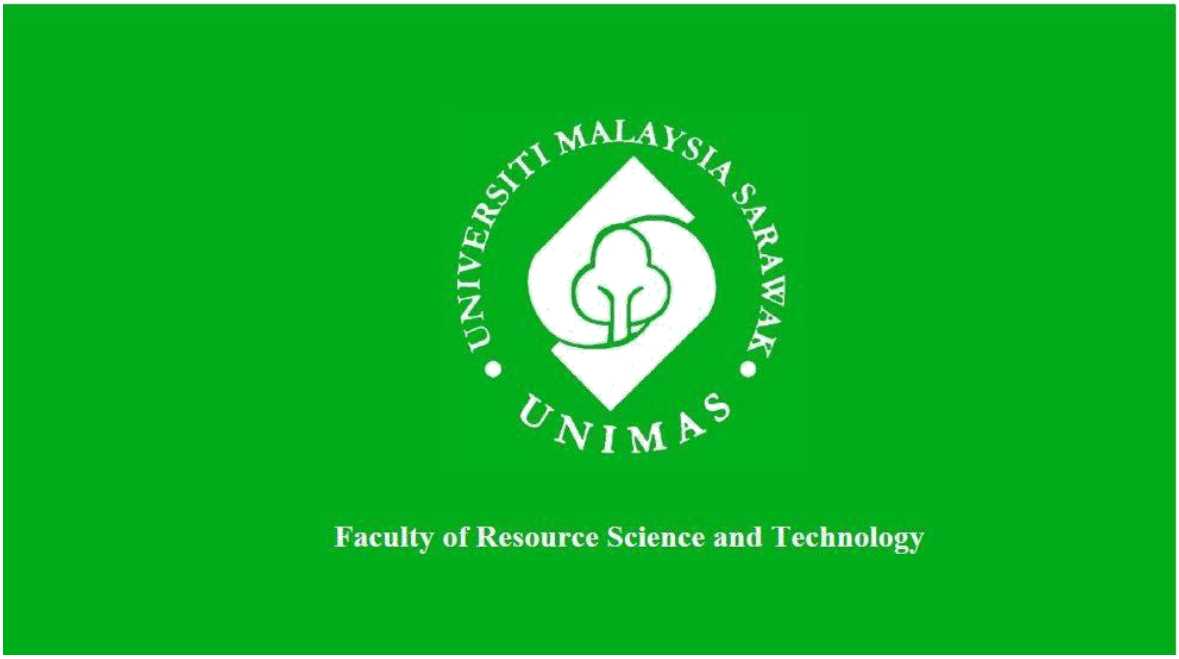

AEROPHYTIC MICROALGAE OF SEMATAN BEACH, SARAWAK

Nor Nasyitah Sobihah Binti Mohd Nasri

Bachelor of Science with Honours
(Aquatic Resource Science and Management)
2015

UNIVERSITI MALAYSIA SARAWAK

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Aerophytic microalgae of Sematan Beach, Sarawak

Nor Nasyitah Sobihah Binti Mohd Nasri

The dissertation is submitted in partial fulfilment of the requirement for the degree of Bachelor with Honours in Aquatic Resources Science and Management

Faculty of Resource Science and Technology

UNIVERSITI MALAYSIA SARAWAK

2015

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LIST OF ABERRATIONS

ºC	: Celcius
m	: metre
ml	: millilitre
µm	: micrometre

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ACKNOWLEDGEMENT

First I would like to thank my supervisors, Associate Professor Dr. Othman Bojo of Aquatic Science Department, Universiti Malaysia Sarawak, and all lecturer of Aquatic Science Department, Universiti Malaysia Sarawak. Special thanks goes to my supervisor who have taught me valuable knowledge and advices throughout the time in completing this study.

