Biodegradation of phenolic effluent of producer gas plant using *Scenedesmus* sp.

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Need for the work

- Acute exposure of phenol can result in myocardial depression, muscle weakness gastrointestinal disturbance, tremors, skin whitening, corneal whitening and finally blindness and even damage central nervous system.(Public Health Statement)

- Phycoremediation can potentially achieve nutrient removal in a less expensive and ecologically safer way with the added benefits of resource recovery and recycling.

- It would be useful to the industries viz. coal chemical plants, refineries, petrochemical industries, fibre glass units, explosive manufacture, polymerization process, pharmaceuticals, plastic, paints, textile units making use of organic dyes, biocides, photographic chemicals etc.

Outline

- Introduction
- Available methods of treatment from literature
- Background of study
- Process flow chart
- Characterization of raw effluent
- Selection and cultivation of targeted algal species
- Experimentation
- Analysis of Phenol
- Result and Discussion
- Conclusion
- Acknowledgements
- References

Introduction

- Producer gas is a gaseous fuel made by the destructive distillation of coal.
- It contains a variety of combustible gases including H_2, CO, CH_4 and volatile hydrocarbons together with small quantities of non-calorific gases such as CO_2 and N_2.
- Byproduct from the producer gas plant includes coal tar and ammonia.

In producer gas plant,

- $200 m^3$/Day of water is used for coal gasification and gas cleaning system.
- $150 m^3$ /Day of water returns as phenolic effluent.
- This waste water contains phenolic compounds, tar and oil. Around $0.05 m^3$ of tar is collected per day using tar oil separator.

Introduction- contd….

Area of Research :

Phycoremediation of Phenolic Effluent of Producer Gas Plant .

Source of sample:

Producer Gas Plant,

Bharath Heavy Electrical (BHEL),Trichy, Tamilnadu, India.

Available methods of treatment from literature

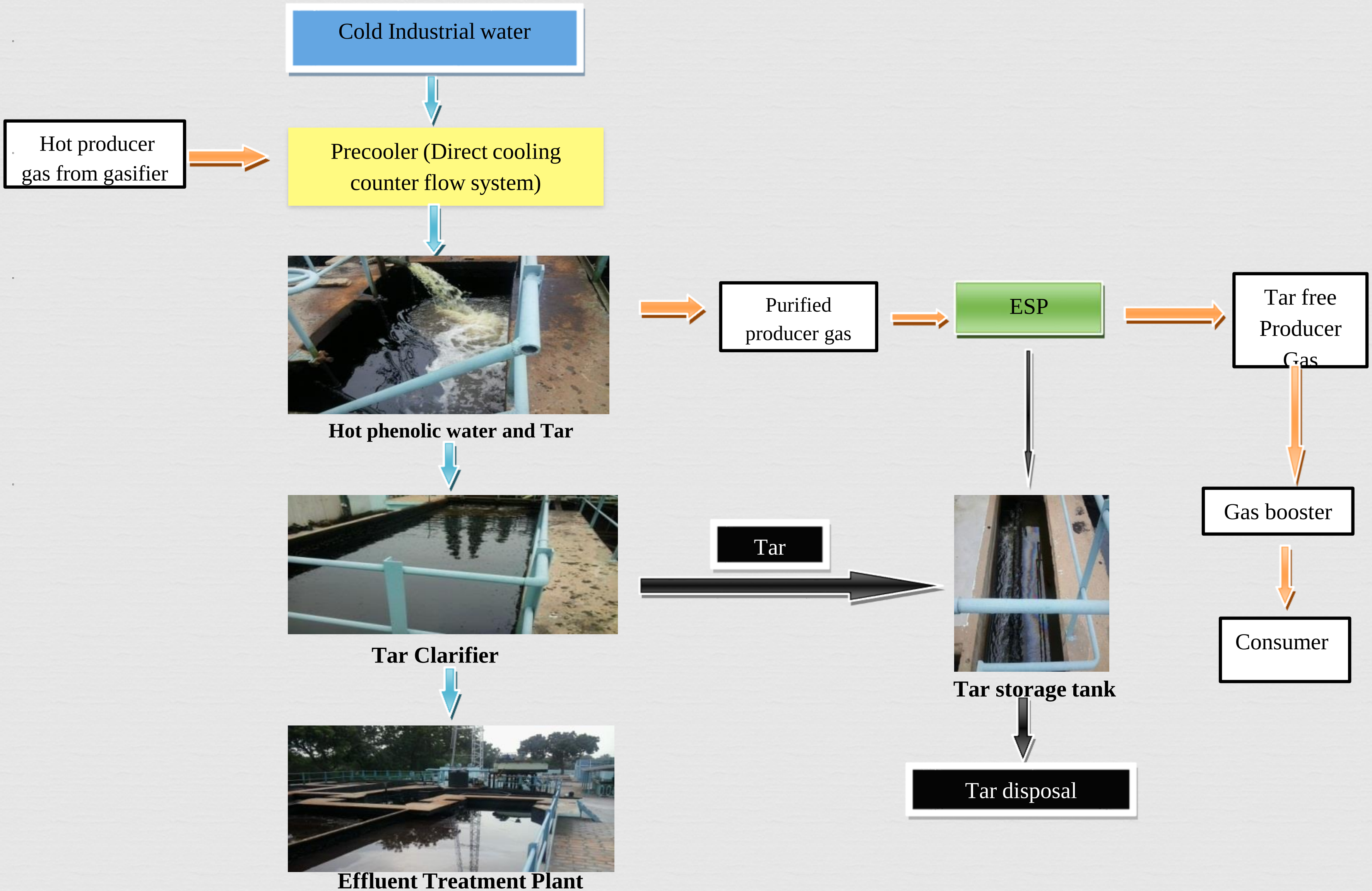
Identified methods of treatment from literature:

