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Optimization of Suitable Eco-Friendly Technology for Bioremediation of Textile Wastewaters

Shubhangi Mishra, Virendra Singh, Monika Sharma, C.K. Sharma

Abstract— Water is one of the major products of nature used enormously by human beings and it is not unnatural that any growing community generates enormous waste water or sewage. As a clean environment is a prerequisite for a healthy living in any urban settlement, proper treatment and safe disposal of sewage call for prime attention. Untreated waste water can cause pollution of surface and ground waters. Many new developments in the field of sewage treatment are eventually taking place. These developments include improvements for more effective removal of pollutants and new treatment processes capable of removing pollutants not ordinarily removed by conventional methods. Three types of textile wastewaters (Acid Yellow dye, Acid orange dye and Basic pink dye) has been used for wastewater treatment and microalgal (Chlorella pyrenoidosa and Scenedesmus obliquus) biofuel production. Nitrogen content in textile wastewaters is very less, hence urea is used as nitrogen source in wastewater. Discharge of untreated domestic and industrial wastewater into aquatic bodies is posing a serious eutrophication threat, leading to a slow degradation of the water resources. A number of physical, chemical and biological methods have been developed for the treatment of wastewaters; among these, the use of microalgae is considered as a more eco-friendly and economical approaches.

Index Terms— Bioremediation, Economic, Ecofriendly, Optimization

I. INTRODUCTION

Textile industries is among one of the most leading industries of India contributing a big financial share to the economy. As per the recent research these industries has confronted energy shortage resulting with huge financial loss. Most of the industries have already switched their sources of energy from national grid to inbuilt diesel run generators in order to meet their energy requirements. However this strategy has partialy worked and provided continuous energy inputs to the industry on the other hand unfortunately it adds up to the financial liabilities(Maqbool et al., 2016). For the sake to save local textile industries, where there is critical urge to go for sustainable energy sources. Apart from energy supply, textile industries are also facing the challenges for wastewater management(Rahman et al., 2016). Textile wastewater comprises of number of dyes and auxiliary chemicals and consumes several hundred thousand gallons of water per day and in proportion to that results with huge volume of wastewater generated (Khatri A., et al., 2015).

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II. MATERIALS AND METHODS

A. Sampling and characterization

Sampling was done by grab sampling method. Grab samples are single collected at a specific spot at a site over a short period of time (typically seconds or minutes). In this method the textile wastewater samples were collected from the discrete textile dye using industries in Varanasi. Sewage wastewater was collected from the Assi sewage in Varanasi. Domestic waste was collected from the hostels in IIT (BHU) Varanasi.

1. Acid Yellow 2. Acid Pink 3. Acid Orange 4.

Samples being picked up onsites by grab sampling method were characterized for different parameters by standard protocols from APHA. There are various parameters

S.N.	Parameter	Method
1.	Colour	Visual comparison
2.	pH	pH meter
3.	Temperature	Thermometer
4.	Phenol	Direct photometric method
5.	Dissolvedoxygen	Membrane electrode method
6.	Total Hardness	EDTA Titration method
7.	BOD	Titrimetric method
8.	COD	Open reflux method
9	Alkalinity	Titration with H_2SO_4
10.	Chlorine	Iodometric method
11.	Total solids	Evaporation based method
12.	Total dissolved solids	Evaporation based method
13.	Turbidity	Colorimetric method
14.	Nitrogen	Nesslerisation method

B. Culturing of microalgae

Two most suitable microalgal strains were being studied over *Chlorella pyrenoidosa and Scenedesmus obliquus*, were cultured in Bold's basal medium believed to suitable for microalgal growth.

C. Optimization of growth of microalgae

For acclimatization inoculums were transferred into textile wastewater 100ml (50% v/v in water) further acclimatized algae were transferred to 500ml of wastewater samples. In this study Nitrogen source, Carbon source and wastewater % is the varying parameter and used for the optimization of growth using the Response surface methodology.RSM is done by the software Minitab.

Inoculation 0 days | Growth after4 days | Growth after8 days

Fig: Growth of Chlorella pyrenoidosa in BBM

D. Treated wastewater characterization

The wastewater samples were characterized again after treatment for the same parameters in the same way, which were studied prior treatment for comparable analysis.