Thanks to all the staff of Aquatic Science Department, Universiti of Malaysia Sarawak especially Mr Zaidi Ibrahim who has been helped me a lot in preparing the materials and apparatus needed during this study. To all my laboratory mates, all invaluable helps and support were very much appreciated. Great support from the staff during field work sampling were invaluable. Thank you for their kindness in making my field work sampling possible.

To all my friends, thank you very much for your support and help during my ups and downs in completing this study. My appreciation also goes to Tan Kian Leong for teaching me on how to operate and use the software on the advance compound light microscope (Olympus BX51).

I would also like to express my gratitude to Dr. Siti Akmar, my examiner for her invaluable advice. Finally, thanks to the Universiti Malaysia Sarawak for providing financial support. A very special thanks to my parents, siblings and an important person, your endless support, great patience and love has given me the strength in completing this work. Thank you so much

DECLARATION

No portion of the work referred to this dissertation has been submitted of an application for another degree of qualification of this or any other university or institution of higher learning.

_____

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ABSTRACT

Aerophytic microalgae of Sematan Beach, Sarawak

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Aerophytic microalgae are one of the bio-component of atmosphere. Aerophytic microalgae are the least-studied organisms in both aerobiological and phycological studies and this cause no absolute data on the airborne algae. Very less attention has been paid towards aerophytic microalgae although Malaysia climate is most suitable for algae to become airborne and subsequent spread through air. The present study, discovered the diversity of aerophytic microalgae in the atmosphere of Sematan Beach in Sarawak, and was conducted for three months from December 2014 to February 2015. The objective of this study are to investigate the composition of aerophytic microalgae and document the aerophytic microalgae that potentially harmful in the atmosphere of Sematan Beach Sarawak and to estimate the vertical distribution of aerophytic microalgae in the air of Sematan beach area. Air samples at five selected sites obtained during study period using gravity slide sampler and Petri dish containing Bold's Basal Medium exposure technique. Fourteen genera of aerophytic microalgae found and nine of them possibly give negative impact on the human health were discovered in the air of Sematan Beach, Sarawak. Finally this study also shows no fixed pattern between the composition of aerophytic microalage and elevation (vertical height).

Keyword: Airborne algae, Aerophytic algae

ABSTRAK

Alga bawaan udara ialah salah satu bio-komponen yang terdapat di dalam udara sekeliling. Kajian terhadap alga bawaan udara ialah kurang dalam kedua-dua bidang sama ada daripada aspek biology udara dan aspek fizikal udara. Hal ini, menyebabkan tiada data yang sahih tentang alga bawaan udara di sekitar Malaysia. Kurang tumpuan diberikan kepada kajian tentang alga bawaan udara walaupun iklim Malaysia sesuai untuk alga disebarkan melalui udara. Untuk mengkaji kepelbagaian alga bawaan udara dalam udara Pantai Sematan di Sarawak, eksperimen telah dijalankan selama tiga bulan dari Disember 2014 hingga Februari 2015. Objektive kajian ini dijalankan ialah untuk mengenal pasti kehadiran alga bawaan uadara dan mendokumentasi alga bawaan udara yang berpotensi memberi masalah kesihatan ke atas manusia serta memperoleh data tentang kepelbagaian alga bawaan udara pada perbezaan ketinggian dalam udara Pantai Sematan. Sampel-sampel udara daripada lima tapak-tapak terpilih yang terdiri daripada kepelbagaian ketinggian diperoleh sepanjang tempoh kajian dengan menggunakan "Gravity Slide" dan "Petri Dish" yang mengandungi media "Bold's Basal" . Kajian ini menemui sebanyak 14 genra algal bawaan udara dan 9 daripada mereka mempunyai risiko memberi kesan negatif terhadap kesihatan manusia di dalam udara kawasan Pantai Sematan. Akhirnya sekali, kajian ini merekodkan tiada perbezaan yang ketara antara taburan alga bawaan udara dalam udara Pantai Sematan mengikut ketinggian.

Kata kunci: Alga bawaan udara.

