Effect of Different LED Lights on Enhancing the Biomass Yield of *Scenedesmussp.* grown in Industrial Dye Effluent

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***Abstract*—The environment is getting polluted predominantly due to the discharge of effluents from different industries. Industrial discharges are the main cause of surface and groundwater contamination which is specifically due to the hydrocarbon rich solvents, heavy metals, dyes and so on. Bioremediation is one of the very effective biological methods to treat various industrial effluents which utilize algal technology. Algae have the ability to take up nitrogen and phosphorous and thus the wastewater is treated by using algal technology. Algae ranges from micro algae to macro algae which are capable of producing food on their own through photosynthesis from both fresh and contaminated water similar to any plant. Micro algae need a light/dark regime for productive photosynthesis where it needs light for photochemical phase and needs darkness for biochemical phase to synthesise essential molecules for their growth. The LED (Light Emitting Diode) has the potential to stimulate the growth rate of algae. Experiments conducted in this current research using various LED's showed that, the growth rate of *Scenedesmus sp.* is increased by 12.49%, 14.44% and 14.7% at varying concentrations of dye industry effluent. The result of effluent analysis of *Scenedesmussp.* in white and blue LED light shows that the physiochemical parameters such as BOD (Biochemical Oxygen Demand), TDS (Total Dissolved Solids) and TSS (Total Suspended Solids) are reduced by 20.1%, 96%, 100% and 18.24%, 90.47%, 100% respectively. The overall results proved that the degradation rate of effluent is found to be increased in the presence of LED lights and also the biomass yield is increased.**

Keywords: Micro algae, Photo-Bio Reactors, LED.

I. INTRODUCTION

Global warming, discharge of CO_2 and many other problems clearly makes us want to think about a green future, renewable energy and alternative sources. It is truism nowadays to recognize that pollution associated problems are a major concern of society. Environmental laws are given general applicability and their enforcement has been increasingly stricter. So, in terms of health, environment and economy, the fight against pollution has become a major issue. Significant developments in industrialization have led to increased pollution mainly due to the disposal of liquid and solid wastes in to the environment. Industries such as dairy, textile, tannery, pharmaceuticals and paper produce goods necessary for the sustenance of life and are the primary sources of pollution. Pollution is a man-made phenomenon, arising either when the concentrations of naturally occurring substances are increased or when non-natural synthetic compounds (xenobiotics) are released into the environment. Organic and inorganic substances which are released into the environment as a result of domestic, agricultural and industrial water activities lead to organic and inorganic pollution. Today, although the strategic importance of fresh water is universally recognized more than ever before, and although issues concerning sustainable water management can be found almost in every scientific, social, or political agenda all over the world, water resources seem to face severe quantitative and qualitative threats. The pollution increase, industrialization and rapid economic development, impose severe risks to availability and quality of water resources, in many areas worldwide. Discharges are the main causes of surface and groundwater contamination. Various techniques have been developed to effectively treat the wastewater disposed by industries.These effluents typically contain high concentrations of organic and inorganic chemicals such as hydrocarbon solvents, heavymetals, pesticides, dyes and so on. For the treatment of wastewater large amount of materials are to be supplemented. Nutrient rich wastewater instead of discharging into environment is supplemented for the growth of algae in the wastewater treatment. Thus nutrients can be reused and wastewater can be treated and thus reducing the negative impacts. The effective method to treat effluent is bioremediation process using algal technology. As the algae takes up N and P, the wastewater can be treated with algae.

A. ALGAE

Algae are simple plants that can range from the microscopic (microalgae), to large seaweeds (macro algae), such as giant kelp more than one hundred feet in length. Microalgae include both cyanobacteria similar to bacteria, and formerly called “blue green algae” as well as green, brown and red algae. Algae can be grown

using water resources such as brackish-, sea-, and wastewater unsuitable for cultivating agricultural crops. When using wastewater, such as municipal, animal and even some industrial runoff, they can help in its treatment and purification, while benefiting from using the nutrients present. It is unicellular or simple multicellular body plant which has ability to produce food material by photosynthesis on their own from fresh or contaminated water. Most microalgae grow through photosynthesis – by converting sunlight, CO2 and a few nutrients, including nitrogen and phosphorous, into material known as biomass. This is called "autotrophic" growth. Other algae can grow in the dark using sugar or starch called "heterotrophic" growth, or even combine both growth modes called "mixotrophic" growth. Microalgae are single-cell microscopic organisms which are naturally found in fresh water and marine environment.Recent studies on microalgae have a great deal of attraction as they have a potential of producing bio-fuel depending on the species and cultivation conditions. They can also spontaneously convert CO_2 and nutrients into biomass in the presence of light at much higher rates than conventional oil producing crops. Microalgae are capable of producing polysaccharides and triglycerides which form the raw materials for bioethanol and biodiesel production. Besides this they can also be used as a source of animal feed.