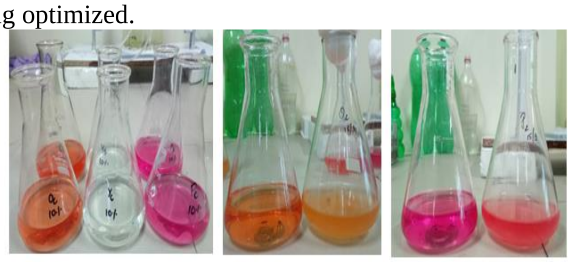
E. Optimization of Microalgal biomass harvesting

Flocculation is basically used here for harvesting the microalgal biomass. Chitosan is used as flocculanting agent for flocculation. Other flocculating agents like gelatin or starch can be used for the flocculation method. Optimization is done by the Response surface methodology (RSM) using chitosan as flocculant. Various parameter is selected for the optimization like Chitosan%, pH, mixing time and settling time.

III. OBSERVATION

A. Growth optimization

Numerous aspects with respect to design of production and treatment of wastewater using microalgae for bioremediation of wastewater and biodiesel production are being optimized.



(a) Various dyes with Chlorella (b) Acid yellow with growth (c) Acid Pink with growth

Fig : Growth optimization of Chlorella pyrenoidosa in various textile dye

B. Nitrogen Source optimization

Nitrogen being optimized as a source for the two species and also by using urea as a nitrogen source for *Chlorella pyrenoidosa* and *Scenedesmus obliquus*.

(A) (B) (C)

Figure : Nitrogen Source optimization in (a) Chlorella pyrenoidosa (b) Scenedesmus obliquus(c) Urea as Nitrogen

C. Carbon Source optimization

Carbon Source optimization was performed for *Chlorella pyrenoidosa* and *Scenedesmus obliquus.*

Figure : Carbon Source optimization for Chlorella pyrenoidosa and Scenedesmus obliquus

D. Bioremediation of wastewater in raceway pond (8 Lt.)

A raceway pond is artificially designed shallow pond at lab scale which is an open raceway pond cultivation system facilitating more light exposure ensuring enhanced algal growth due to increased surface area. Here the pond has the maximum volume of 8 Liters where the working volume has been taken as 4 Litres with the inoculum set up of Chlorella pyrenoidosa.

IV. RESULTS AND DISCUSSION

The intense colours of the dyes are significantly reduced after treatment with microalgae proving decolourisation as a part of bioremediation.

A) Treated and untreated Acid yellow dye | B) Treated and Untreated Acid orange dye | C) Treated and Untreated Acid pink dye

Figure: Dye colour reduction of various dyes using microalgae

The method of harvesting has been optimized by flocculation using Chitosan at variable concentrations and pH.

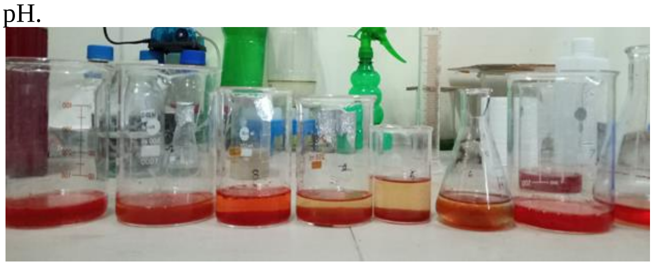


Figure: Optimization of Harvesting using flocculation method

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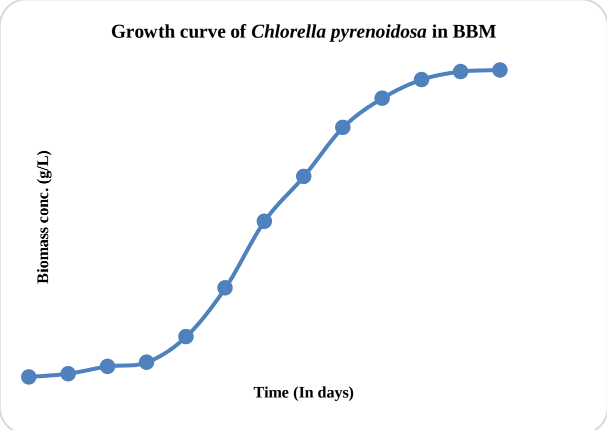
A. Growth curve and growth constant for the *Chlorella pyrenoidosa*

Day	Biomass Conc. (g/L)	Optical density (680nm)
0	0.513595	0.068
1	0.574018	0.076
2	0.70997	0.094
3	0.785498	0.104
4	1.261329	0.167
5	2.167674	0.287
6	3.413897	0.452
7	4.244713	0.562
8	5.15861	0.683
9	5.702417	0.755
10	6.049849	0.801
11	6.200906	0.821
12	6.231118	0.825