1.0 Introduction

Sematan is a fishing village looking out over the South China Sea approximately 67.5 kilometres from the state capital Kuching. It has reasonably clean beaches, a promenade along the waterfront and a concrete pier into the sea. Sematan Beach is one of the tourism destination and recreational places for the local people. As a popular recreational destination, the beach must be kept clean including the air quality. This is why this study is important to reveal the living matter that contain in the air such as the aerophytic microalgae that are known to have health implication on human (Mittal *et al*., 1979; Schlichting, 1969; Sharma and Rai, 2008; Genitsaris *et al*., 2011).

Although they may exert an unfavourable impact on human health, least studied on airborne algal in aerobiology field (Sharma *et al*., 2007). The history of airborne algae was started when Darwin wrote: "On the 16 January 1833, when the Beagle was ten miles of the North West end of St. Jago (Cape Verde Islands), some very fine dust was found adhering to the underside of the horizontal wind wane at the mast-head" (Sharma *et al.,* 2007). As cited in Sharma *et al*. (2007), Ehrenberge (1844) reported, 18 species of freshwater diatoms originated from Africa, from dust samples sent by Darwin. After the discovery, direct sampling of the algae from the atmosphere has been established (Sharma *et al.,* 2007). The aerophytic microalgae are known being part of the naturally occurring airborne biota (Sharma *et al.,* 2007).

Algae are subsequently transported into the atmosphere through diffusion and dispersal by wind. One of the natural occurring aerophytic microalgae is the algae in foam and scum fragments at the shoreline are picked up by the wind (Sharma *et al*., 2007). The shoreline water sample taken will be one of the comparison agent to prove this statement. Algae are also dispersed passively by organisms such as insects, birds, and mammals

including humans (Kristiansen, 1996). Algal propagates in the air are known to have the ability to survive long-distance transportation (Marshall and Chalmers, 1997).

Knowledge on algae of aquatic habitats is wide and diverse but information on non-aquatic algae is rather limited. The term aerophytic microalgae less frequently used (Gregory *et al*. 1955), often as a synonym for non-aquatic specimens. Unfortunately, this term has never been defined clearly. Sometimes it is used in a broader sense to algae which may have settled their habitat via airborne transportation mechanisms, while in other cases it is restricted only to algae which can be isolated directly from the air itself. Little attention has been paid towards aeroalgal even though Malaysia has most suitable climate is for algae to become aeroalgal and successfully disperse through air (Ng *et al*., 2011).

The scarcity of aerophytic microalgae information and data in the country has led to the proposed study. Composition of aerophytic microalgae in the atmosphere of Sematan Beach coastal area was investigated. The objectives of this study are:

- To investigate the composition of aerophytic microalgae including the potentially harmful genera in the air of Sematan Beach Sarawak.
- To estimate the vertical distribution of aerophytic microalgae in the air of Sematan beach area.

2.0 Literature Review

2.1 Microalgae

Microalgae are much smaller organisms range from 20–200 µm (Ng *et al*., 2011). With the aid of microscope, the morphology and characteristic of the microalgae can be seen. They are varies in shape, from ellipsoidal, spherical, cylindrical and filamentous either in unicell or colonies (Lee, 1989). Based on Sharma *et al*., (2007), define the microalgae as unicell, filaments and colonies in variety shape and size. Unicellular cell varies from spherical to fusiform, ellipsoidal and lunate, whereas the structure of the filaments either single or in packets (Sharma *et al*. 2007). The colonies generally are spherical, ellipsoidal, cubical, and amorphous (Sharma *et al*., 2007). According to Schlichting (1969), most of microalgae occur in form of vegetative stage, however also common in form of spores and cysts while they are up in the atmosphere.

