**Abstract**

Under the present investigation, the research work is mainly focused in the following topics: (I) Isolation and Characterization of Power Plant Blue green Alga, (II) Studies on the performance of the isolated blue green alga with respect to $CO_2$ fixation and its growth kinetics under photoautotrophic condition using white light, (III) Studies on the growth kinetics of the isolated blue green alga under photoheterotrophic (Glycerol) and photomixotrophic ($CO_2$+Glycerol) conditions using white light,(IV) Studies on lipid production by alga under photoautotrophic, photoheterotrophic and photomixotrophic conditions using white light,(V) Studies on pigment production by alga under photoautotrophic, photoheterotrophic and photomixotrophic conditions using white light,(VI) Study the effect of different light wavelengths on algal growth, lipid accumulation and pigment production by Blue-Green Alga *L.subtilis* JUCHE, and (VII) Studies on Power plant blue-green alga *Leptolyngbya subtilis* JUCHE1 for production of biochar ,pyro-oil and pyro-gas through slow pyrolysis have been performed. The trends of production of biomass and lipid during the photoautotrophic, photoheterotrophic and photomixotrophic growth of newly isolated blue-green algae, *Leptolyngbya subtilis* JUCHE1 were compared and correlated with the variation in C-sources. In the photoautotrophic and photoheterotrophic and photomixotrophic growth studies, $CO_2$ and glycerol were respectively used as the inorganic and organic C-sources maintaining equivalence in the initial amount of carbon. Light was used as the source of energy in all cases. The higher biomass production from glycerol compared to $CO_2$ was observed. In case of photoautotrophic growth, the maximum values of biomass concentration and lipid content, obtained at 15% $CO_2$, were 0.7286 g/L and of 12.5% w/w respectively. Under photoautotrophic growth using $CO_2$ as substrate Haldane model explains the growth kinetics. The values of growth kinetic parameters such as $\mu_{max}$, $K_s$, $K_I$ have been determined to be 0.6064$d^{-1}$, 0.0165 g/L and 1.7429 g/L, respectively. Under photoautotrophic growth when $NaNO_3$ has been used as substrate Monod model was valid for growth kinetics. The values of $\mu_{max}$ and $K_s$ of 0.667 $d^{-1}$ and 0.644 g/L respectively were determined. Under nitrogen limited condition, the higher value of lipid content of 53.87% (w/w) was obtained at 1g/L of $NaNO_3$ concentration. The maximum biomass concentration of 0.817 g/L has been observed on 4$^{th}$ day at glycerol concentration of 0.1139 g/L (Equivalent to 15%v/v $CO_2$ concentration in gas phase). However, under photoheterotrophic growth, lipid content and productivity of 56.34% (w/w) and 0.0702 g/L/d were obtained at glycerol concentration equivalent to 5% (v/v) $CO_2$, which is 4.66 folds higher than that obtained under

corresponding photoautotrophic condition. The values of $\mu_{max}$ and $K_s$ have been determined from the intercept and the slope. Whereas, the value of $K_I$ has been determined by using the correlation, $C_{S,max} = \sqrt{K_S K_I}$ (Method-I). The values of growth kinetic parameters, namely, $\mu_{max}$, $K_s$, $K_I$ were determined to be 0.8824 $d^{-1}$, 0.0261 g/L and 0.4974 g/L, respectively. According to Method-II, it appears that Haldane model has been difficult to be valid in case of the heterotrophic growth on glycerol. Accordingly, $C_{S,crit}$, i.e., the glycerol concentration at which no growth is obtained and has been determined to be 0.25g/L. The value of $\mu_{without\ inhibition}$ at 0.152g/L has been determined using Monod model with already determined values of $\mu_{max}$ and $K_s$ of 0.8824 $d^{-1}$, 0.0261 g/L respectively. Under mixotrophic growth, the maximum biomass concentration and lipid content of 0.6393 g/L and 26.71%w/w were achieved at using 7.5% $CO_2$ and 0.0569g/L glycerol (equivalent to 7.5% $CO_2$). Under mixotrophic growth, the lipid content was 2.13 folds higher as compared to photoautotrophic growth. Steele model is valid for the functionality of growth rate on light intensity. Multi-variable functionality of specific growth rate on simultaneous variation of $CO_2$ and $NaNO_3$ and light intensity (I) have been determined through fundamental kinetic analysis. A statistical analysis through the application of Box-Behnken method has also been made and a quadratic model equation has been obtained through RSM technique to explain the influence of simultaneous variation of $CO_2$, $NaNO_3$ and I. Box–Behnken method of RSM is performed using three input variables (A: $CO_2$, B: $NaNO_3$ and C: light intensity) and specific growth rate(μ) of *L. subtilis* JUCHE1 as the response. From the statistical summary it was found that the p-value is less than < 0.0001 and the predicted and adjusted values of $R^2$ are 0.9976 and 0.9997. All models have been validated through the satisfactory comparison with the experimental results. Among all the wavelengths of light (Blue, Green, Yellow and Red), the highest biomass concentration and productivity of 1.2251 g/L and 1.1838 g/L/d respectively are observed under the irradiance of yellow light on $6^{th}$ day of culture period. The maximum lipid content of 22.15% (w/w) has been obtained on $6^{th}$ day of growth under yellow wavelength of light. The maximum $CO_2$ fixation rate of 0.3520g/L/d has been achieved on $5^{th}$ day under irradiance of yellow light. Under blue light, the highest values of chlorophyll and carotenoid contents of 0.93 %w/w and 0.2728 % w/w have been achieved on $6^{th}$ day. Under semi-continuous cultivation mode, the maximum biomass concentration and productivity of 2.72g/L and 0.2224 g/L/d were observed for Internally Externally Gas-lift Photobioreactor (IEIGPBR) on $14^{th}$ day and $8^{th}$ day of culture periods under the irradiance of yellow light (590 nm). The highest value of lipid content and productivity of

58.86 (% w/w) and 0.1043 g/L/d respectively were observed for yellow wavelength of light on $14^{th}$ day and $12^{th}$ day of culture periods. It has been found that the $CO_2$ fixation rate reaches its maximum on $8^{th}$ day and the value was observed to be 0.2855g/L/d. The pyrolysis characteristics of the dry algal biomass under isothermal condition varying the temperature range of 300-700$^oC$ from the perspective of production of bio-char and oil have also been studied. The maximum weight loss of 92 (%w/w) was observed after 60minutes at 700 $^oC$ . The highest yield of biochar of 29% (w/w) was achieved at 300$^oC$. The maximum yield of oil and gas of 23.65% and 69.12% respectively were obtained at 700$^oC$. The higher lipid production by *L. subtilis* JUCHE1 under photoheterotrophic growth using glycerol as organic carbon source as compared to other algal strains confirms the oleaginous nature of this algal strain. Since the power plant blue green alga, *Leptolyngbya subtilis* JUCHE1, can produce lipid at a high rate both under photoautotrophic condition with nitrogen stress and under photoheterotrophic condition using glycerol, a zero-effluent biodiesel plant can be integrated with the cultivation unit of *Leptolyngbya subtilis* JUCHE. Pigments (chlorophyll, carotenoid etc.) and biochemicals (DHA) are also extracted from the same algal strain. Hence, a complete biorefinery can actually be integrated with a $CO_2$-emitting power plant which will ensure sequestration of greenhouse gas and simultaneous production of bio-oil, biochar and biochemicals (pigments and omega 3-fatty acids).