The growth curve is explained in the figure in which lag phase occurred for 3 days and log phase occurred for 7 days for the *chlorella pyrenoidosa.* The growth rate constant and maximum growth rate constant can be calculated as:

Growth constant (μ)= ln $(X_f/X_0)/(t_2-t_1)$ = ln (6.23/0.51)/12=0.21g/L/day

Maximum growth rate constant (μ_{max}) = ln (6.2/0.78)/7=0.29g/L/day

Standard curve of *Chlorella pyrenoidosa* is explained below:

Biomass Conc.(g/L)	Optical density (680nm)
0.5	0.088
1	0.132
1.5	0.192
2	0.263
2.5	0.324
3	0.388
3.5	0.456
4	0.514
4.5	0.598
5	0.688

5.2.2. Growth curve and growth constant for the *Scenedesmus obliquus*

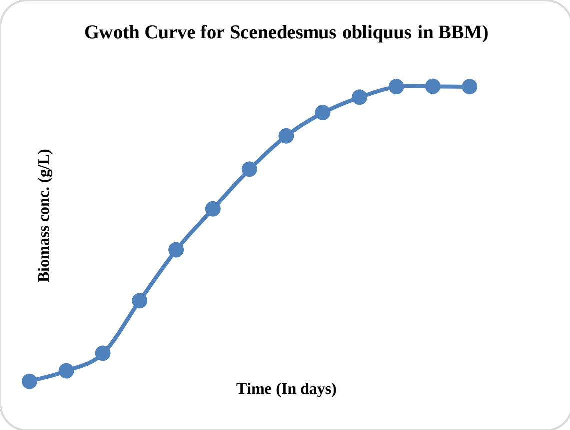


Table 5.3: Growth curve of Scenedesmus obliquus

Day	Biomass conc.(g/L)	Optical density
0	0.31728	0.056
1	0.487252	0.086
2	0.770538	0.136
3	1.620397	0.286
4	2.441926	0.431
5	3.104816	0.548
6	3.745042	0.661
7	4.283286	0.756
8	4.657224	0.822
9	4.906516	0.866
10	5.076487	0.896
11	5.082153	0.897
12	5.076487	0.896

The growth curve is explained in the figure in which lag phase occurred for 2 days and log phase occurred for 7 days for the *Scenedesmus obliquus.* The growth rate constant and maximum growth rate constant can be calculated as:

Growth constant (μ)= ln $(X_f/X_0)/(t_2-t_1)$ = ln (5.081/0.317)/12=0.23 /day

Maximum growth rate constant (μ_{max}) = ln (4.91/0.77)/7=0.265 /day

Standard growth curve of *Scenedesmus obliquus* is given below:

Table 5.4: standard Growth curve of *Scenedesmus obliquus*

Biomass Conc.(g/L)	Optical Density
0.5	0.089
1	0.169
1.5	0.245
2	0.328
2.5	0.429
3	0.524
3.5	0.635
4	0.724

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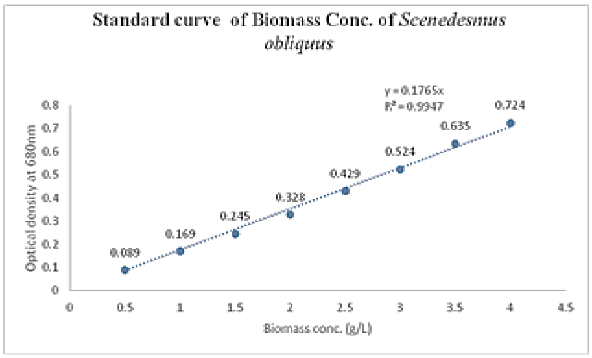

Figure 5.15: standard Growth curve of Scenedesmus obliquus

Characterization of Wastewater

The analysis of pollution parameters including COD, ammonia, colour and phosphorus were accomplished at the commencement as well as at the end of the run with respect to the methodology described in APHA (2000).

Growth optimization of Microalgae

5.2.4.1. Carbon source optimization in *Chlorella Pyrenoidosa*

Different types of carbon source are used for the optimization of growth of the *Chlorella pyrenoidosa* like Sodium Bicarbonate (SBC), Sodium Bicarbonate (SBC) and Potassium Bicarbonate (PBC). The most suitable carbon source is the Sodium Carbonate as from the obtained results.

