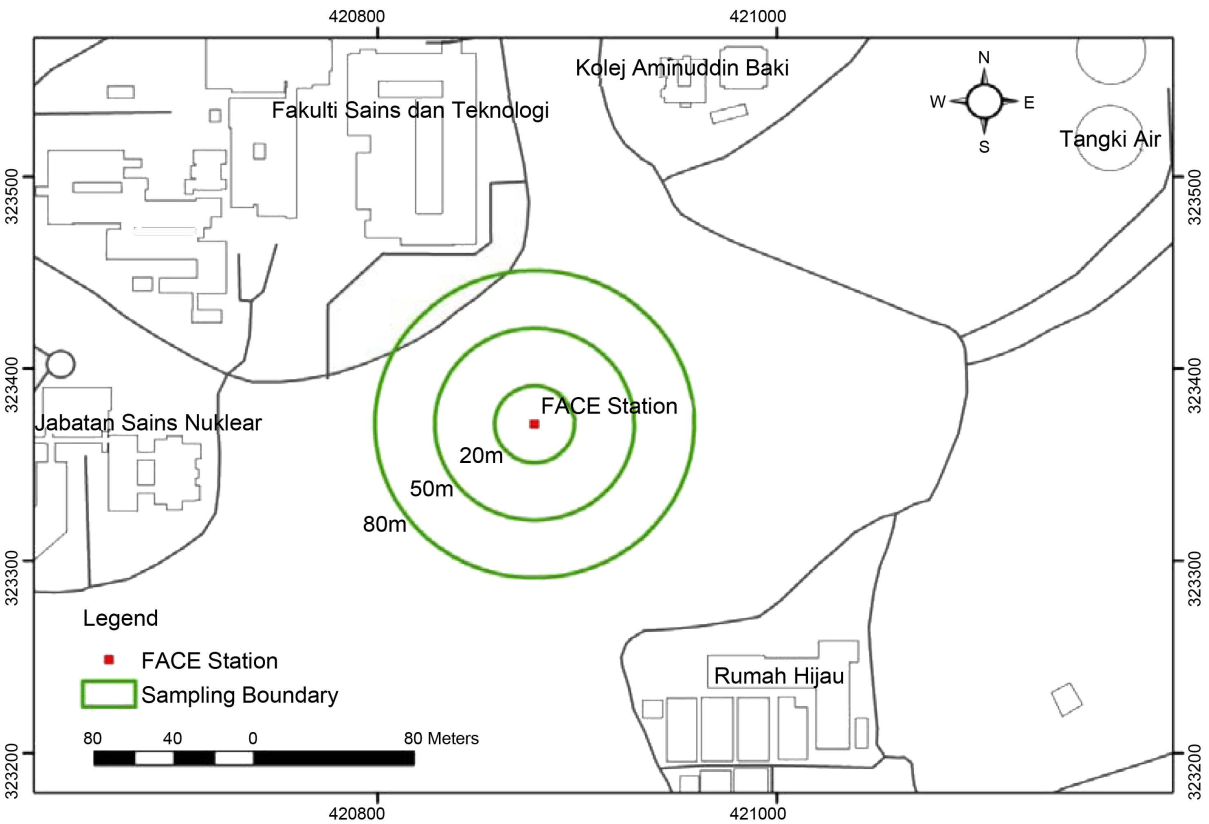

Figure 1. FACE Station location (02˚55'20.3"N 101˚46'59.4"E) with three different boundaries for collecting lichen samples.

2.2. Lichen Identification

Lichen samples were collected in FACE Station and from its 80 m perimeters. All epiphytic lichen specimens were identified using a stereomicroscope and chemical spot tests, a UV lamp, and TLC following the standard checklists of Sipman in Singapore [6].

2.3. Lichen Diversity Distribution

Lichen diversity frequencies were determined using quadrate (20 cm × 50 cm). For each sampling points, 20 trees were selected randomly to evaluate lichen species distribution frequency. Lichen was sampled by each wind directions at approximately 3 meters height. Only trees with circumference around 60 - 120 cm selected to conduct the sampling. Sampling was conducted in three different distances (20 m, 50 m & 80 m) [7].