2.2 Aerophytic microalgae

Algae are the most abundant photosynthetic life and play important role in aquatic and terrestrial ecosystem (Jadhav and Quazi, 2010). Algae are broadly found in water bodies and they also live in terrestrial habitats, including extreme environments such as hot spring, glaciers and snow. This proven based on the study conducted by Saxena (1983); Broady and Smith (1994); Elster *et al*. (2007); Marshall and Chalmers (1997). Algae are abundant in nature living almost all possible habitats including air (Mittal *et al*., 1979; Rosas *et al*., 1989; Sharma *et al*., 2007; Ng, *et al*., 2011). According to Roy-Ocotla *et al*. (1993), there is variety of sporulated and non-sporulated organisms (aerophytic microalgae) in the air. Aerophytic microalgae take advantage of atmospheric turbulence as

a medium to be dispersed in the air and this is why the aeroalgal can be isolated from the atmosphere.

2.3 Origin of airborne microalgae

According to Sharma *et al.* (2007), dispersal is an action of moving cells from one area to other area and stated that, dispersal is most important aspect leading to the widely distribution of the organisms. Algae can be disperse passively by the action of water (Stevenson and Collier, 1962; Maynard, 1968; Schlichting 1974; Roy-Ocotla, 1993; Kristiansen, 1996; Burge and Rogers, 2000), air transport (Brown *et al*., 1964; Parker *et al*., 1969; Folger, 1970; Schlicthing *et al*., 1972; Brown, 1973 ; Broady, 1996; Kristiansen, 1996; Schlicthing, 2000; Sharma *et al*., 2006; Pearce *et al*., 2009) and other organisms activities, including human activities (Mahoney, 1968; Schlichting, 1974; Kristiansen, 1996; Ng *et al*., 2011).

Water action such as rainfall and raindrop splashed (Burge and Rogers, 2000), evaporation (Roy-Ocotla, 1993), formation of the aerosol by bursting of bubbles at the water-air interface and wave are several actions that transport the airborne microalgae into the atmosphere (Schlichting, 1974). According to Lee *et al*. (1989), assumption on photosynthetic plankton are regularly launched in the air are reasonable due to the huge amount of seawater emission to the atmosphere daily.

Aerophytic microalgae size is small enough to be transported by any atmospheric movement into the atmosphere. Wilkinson (2001), stated that free floating and free living organisms such as the phytoplankton are small enough to enable them become airborne and disperse over the entire world. Based on study conducted by Roy-Ocotla and Carrera (1993), he suggest that the algae, discovered in the air originate either from surfaces

directly exposed under the considered air volume, or moved, through atmospheric actions, from distant surfaces.

Human plays an important role as the transportation agent in the dispersion of the airborne algae. Acoording to Ng *et al.* (2011) study conducted in Bukit Jalil, Kuala Lumpur, concluded that human movement might be the important factor affecting the present of airborne algae. Ng *et al.* (2011), conclude this statement because they recorded that the occurrence of airborne algae at the lake site which do not have high frequency of human activities, is low while high occurrence of aeroalgal at the location which has great numbers of human movement, traffic movement which is a busy area. The summary of the dispersion of aerophytic microalgae into the atmosphere by Sharma *et al*. (2007), can be refered in Figure 2.3.