Fig 1. Algae culture in laboratory environment

II. IMPORTANCE OF ALGAE

Algae fuel or algal biofuel is an alternative to liquid fossil fuels that uses algae as its source of energy-rich oils. Also, algae fuels are an alternative to common known biofuel sources, such as corn and sugarcane. Several companies and government agencies are funding efforts to reduce capital and operating costs and make algae fuel production commercially viable. Like fossil fuel, algae fuel releases CO_2 when burnt, but unlike fossil fuel, algae fuel and other biofuels only release CO_2 recently removed from the atmosphere via photosynthesis as the algae or plant grew. The energy crisis and the world food crisis have ignited interest in alga culture (farming algae) for making biodiesel and other biofuels using land unsuitable for agriculture. Among algal fuels' attractive characteristics are that they can be grown with minimal impact on fresh water resources, can be produced using saline and wastewater, have a high flash point, and are biodegradable and relatively harmless to the environment if spilled. Algae cost more per unit mass than other second-generation biofuel crops due to high capital and operating costs, but are claimed to yield between 10 and 100 times more fuel per unit area. The United States Department of Energy estimates that if algae fuel replaced all the petroleum fuel in the United States, it would require 15,000 square miles (39,000 km2), which is only 0.42% of the U.S. map and is less than 1⁄7 the area of corn harvested in the United States in 2000.

A. Impact of Light on Algal Growth

The growth of algae is directly proportional to intensity of light. Conventionally micro algae are grown in Photo Bio Reactor (PBR) with the help of sunlight and white light. But apart from this many lights have more impact on the growth of algae.

1) Light Emitting Diode (LED)

A light-emitting diode (LED) is a two-lead semiconductor light source. It is a P–N junction diode, which emits light when activated. When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor.

Light-Emitting Diode (LED) array, which can supply only the wavelengths of light most useful for algae growth. Green algae contain chlorophyll A and B in the ratio (3 chlorophyll A: 1 chlorophyll B). Chlorophyll A has two absorption peaks, the first around 430 nm (blue/violet color) and the second at 660 nm (deep red). Chlorophyll B absorption peaks are 460 nm (blue) and 630 nm (red). In more mature cultures, red and blue light is absorbed by the algae cells closest to the LEDs source.

III. MATERIALS AND METHODS

A. Estimation of Growth Rate

The sample (effluent) was collected from the dye industry, Tirupur city and physico-chemical parameters of the dye effluent were analyzed before the treatment process. Algae species were cultured in Algae Culture Lab, SVCE. Studies on growth pattern of algae species (10mL, 100mL) were carried out. Two algae cultures were selected and inoculated in 10 ml boiler tubes kept at slanted positions in order to provide maximum and

constant light intensity of 24 hours and 1800 lux (measured via lux meter), to the micro-algae. Cell countwas taken at regular interval and the algae which adapted well and grew fast was selected for further process.

B. Growth measurement

Cell count of the micro algal culture was estimated by using Haemocytometer line method. The no. of cells present in the matrix present on the Haemocytometer was observed under microscope with 10X and 40X resolution and the no. of cells present was noted.

Formulae to determine growth rate

Growth rate (μ)

$$\mu = \frac{\left[\frac{\ln(x1)}{\ln(x2)}\right]}{[t2 - t1]}$$

where,

-'t' in days

- x_1 and x_2 are densities at times t_1 and t_2

C. Medium Composition

TABLE I
3N-BBM+V (BOLD-BASAL MEDIUM WITH 3-FOLD NITROGEN ANDVITAMINS; MODIFIED)

S.No	Macronutrients	Quantity
1	$NaNO_3$	25.0 g/L
2	$MgSO_4.7H_2O$	7.5 g/L
3	NaCl	0.5 g/L
4	$K_2HPO_4.3H_2O$	7.5 g/L
5	KH_2PO_4	17.5 g/L
6	$CaCl_2.2H_2O$	2.5 g/L
7	Trace elements	
	$FeCl_3.6H_2O$	97.0 mg
	$MnCl_2.4H_2O$	41.0 mg
	$ZnCl_2.6H_2O$	5.0 mg
	$CoCl_2.6H_2O$	2.0 mg
	$Na_2Mo_4.2H_2O$	4.0 mg
	Na_2EDTA	0.75g
	GD water	1000 mL
	pH	6.8
8	Vitamin B1	0.12g
9	Vitamin B12	0.001g

Bold Basal Medium is used for fresh water algae and has micro and macro nutrients for the growth of algae.

