1.0 INTRODUCTION

Ocean or marine habitats harbored more than 7000 species of planktonic microscopic algae known as phytoplankton. Reynolds (2006) defined the term phytoplankton as the collective of photosynthetic microorganisms, adapted to live partly or continuously in the open seas, lakes including reservoirs, ponds and river water, where they contribute part or most of the organic carbon available to pelagic food webs. Phytoplankton is known to be the most diversified group among microorganisms (Barsanti & Gualtieri, 2006). They normally are aquatic microorganisms inhabiting both fresh and marine ecosystems. Present in its habitat in variety of sizes, phytoplankton are single celled microorganisms. Some are usually found as individual cell while others present in colonies (Verlencar & Desai, 2004).

Vegetative structure and process of reproduction are important for classification of phytoplankton at specific, generic and family level (Morris, 1971). But they are not particularly useful for primary classification of phytoplankton. There is no easily definable classification system applicable to all phytoplankton because its taxonomy is under constant and rapid revision at all level following new morphological, genetic and ultrastructural evidence (Barsanti & Gualtieri, 2006). Phycologists believed that the taxonomic opinion may change as information accumulates, thus altering current classification system. Generally, most phytoplankton is classed under a few divisions of algae group; which are the prokaryotae (Cyanobacteria) and eukaryotic (Bacillariophyta, Chlorophyta, Rhodophyta, Chrysophyta and Pyrrophyta) groups.

Phytoplankton community commonly comprises of million species of different divisions. Experts believed most of them are from division of Bacillariophyta (Salleh, *et. al*, 2005). In marine and brackish water, Bacillariophyta and Pyrrophyta are the most dominant to inhabit both ecosystems. While in freshwater such as waterfall and river, there are four dominant divisions which are the Chrysophyta, Cyanobacteria, Chlorophyta and Bacillariophyta (Salleh & Tajuddin, 2006). Thousands of year's adaptations enable them to tolerate broad range of physical and chemical parameters, hence making their present in normal and extreme habitats possible.

As photosynthetic microorganisms, phytoplankton is highly dependent on sunlight. In addition to high supply of CO_2 and inorganic materials such as phosphate and nitrate are also vital to carry out photosynthesis. The ability to photosynthesize, enable them to benefit the ecosystems which they inhabiting. For example, through photosynthesis the concentration of CO_2 in the atmosphere will decrease in a process called CO_2 sequestration. Besides, photosynthesis releases vital oxygen which is used by heterotrophic organisms in respiration. It is estimated that phytoplankton contribute almost 50% of O_2 to both flora and fauna of mangrove ecosystem (Cortes, *et. al*, 2001).

Either in the marine or freshwater, in most of their habitats, phytoplankton are found in high density and composition. The enormous numbers make them valuable in the ecosystem as base of the food chain, which also known as the primary producer in aquatic ecosystems (Rajkumar *et. al*, 2009). Therefore, phytoplankton is important in maintaining and conserving the aquatic ecosystem.

Change in phytoplankton numbers in any aquatic ecosystem able to alter the whole ecosystem in which they inhabit. For example, decreased or increased of its numbers influenced small fishes and small invertebrate numbers, since they are the major food source for both organisms. In certain aquatic condition, phytoplankton blooms occur and it becomes one of the major environmental problems. There are some species of phytoplankton such as *Pyrodinium* spp. that able to cause toxin or poisonous bloom that are potent to other organism including human poisoning occurred due to consumption of contaminated fish or shellfish, drinking contaminated water, inhaling contaminated aerosol or by contacting contaminated water (Moore *et. al.*, 2008). If harmful algae bloom (HAB) species are identified in certain places, means HAB could be a threat to those particular areas.

The ability of phytoplankton to give instance response to environmental change makes them useful as aquatic bioindicator for monitoring water quality. Shifts in the relative abundance of phytoplankton species richness and density can be used to detect any changes in environmental profiles. In Hungary, diatom was used to assess the ecological status of its shallow lakes (Stenger-kovais *et. al.*, 2007). 127 species of diatom were defined for Trophic Diatom Index for lakes (TDIL). By using TDIL, the ecological status of the lakes was determined, based on the optimum and tolerance of total phosphate parametric of the diatom species.