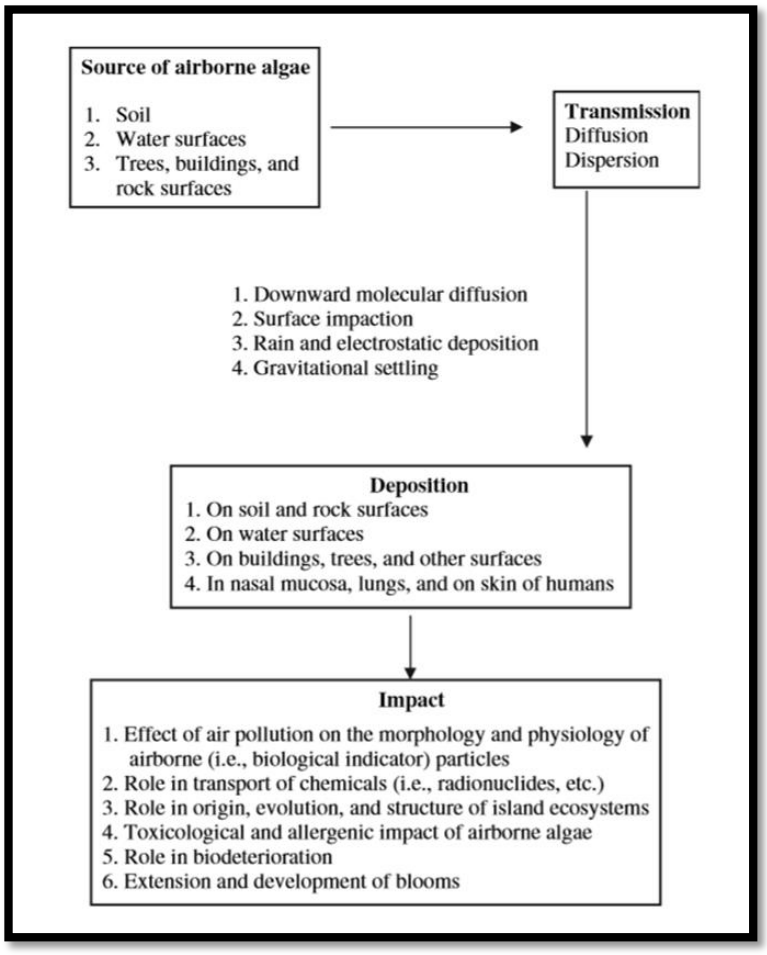

Figure 2.3: Summary on the path and impact associate with aerophytic microalgae by Sharma et al. (2007).

2.4 Diversity of airborne microalgae in the world atmosphere

Previous study of airborne algae proved that the airborne algae are dispersed successfully around the world's atmosphere. Roy-Ocotla and Carrera (1993), conclude that the scheme of species at different sampling locations, even very far to another, and even between sampling at sea surface level and other at higher elevations has been experimentally displayed to be basically the same. Abundant species of airborne algae around the world atmosphere based on the previous studies tabulated into Table 2.4. Based on the table, Ojcow National Park, South Poland has the highest number of taxa of airborne algae. The least number of taxa of airborne microalgae was documented in Bukit Jalil, Kuala Lumpur, Malaysia.

Table 2.4: List of airborne algae from previous studies around the world atmosphere.

Location	**No. of Taxa**	**Reference**
Ojców National Park, South Poland.	85 species	Marcinkowska (2013)
Kanpur, India.	16 species	Verma *et al.* (2012)
Thessaloniki, Greece.	60 species	Genitsaris *et al*. (2011)
Aurangabad, India.	47 species	Jadhav *et al*. (2010)
Kanpur, India.	20 species	Dubey *et al.* (2010)
Bukit Jalil, Kuala Lumpur, Malaysia.	9 species	Ng *et al*. (2011)
Cairo, Egypt.	23 species	El-Gamal (2008)
Mexico City.	20 species	Roy-Ocotla *et al.* (1993)
New England, USA.	11 genera	Lee *et al*. (1989)
Mexico City.	10 species	Rosas *et al*. (1986)
North Carolina, US.	25 species	Smith (1973)
Oahu, Hawaii.	29 species	Brown-Jr (1971)
Denton, USA.	7 species	Mchoney (1967)
Michingan, Texas, North Carolina, USA.	46 species	Schlicthing (1956) Schlicthing (1967)
Taiwan.	55 species	Chang. (1965)
Tuscon & Santa Catalina Mountain, Arizona.	17 species	Luty *et al*. (1965)
North Carolina	25 species	Smith (1973)