IV. RESULTS AND DISCUSSION

A. Textile dye industry effluent collection and analysis

The dye effluent was collected from a textile industry from Tirupur city in a 50L capacity cane. 1L of the effluent was sent for physicochemical analysis to determine the standard levels to proceed to further treatment process.

TABLE 2
TEXTILE DYE INDUSTRY EFFLUENT ANALYSIS

S.No	Parameters	Unit	Result
1	Total dissolved solids	mg/L	35520
2	Nitrate as NO_3	mg/L	241
3	Phosphate as PO_4	mg/L	20.0
4	COD	mg/L	1958
5	BOD@ 27˚C for 3 days	mg/L	504
6	Total Suspended Solids@ 105˚C	mg/L	712
7	Chloride as Cl	mg/L	10370
8	Sulphate as SO_4	mg/L	19284
9	pH@ 25˚C	-	6.68
10	Conductivity@25˚C	μmhos/cm	37500

From Table 2, it is shown that the TDS, COD, pH, Cl, Sulphate and Conductivity is more and need to be reduced from the dye effluent by using various sources of light at different light intensity.

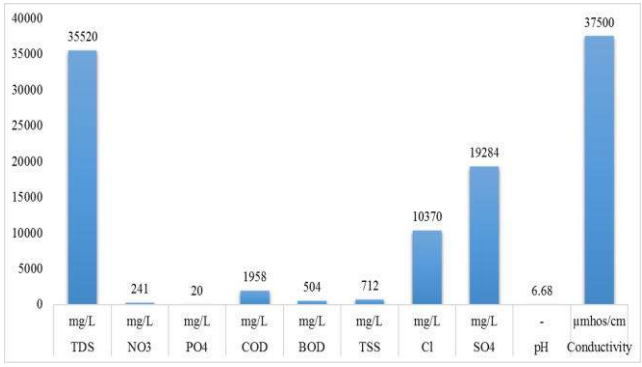

Fig 2. Graphical representation of the physicochemical parameters estimated for the collected dye industry effluent sample

B. Growth Studies of Scenedesmus sp. under Various Led Lights

The mother culture should be maintained to carry out the process. So, 9ml of BBM medium was taken and 1ml of the centrifuged algae culture was inoculated in it. The growth studies were monitored at regular intervals. Then, this 10ml of the culture was centrifuged and inoculated in 100ml of medium and growth studies were monitored. Cell count was taken using Haemocytometer and number of cell was calculated using growth rate formula.

Three LED light (Red, Blue, and White) setup was designed and fabricated. The light arrangement were kept in a position to get 1800 lx of light intensity. The prepared four 10ml algae culture was kept in three LED light setup and one in normal tube light for comparison. Cell count was taken at regular intervals till the Declining phase.

1) Growth kinetics of Scenedesmus sp. in normal tube Light

TABLE 3
GROWTH RATE OF *SCENEDESMUS SP.* IN NORMAL TUBE LIGHT(X 10^4)

Day	Cell Count(Fresh Water)	Growth Rate, μ (Fresh Water)
0	78	0
3	201	0.32
5	291	0.19
7	440	0.21
10	689	0.15
12	788	0.07
14	896	0.06
17	1408	0.15
19	1616	0.07

Table 3 represents the cell count and the growth rate of *Scenedesmus sp.* in normal tube Light. The cell count was stopped when it reached the decline phase.

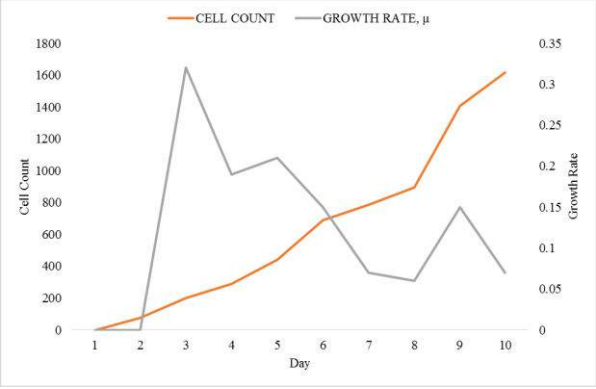

Fig 3. Graphical representation of the growth kinetics of *Scenedesmus sp.* in normal tube light

2) Growth Kinetics of Scenedesmus sp. in Red LED Light vs Tube Light

TABLE 4
GROWTH RATE OF *SCENEDESMUS SP.* IN RED LED LIGHT(X 10^4)

Days	Cell Count (Fresh water)	Growth Rate,μ (Fresh Water)	Cell Count (Effluent)	Growth Rate, μ (Effluent)
0	54	0	54	0
3	280	0.55	64	0.06
5	656	0.43	47	-0.15
7	864	0.14	61	0.13
10	2176	0.31	93	0.14
12	2848	0.13	122	0.14

Table 4 represents the cell count and the growth rate of *Scenedesmus sp.*in fresh water and effluent with Red LED Light. The cell count was stopped when it reached the decline phase.