2.4. Data Analysis

Every data recorded was analyzed using statistical analysis Shannon's Diversity Index and Evenness to understand the diversity's rate of lichen species at FACE Station and its surrounding. Lichen species frequency density also analyzed using graphical analysis ArcGIS 10.3 to evaluate the distribution of lichen species based on its frequency [7] [8].

3. Result

3.1. Lichen Species in FACE Station

Seven species of lichen were identified and divided into three genera. All of them belong to crustose groups: *Cryptothecia striata*, *Cryptothecia scripta*, *Cryptothecia granularis Cryptothecia subtecta*, *Porina tetracea*, *Myriotrema minutum* and one unknown species labelled as crustose 1. All lichen been found were identified and matched with Sipman (2009) publication from Singapore. All lichen's picture that has been found in FACE station were shown in **Figure 2**.

3.2. Lichen Frequency Distribution

From 20 trees from each sampling locations, **Table 1** shows the lichen species been found, the frequencies for each species from each location, the species diversity index (H) and the evenness value (E). **Figure 3** shows the frequencies distribution for each of lichen species for all sampling locations graphically.

Based on **Figure 3**, the highest frequencies for all species is *Cryptothecia striata* with 35% at FACE Station, 21% at 50 m from FACE Station and 80 m from FACE Station. Followed by *Cryptothecia granularis*, *Cryptothecia scripta*, *Porina tetracea*, *Myriotrema minutum*, *Cryptothecia subtecta* and the lowest is Crustose 1 with 6.5% frequency and only can be found at 80 m from FACE Station. It shows that there are significant differences in the frequencies of lichen species in term of CO_2 effects. Increase in CO_2 concentration (inside FACE Station) unequivocally also increase the rate of photosynthesis occurred inside lichen's photobiont. In general, photosynthesis process needs CO_2 and water in order for the process run in optimal condition. That's the reason why frequencies of lichen species that exist inside FACE Station were much higher compare to 50 m from FACE Station and 80 m from FACE Station.

In term of diversity, different CO_2 concentration affected lichen diversity substantially. Lichen diversity increased gradually when receding the FACE Station. According to species diversity index (H) in **Table 1**, the value of the index increased from FACE Station is 1.35, 50 m from FACE Station 1.53 and 80 m from FACE Station is 1.89. Increase in CO_2 concentration affected several of lichen's growth such as *Cryptothecia scripta*, *Cryptothecia subtecta* and Crustose 1. These three species only existed outside the FACE Station. The difference in lichens distribution shows that lichens get affected with the elevation of CO_2. The elevation of CO_2 concentration acidified the bark of tree which is important for epiphytic lichen attachment. The rhizine of lichen only recognize particular pH of substrate. Changes in pH bring no growth for that particular of lichens.

4. Conclusion and Recommendation

CO_2 concentration has various effects on lichen distribution in terms of frequency and diversity. Lichen frequencies

Figure 2. Lichens from FACE station, 20 m and 50 m.

are proportional with CO_2 concentration and lichen diversity is inversely proportional with CO_2 concentration as showed in this research. For further research, we should look up into lichen physiology, for example, chlorophyll a and b which are important in photosynthesis. This may give a brand new perspective and precise observation into how elevation of CO_2 affects on lichen physiologically.