2.6 Study of airborne microalgae in Malaysia

Study of aerophytic microalgae in Malaysia wasconducted in Bukit Jalil, Kuala Lumpur in a busy area and less busy area. According to the study, Ng *et al*. (2011), stated that there were least studies on aeroalgal even though they are possible in exerting hazard impact on human health. Certain species of airborne algae isolated proven to induce allergic reactions on humans bodies. Study by Ng *et al.* (2011), revelead that cyanobacteria *Phormidium tenue* were the most abundant species of airborne algae suspended in the atmosphere of Bukit Jalil, Kuala Lumpur. Nine genera of aerophytic microalgae discovered in the samples of the study. Based on the result, all the airborne algae recorded were filamentous cyanobacteria. The dominant airborne algae were from the genus *Phormidium* while other taxa found were mainly *Nostoc* sp.

The study conducted by Ng *et al*. (2011), was the first study recorded the occurrence of aerophytic microalgae in Malaysia. The dominance of cyanobacteria in airborne algal sampled, also has been emphasized in other studies which have been conducted in Cairo, Egypt (El-Gamal, 2008) and in Varanasi, India (Sharma *et al*., 2006). According to Ng *et al*. (2011), Malaysia is a tropical country which means Malaysia has an ideal climate for the growth of aerophytic cyanobacteria.

2.7 Hazard impact of aerophytic microalgae towards human

Aerophytic microalgae can give unfavourable impact on human respiratory system and allergic problems. Their status as allergenic agents is known (Schlichting, 1969; Mittal *et al*., 1979; Sharma and Rai, 2008; Genitsaris *et al*., 2011). The airborne algae can cause respiratory problems such as asthma, respiratory allergy and bronchial mucous secretion.

The first man that suggested the aerophytic microalgae has the ability to induce the asthma and allergy to human respiratory system was Heise in 1949. Schlichting (1969), stated that the recent investigation on the aerophytic microalgae revealed that the aerophytic microalgae can cause allergies and if they are introduced into the body through the respiratory system they can possibly harmful towards human health. According to Genitsaris *et al*. (2011), others allergenic problems that caused by the aerophytic microalgae are rhinitis, bronchial asthma, hypersensitivity, pneumonitis, and bronchiole provocation. Hay fevers also one of the health problem causes by the aerophytic microalgae. Dubey *et al.* (2010), identified 20 species that have been reported to cause hay fever, allergy, dermatic problem and produce toxin that can give bad impact on human respiratory system.

According to Genitsaris *et al.* (2011), stated that there are about 38 species of aerophytic microalgae that have hazard impact on human when they were aerosolised and inhaled. Species of aerophytic microalgae that have impact on human health and produce toxin to the surrounding can be refer in Table 2.7. Based on the table, the highest taxa of airborne algae that give hazard impact on human documented was from the Class Cyanophyceae and the least one was from Family Baccilariophyceae.

A case study was done by Freeman (2005), shows that algae toxins from organism such as *Kerania brevis* can be arosoilzed in sea mist and breathed in by people. The study examines the hazard they pose towards human.

Table 2.7: List of airborne algae from previous studies that give hazard impact on human/ excrete toxin to surrounding.