- Chemical Degradation
- Biodegradation
- Degradation using UV
- Enzymatic Degradation
- Physical techniques

Algae used for the treatment of phenol and its types

Types of phenol	Name of microlagae	Reference
Nonylphenol	*C. caspia, Chlorella vulgaris, Selenastrum capricornutum, Chlorella* sp.	Yu, Liu1, Dai, Xiaokang., Wei, Jie., 2013. Toxicity of the xenoestrogen nonylphenol and its biodegradation by the alga *Cyclotella caspia.* Journal of Environmental Sciences, 25(8) 1662–1671. Gao, Q.T., Wong, Y.S., Tam, N.F.Y., 2011, Removal and biodegradation of nonylphenol by immobilized *Chlorella vulgaris*, Bioresource Technology 102:10230–10238. Gao, Q.T., Tam, N.F.Y., 2011, Growth, photosynthesis and antioxidant responses of two microalgal species, *Chlorella vulgaris* and *Selenastrum capricornutum*, to nonylphenol stress, Chemosphere 82:346–354. Gao,Q.T., Wong, Y.S., Tam, N.F.Y., 2011. Removal and biodegradation of nonylphenol by different *Chlorella* species; Marine Pollution Bulletin. 63 :445–451.
Nonylphenol, Octylphenol	*Scenedesmus obliqus*	Zhou,G.J., Peng, Fu-Qiang., Yang, Bin., Ying, Guang-Guo., 2013. Cellular responses and bioremoval of nonylphenol and octylphenol in the freshwater green microalga *Scenedesmus obliquus*, Ecotoxicology and Environmental Safety 87:10–16
Chlorophenol	*Chlorella* VT-1	Olivier, S., Scragg, A.H.., Morrison, J., 2003. The effect of chlorophenols on the growth of *Chlorella* VT-1, Enzyme and Microbial Technology 32 :837–842.
Phenol	*Phormidium valderianum, Ochromonas danica, Chlorella* VT-1	Shashirekha, S., Uma,L., Subramanian, G., 1997. Phenol degradation by the marine cyanobacterium *Phormidium valderianum* BDU 30501, J. Indust. Microbiol. and Biotech. 19(2): 130-133. Scragg, A.H., 2006. The effect of phenol on the growth of *Chlorella vulgaris* and *Chlorella* VT-1 , Enzyme and Microbial Technology 39, 796–799.

Process flow chart of gas cooling system of producer gas plant



Characterization of raw effluent

Parameters and the standard testing procedures

Parameter	Test procedure	Range limit
Colour	IS: 3025 (Part-4) :1983/ APHA 22nd -2120B-2012	1 to 50 Hazen
Oil & Grease	IS: 3025 (Part-39) : 1991/ APHA 22nd ed. -5520-2012	5 to 1000 mg/l
pH	IS: 3025 (Part-11) :1983/ APHA 22nd ed. -2500-2012	1 to 14
TDS	IS: 3025 (Part-16) :1984/APHA 22nd ed. -2541-2012	1 to 20000 mg/l
TSS	IS: 3025 (Part-17) :1984/ APHA 22nd ed.-2540-2012	1 to 1000 mg/l
Phenolic Compounds (as C_6H_5OH)	IS: 3025 (Part-43) : 1992/RA2003	0.02 to 150 mg/l
Biochemical Oxygen Demand (BOD)	IS: 3025 (Part-44) : 1993/ APHA 22nd ed.-5210B-2012	1 to 10000 mg/l
Chemical Oxygen Demand (COD)	IS: 3025 (Part-58) : 2006/ APHA 22nd ed.-5220-2012	1 to 20000 mg/l

Initial concentration of conventional parameters and Total phenol concentration of raw effluent

(Total Phenol concentration was determined by **IS 3025 part no 43**)

Parameter	Units	Mean ± SD
Total suspended solids	mg/l	244.75 ±48.7
Total dissolved solids	mg/l	827.4 ±92.1
Biological oxygen demand	mg/l	62.5 ±12.3
Chemical oxygen demand	mg/l	2116 ±119.9
Oil & grease	mg/l	97.25 ±13.5
Phenolic concentration	mg/l	1024±21.8
pH		8-9.2
Color		Dark Brown

Analysis of types of phenolic compounds

- The Phenolic compounds present in effluent was characterized by using Gas Chromatographic method.