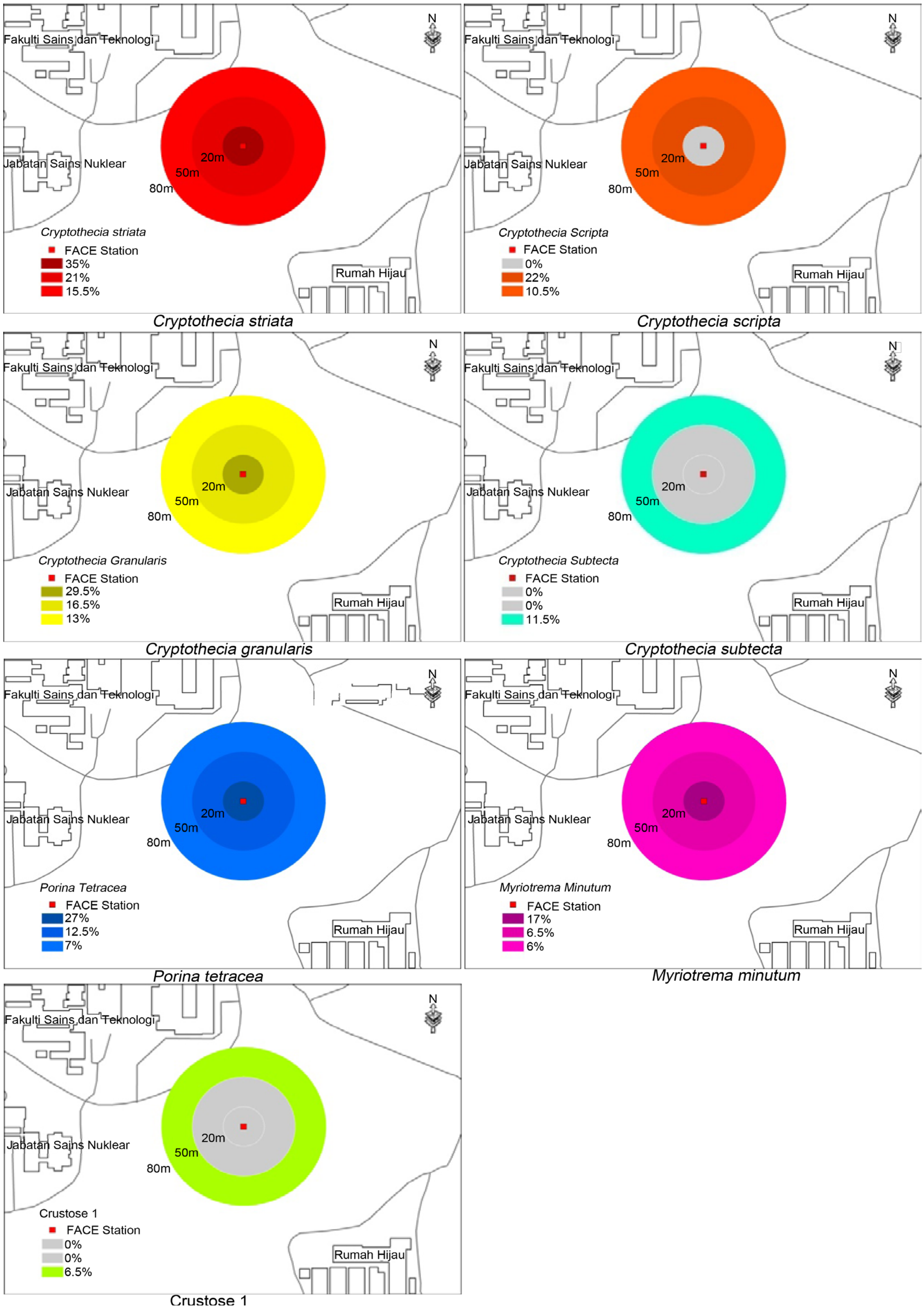

Figure 3. Frequencies distributions for each lichen species.

Table 1. Lichen frequency distribution in FACE Station.

Sampling Location	List of Species	Frequency (%)	Species Diversity Index (H)	Evenness (E)
FACE Station (20 m radius)	*Cryptothecia striata*	35	1.35	0.97
	Cryptothecia granularis	29.5		
	Porina tetracea	27		
	Myriotrema minutum	17		
50 m from FACE Station	*Cryptothecia striata*	21	1.53	0.95
	Cryptothecia scripta	22		
	Cryptothecia granularis	16.5		
	Porina tetracea	12.5		
	Myriotrema minutum	6.5		
80 m from FACE Station	*Cryptothecia striata*	15.5	1.89	0.97
	Cryptothecia scripta	10.5		
	Cryptothecia granularis	13		
	Cryptothecia subtecta	11.5		
	Porina tetracea	7		
	Myriotrema minutum	6		
	Crustose 1	6.5		

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