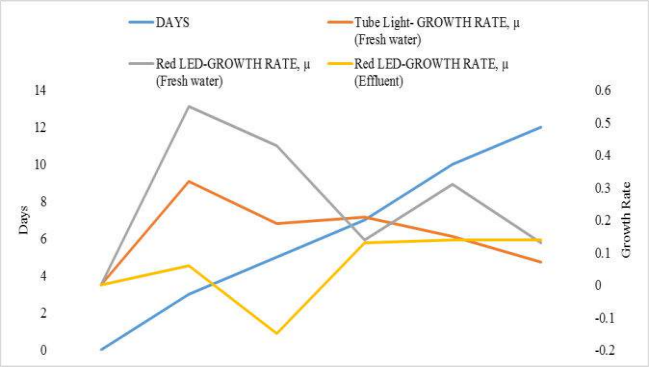

Fig 4. Graphical representation of the growth kinetics of *Scenedesmus sp.* in Red LED Light vs Tube Light

3) Growth Kinetics of Scenedesmus sp. in Blue LED Light vs Tube Light

TABLE 5
GROWTH RATE OF *SCENEDESMUS SP.* IN BLUE LED LIGHT(X 10^4)

Days	Cell Count (Fresh Water)	Growth Rate, μ (Fresh Water)	Cell Count (Effluent)	Growth Rate, μ (Effluent)
0	54	0	54	0
3	480	0.73	36	-0.14
5	1056	0.39	49	0.15
7	1408	0.14	58	0.08
10	3424	0.30	72	0.07
12	4256	0.11	96	0.14

Table 5 represents the cell count and the growth rate of *Scenedesmus sp.*in fresh water and effluent with Blue LED Light. The cell count was stopped when it reached the decline phase.

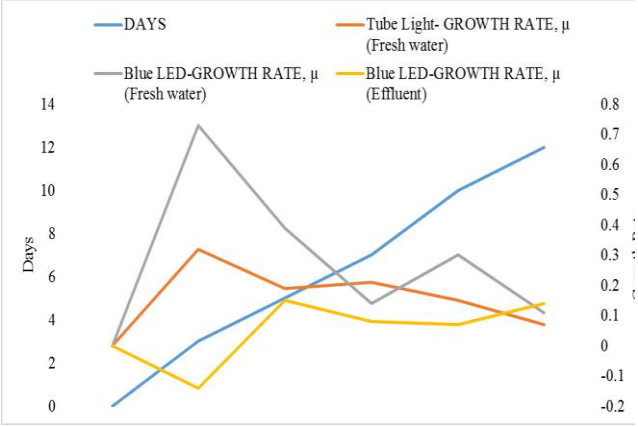

Fig 5. Graphical representation of the growth kinetics of *Scenedesmus sp.* in Blue LED Light vs Tube Light

4) Growth Kinetics of Scenedesmus sp. in White LED Light vs Tube Light

TABLE 6
GROWTH RATE OF *SCENEDESMUS SP.* IN WHITE LED LIGHT(X 10^4)

Days	Cell Count (Fresh Water)	Growth Rate, μ (Fresh Water)	Cell Count (Effluent)	Growth Rate, μ (Effluent)
0	54	0	54	0
3	896	0.94	62	0.05
5	1376	0.21	39	-0.23
7	1904	0.16	56	0.18
10	4544	0.29	81	0.12
12	5376	0.08	98	0.10

Table 6 represents the cell count and the growth rate of *Scenedesmus sp.*in fresh water and effluent with White LED Light. The cell count was stopped when it reached the decline phase.