Aerophytic microalgae taxa:	**Reported by:**
Bacillariophyceae	
Amphora sp.	Genitsaris *et al*., 2011
Nitzschia palea	Dubey *et al.,* 2010; Jadhav *et al.*, 2010
Pinnularia sp.	Jadhav *et al*., 2010
Chlorophyceae	
Ankistrodesmus falcatus	Dubey *et al.,* 2010
Gleocystis major	Jadhav *et al.*, 2010
Oocystis sp.	Genitsaris *et al*., 2011
Palmella sp.	Genitsaris *et al*., 2011
Cyanophyceae	
Anabaena circularis	Genitsaris *et al*., 2011
A. circinalis	Genitsaris *et al*., 2011
A. fertilissima	Dubey *et al*., 2010
A. iyengarii var attenuate	Dubey *et al*., 2010
Anabaena sp.	Genitsaris *et al*., 2011
Aphanothece nidulans	Jadhav *et al.*, 2010
Arthrospira sp.	Genitsaris *et al*., 2011
Chlothrix breviarticulata	Jadhav *et al*., 2010
Cylindrospermum sp.	Genitsaris *et al*., 2011
Gloeocapsa rupestris	Jadhav *et al.*, 2010
Gloeothece palea	Jadhav *et al.*, 2010
Hapalosiphon sp.	Genitsaris *et al*., 2011
Lyngbya hieronymusii	Dubey *et al.,* 2010
Oscillatoria sp.	Genitsaris *et al*., 2011
Phormidium usterii	Jadhav *et al*., 2010
P. molie	Jadhav *et al*., 2010
P. abronema	Jadhav *et al*., 2010
P. fragile	Dubey *et al*., 2010
P. angustissimum	Genitsaris *et al*., 2011
P. tenue	Dubey *et al*., 2010
Phormidium sp.	Genitsaris *et al*., 2011
Plectonema gracillimum	Jadhav *et al.*, 2010
P. hansgirgi	Jadhav *et al*., 2010
Scytonema bohneri	Jadhav *et al*., 2010
S. schmidtii	Jadhav *et al.*, 2010

Table 2.7 Continue

Aerophytic microalgae taxa:	**Reported by:**
Cyanophyceae	
Synechococcus sp.	Genitsaris *et al*., 2011
Tolypothrix byssoidea	Genitsaris *et al*., 2011
Dinophyceae	
Prorocentrum sp.	Genitsaris *et al*., 2011
Chlamydomonas sp.	Genitsaris *et al*., 2011
Dinophyceae	
Chlorella vulgaris	Dubey *et al*., 2010; Jadhav *et al.*, 2010
Chlorella sp.	Genitsaris *et al*., 2011
Chlorococcum humicola	Dubey *et al*., 2010; Jadhav *et al.*, 2010
C. infusionum	Dubey *et al*., 2010
Chlorococcum sp.	Genitsaris *et al*., 2011
Chlorosarcinopsis sp.	Genitsaris *et al*., 2011
Scenedesmus bijuga	Dubey *et al*., 2010
S. cf. quadricaudata	Dubey *et al*., 2010
Scenedesmus sp.	Genitsaris *et al*., 2011
Stichococcus sp.	Genitsaris *et al*., 2011
Tetraspora sp.	Jadhav *et al*., 2010
Trebouxia sp.	Jadhav *et al*., 2010
Chrysophyceae	
Lyngbya major	Genitsaris *et al*., 2011
Lyngbya sp.	Jadhav *et al*., 2010; Genitsaris et al., 2011
Microcoleus accutissimus	Jadhav *et al*., 2010
Microcoleus sp.	Genitsaris *et al*., 2011
Microcystis aeruginosa	Dubey *et al*., 2010
M. flos-aquae	Genitsaris *et al*., 2011
Microcystis sp.	Genitsaris *et al*., 2011
Chrysophyceae	
Myxosarcina burmensis	Jadhav *et al.*, 2010
Myxosarcina sp.	Genitsaris *et al*., 2011
Nostoc commune	Genitsaris *et al*., 2011
N. linckia	Dubey *et al*., 2010
N. muscorum	Dubey *et al*., 2010; Jadhav et al., 2010
N. punctiforme	Jadhav *et al.*, 2010

Table 2.7 Continue

Aerophytic microalgae taxa:	**Reported by:**
Chrysophyceae	
Nostoc sp.	Genitsaris *et al*., 2011
Oscillatoria curvicep	Dubey *et al*., 2010
O. farmosa	Dubey *et al*., 2010
O. angustissima	Dubey *et al*., 2010
O. simplicissima	Genitsaris *et al*., 2011
O. subbervis	Dubey *et al*., 2010
Klebsormidium (Hormidium) sp.	Genitsaris *et al*., 2011
Mesotaenium micrococcum	Genitsaris *et al*., 2011
Zygnema affine	Dubey *et al*., 2010