Carbon source is the Sodium Carbonate as from the obtained results. Fixed concentration of sodium carbonate (5g/L) is used to treat various types of textile wastewater like acid yellow, acid orange and basic pink dye. The Biomass productivity is almost similar in all the three dyes.

5.2.4.2. Carbon source optimization in Scenedesmus obliquus

Different types of carbon source are used for the optimization of growth of the *Scenedesmus obliquus* like Sodium Bicarbonate (SBC), Sodium Bicarbonate (SBC) and Potassium Bicarbonate (PBC). The most suitable carbon source is the Sodium Carbonate as from the obtained results.

5.2.4.3. Nitrogen source optimization

After the characterization it was found that textile wastewater has the low Nitrogen (Ammonia and Nitrate) content and Growth of Microalgae is dependent upon the Nitrogen content. Hence, Different types of Nitrogen source are used for the optimization of growth of the *Chlorella pyrenoidosa* and *Scenedesmus obliquus* like Sodium Nitrate ($NaNO_3$), Ammonium nitrate (NH_4NO_3), Ammonium chloride (NH_4Cl) and Urea (NH_2CONH_2). The most suitable Nitrogen source is the urea as it is cheapest and shows significant biomass productivity.

CONCLUSION

Three types of textile wastewaters (Acid Yellow dye, Acid orange dye and Basic pink dye) has been used for wastewater treatment and microalgal (*Chlorella pyrenoidosa* and *Scenedesmus obliquus*) biofuel production. Nitrogen content in textile wastewaters is very less, hence urea is used as nitrogen source in wastewater. Optimal growth condition (Urea-0.4g/L, wastewater- 40%(v/v)) is developed through Response surface methodology (RSM). The flocculation efficiency is maximum for Alumina but chemical flocculants further causes a problem in purification hence chitosan or starch can be best flocculating agent having the flocculation efficiency 80-90%. Hence, this technology can be used for sustainable and economic wastewater treatment and biofuel production process

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Ms. Shubhangi Mishra obtained her Masters in Bitoechnology from C.C.S. University, Meerut in 2011 and presently is pursuing Ph.D in biosciences and biotechnology from Banasthali Vidyapith, Rajasthan. Her research areas are treating wastewaters, bioremediation and scale up of pilot scale photobioreactors.

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Dr. Monika Sharma has B.Sc. in Biology and M.Sc. in Applied Zoology then M. Tech. and Ph.D. in Biotechnology, she is recipient of gold medal for securing the first position in M.Sc. she secured second position in M.Tech.

Biotechnology, she is having more than 12 years of teaching and research experience, she is the recipient of young scientist award, she is the member of B. Tech. and M. Tech. Biotechnology program committee, presently she is working in Deptt. of Biosc. and Biotechnology, Banasthali Vidyapith, Rajasthan, India. She is the member of Board of Studies, she worked as an external examiner for various examinations. She received fellowship from CCRUM, New Delhi. She has visited abroad, she has joined some programs of IIT Kanpur and NIT Nagpur. She has published more than 35 papers in the various journals of national and international repute. She has published 2 books. She has delivered the invited lectures in different events. She has guided and guiding the students for research in the fields of advanced sciences like as Nanobiotechnology, Molecular Biology, Toxicology, Wastewater treatment and Bioremediation.

Prof. (Dr.) Chandra Kant Sharma has done M. Tech. and Ph.D. in Biotechnology, he is having more than 13 years of teaching and research experience, he was the founder member for starting the courses B. Tech. and M. Tech. Biotechnology, and he has coordinated the B. Tech. and M. Tech. Biotechnology for almost 10 years, presently he is working as Professor and Head of the Institute (HoI) in Institute of Agriculture Sciences, SAGE University, Indore. He is the recipient of best faculty award. He has been the Convener of International Education Opportunity committee. He is the member of Board of Studies and Academic Council, he worked as an external examiner for various examinations. He has completed the research project funded from the UGC, New Delhi. He has visited abroad as young scientist from DST, Ministry of Science and Technology, New Delhi. He has joined some programs of CCMB Hyderabad, IIT Kanpur and NIT Nagpur. He has published more than 50 papers in the various journals of national and international repute. He has published 3 books. He has chaired the sessions, delivered the keynote addresses and invited lectures in almost 35 events. He has guided the students for research in the fields of advanced sciences like as Bioprocess Engineering, Nanotechnology, Molecular Biology, Toxicology and Horticulture etc.

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