Chapter 5

Effect of Abiotic Factors on Photomovement Parameters of *Dunaliella*

Motile microorganisms are exposed to the influence of a number of abiotic factors such as mechanical (mechanical shocks, hydrostatic pressure), gravitational, thermal, electromagnetic (ultraviolet, visible, infrared, and microwave radiation), electrical and magnetic fields, and ionizing radiation. They are also influenced by the chemical, gas and ion composition and the pH of the aquatic media, biogenous elements and other organisms, each of which can affect their photomovement responses [Jahn and Bovee, 1968; Marbach and Mayer, 1970; Kritsky, 1982; Sineschekov and Litvin, 1982; Colombetti et al., 1982]. The effects of light on the photomovement parameters of two species of *Dunaliella* were described in the Chapter 4.

Motile microorganisms respond to various abiotic factors in their environment gravitating toward conditions that enhance their survival and population growth. Thermal [Gimmeller et al., 1978; Lynch, 1984; Lynch et al., 1984; Poff, 1985; Norman and Thompson, 1985; Yang, 1988; Ramazanov et al., 1988; Ben-Amotz, 1996; Krol et al., 1997] and chemical [Berg, 1985] gradients, gravitational [Häder, 1987b], electrical [Mast, 1911; Häder, 1977] and magnetic [Esquivel and de Barros, 1986; Yamaoka et al., 1992] fields, solar radiation [Nultsch and Häder, 1988; Richter et al., 2007], and ionizing radiation [Saraiva, 1972] have all been shown to modulate their behavior. Several articles have elucidated the effect of multiple abiotic factors on the physiology and behaviour of algae [Mil'ko, 1963; Jimenez and Niell, 1991; Thakur and Kumar, 1998b; Gomez and Gonzalez, 2005; Zhang et al., 2006].

The effects of abiotic factors such as temperature, electrical fields, medium pH, and ultraviolet and ionizing radiation, as well as the influence of physical factors (i.e., optical radiation, temperature, electrical fields) on the photomovement parameters of two species of *Dunaliella* are discussed in this Chapter.

5.1. Effect of Temperature

The effect of temperature on cell movement velocity was assessed over a temperature gradient from 16 to 35 °C using a controlled temperature bath and microscope. Precise measurement of the temperature of the algal suspension has shown that changes in temperature caused by switching on the lights did not exceed one hundredth of a degree. This observation provides evidence for the absence of any significant sample heating due to the light treatments [Posudin et al., 1988]. The response to the change in the temperature is calculated as $R(t) = (v_t - v_0)/v_0$ where $v_t$ and $v_0$ are cell movement velocities at the given and minimum (16 °C) temperature (under the conditions of our experiments), respectively [Posudin et al., 1988].

Maximum values for cell velocity were reached around 25 °C. Kinetic reactions for both *Dunaliella* species due to the temperature change (16 °C initial temperature) did not differ significantly (Fig. 5.1).

The value of photokinetic reaction to the increasing temperature between 16-25 °C increased until $R(t) = 0.19$. The sharpest increase occurred between 16 and 20 °C. Further increases in temperature up to 35 °C lead to a diminishing value for the photokinetic reaction $R(t) = 0.12$ (see Fig. 5.1).
The dependence of linear cell movement velocity on temperature can be in part explained by a decrease in the viscosity of medium with increasing temperature between 16 to 25 °C and a progressive inhibition of the flagellar apparatus between 25 and 35 °C. It is important to note that the temperature within this range did not affect phototopotaxis.

5.2. Effect of Electrical Fields

A special rectangular cuvette was constructed for investigating the effect of electrical fields on photomovement. The cuvette consisted of an observation chamber (40×10×4 mm) that contained the algal suspension, two electrode chambers that were separated from the observation chamber by gelatine and a 0.3 M solution of KCl to prevent electrolysis. Gold electrodes, positioned at a 90° angle to the lateral light source, were attached to an electrical source. The distance between the parallel electrodes was 30 mm [Posudin et al., 1991].

Fourier-transform (see Section 4.1.4) was used to determine the level of phototopotaxis inhibition by the electrical field. The method allowed analyzing changes in the amplitude of the principal harmonics to elucidate the possible participation of membrane electrical potentials in algal photomovement.

Application of an electrical field (10-20 V/cm) inhibited phototopotaxis in D. salina during lateral illumination with white light (500 lx illuminance). Fig. 5.2 displays histograms of angular distribution in the absence and presence of an electrical field (20 V/m). Fourier analysis allowed estimating the reduction in amplitude of the principal harmonics (the first harmonic 3 times, the second 3.7 times, etc.). The histogram of angular distribution demon-