While other groups of phytoplankton such as Desmids of division Chlorophyta are widely used as freshwater trophic state bioindicator. Ngearnpat & Peerapornpisal (2007) found 8 species of desmids which are *Staurastrum gutwinskii, Spondylosium pandurifoemae, Cosmarium capitulum, C. mediosrobiculatum* var. *egranutum, S. tortum, Closterium gracile* var. *elongatum, C. kuetzingii* and *C. dianae* var. *dianae* are suitable to be used to assess freshwater trophic status in Thailand. The water quality of 12 freshwater resources in Thailand were successfully classified as oligotrophic to meso-eutrophic by trophic status using those desmids species.

In Malaysia, studies on the freshwater and marine phytoplankton are enormous (Lokman, 1991). The coastal and ocean regions that surround the Peninsular of Malaysia and East Malaysia enable phycologists to isolate, identify and characterize hundreds of phytoplankton species. Freshwater phytoplankton, have been sampled or isolated from waterfalls, rivers, lakes and also water reservoirs. However, studies on phytoplankton in mangrove ecosystem in Malaysia are relatively few.

According to Malaysian Wetlands Working Group (1986), mangrove forest of Malaysia is classed as one of 10 major wetland categories and occurs primarily in the states of Perak, Selangor and Johor. Phytoplankton species diversity at mangrove ecosystem is believed to be as rich as in marine and freshwater. They are also known as extremophile organisms. The ecology of this mangrove phytoplankton is different compared to marine, freshwater and other extremophile phytoplankton since they have already adapted to live in unique mangrove ecosystem, which is also considered as extreme habitat for phytoplankton (Lokman, 1991). The phytoplankton from mangrove ecosystem is unique species because they can tolerate low O_2 concentration, variable salinity level, limited sunlight, tidal ranges and anaerobic soil or mudflat surroundings (Graham & Wilcox, 2000).

The vast distribution of mangrove ecosystem in Peninsular Malaysia makes it impossible for phycologist to cover all the research on phytoplankton at each mangrove ecosystem. Identification and study on the ecology and distribution of phytoplankton are crucial to provide detail information on phytoplankton of this ecosystem which might be important in the field of science, economy, medical and aquaculture (De La Noue & De Pauw, 1988). For example, mangrove ecosystem is one of the potential habitats of Coccolithophoridae that is essential in CO_2 bioremediation (Cortes *et. al.*, 2001). Their ability to tolerate anaerobic condition of mangrove surroundings enables them to produce high poly unsaturated fatty acid (PUFA) to be used in biodegradation of crude glycerol. For example, *Schizochytrium limacinum* that was isolated from mangrove forest of Yap Island in Macronesia proved able to produce the higher amount of PUFA compared to other species of *Schizochytrium* sp. Isolated from marine ecosystem (Pyle, 2008).

New or endemic phytoplankton species are likely to be discovered in mangrove ecosystem of Malaysia as not many studies on the phytoplankton of the ecosystem have been carried out. Nevertheless, this research is crucial to provide information on the species richness and variability. By understanding the ecology of phytoplankton via monitoring programme (Watson, *et. al*., 1992), some potentials of that phytoplankton may be predicted (Lokman, 1991). This study is also important to highlight the hidden biodiversity of phytoplankton and to conserve the resources with biotechnological potentials for the country.

The aim of this research was to investigate the spatial distribution of phytoplankton communities and its temporal distribution to both high tide and low tide for 12 consecutive months. Assessed on relationships between chemical and physical parameters of the mangrove with phytoplankton were analyzed in each month sampling in both tides. Though book of checklist of phytoplankton at Carey Island was published, information only covered generally on phytoplankton inhabiting the aquatic ecosystems of Carey Island, while information on phytoplankton of mangrove area and its relation to physical and chemical factors are still lacking.

Hence, the objectives of this study were, therefore to:

1. To update the checklist of phytoplankton species at Carey Island mangrove ecosystem.

2. To determine the spatial and temporal distribution of phytoplankton at Carey island mangrove ecosystem.

3. To determine factors those influence the distribution of phytoplankton abundance and diversity at Carey Island mangrove ecosystem.

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