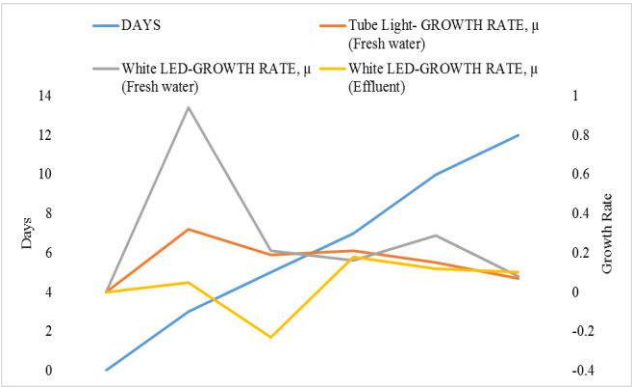

Fig 6. Graphical representation of the growth kinetics of *Scenedesmus sp.* in White LED Light vs Tube Light

5) Growth Kinetics of Scenedesmus sp. in Various Lights- Fresh water

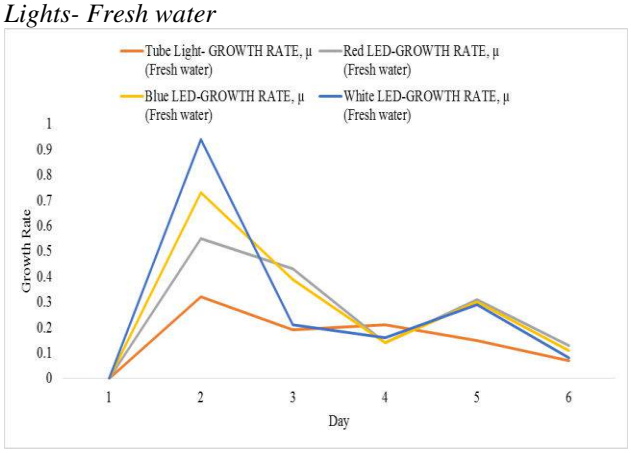

Fig 7. Growth rate of Scenedesmus sp. in Various Lights- Fresh water

Fig 7. Shows the comparative study of various light source (Tube light and LED light) at different intensity of light. The result shows and proves that the light intensity have more impact on the algal growth.

6) Growth kinectics of Scenedesmus sp. in Various Lights- Effluent

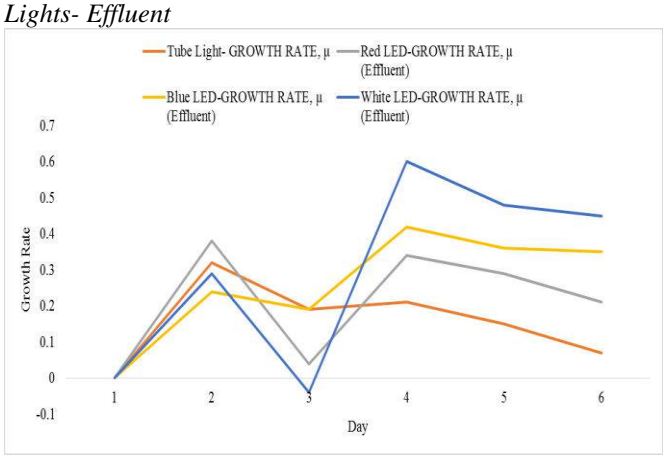

Fig 8.Growth rate of Scenedesmus sp. in Various Lights- Effluent

Fig 8. Shows the comparative study of effluent treatment in various light source (Tube light and LED light) at different intensity of light. The result shows and proves that the light intensity have more impact on the algal growth and effluent treatment.

C. *LED Light Setup*

Fig 9. Closed LED light set-up for efficient algal growth

Fig 9.Shows the LED light setup which is used to stimulate the growth of algae by making it possible to achieve non-scattered required light intensity.

D. *Physical Analysis of Treated Algal Samples*

Fig 10. Without LED light exposure sample

Fig 11. LED light exposed effluent sample

Fig 10 and Fig 11 Show the impact of LED light on the growth of algae. The effluent color changes from light bluish-green to green color, which confirms the growth of green algae in the effluent.

V. CONCLUSION

From the results obtained, it is eminent that the growth of algae can be stimulated by the intensities of various lights sources. LED lights plays a vital role in production of biomass in less time than the time required by normal tube lights. Usage of LED's critically conserves energy because it requires only less than half of the electric energy used by Fluorescent lights to produce the same light intensity, and also do not waste energy producing undesirable wavelengths of light. Thus, LEDs are considered a greener, more cost-effective light source and hence more sustainable than fluorescent lights. Experiments conducted in this current research using various LED's showed that, the growth rate of *Scenedesmus sp.* is increased by 12.49%, 14.44% and 14.7% at varying concentrations of dye industry effluent. The result of effluent analysis of *Scenedesmussp.* in white and blue LED light shows that the physiochemical parameters such as BOD (Biochemical Oxygen Demand), TDS (Total Dissolved Solids) and TSS (Total Suspended Solids) are reduced by 20.1%, 96%, 100% and 18.24%, 90.47%, 100% respectively. The overall results proved that the degradation rate of effluent is found to be increased in the presence of LED lights and also the biomass yield is increased.

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