Method:

- The phenolic compounds was extracted from the effluent using Ethyl acetate as a solvent.
- Extracted samples were analyzed in GC using the following operating conditions.

Standards selected based on EPA:

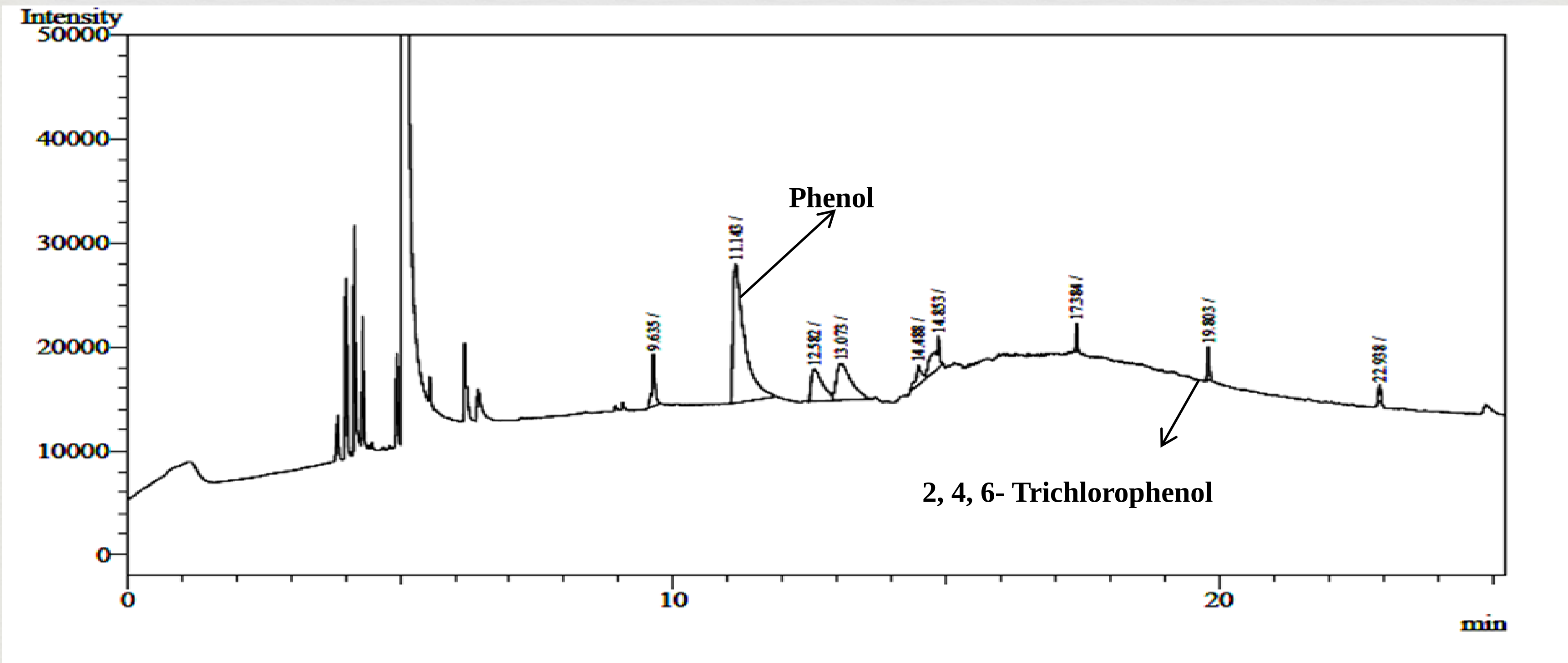
1. Phenol
2. 2-Chlorophenol
3. 2-Methylphenol
4. 2-Nitrophenol
5. 2,4-Dimethylphenol
6. 2,4-Dichlorophenol
7. 4-Chloro-3-methylphenol
8. 2,4,6-Trichlorophenol
9. 2,4-Dinitrophenol
10. 4-Nitrophenol
11. Pentachlorophenol

Reference:

Handbook of Water Analysis, Second Edition, edited by Leo M.L. Nollet, Leen S. P. De Gelder.

Analysis of types of phenol present in the raw effluent

(using Gas Chromatography)



Selection and cultivation of targeted algal species

Source of sample:

Procured from the Bioenergy lab, Department of Energy and environment, National Institute of Technology, Trichy, India.

Cultivation of *Scenedesmus* sp. :

The *Scenedesmus* sp. was cultivated in optimized culture medium comprising potassium bicarbonate and urea in the ratio of 2:1.

Culture condition- Atmospheric

Temperature range - 30 -35° C.

pH- 7-8.

The growth of microalgae was monitored by observing optical density at 600 nm and for the identification of contamination, the algae was monitored daily in fluorescent inverted microscope (Nikon DS-Fi2).

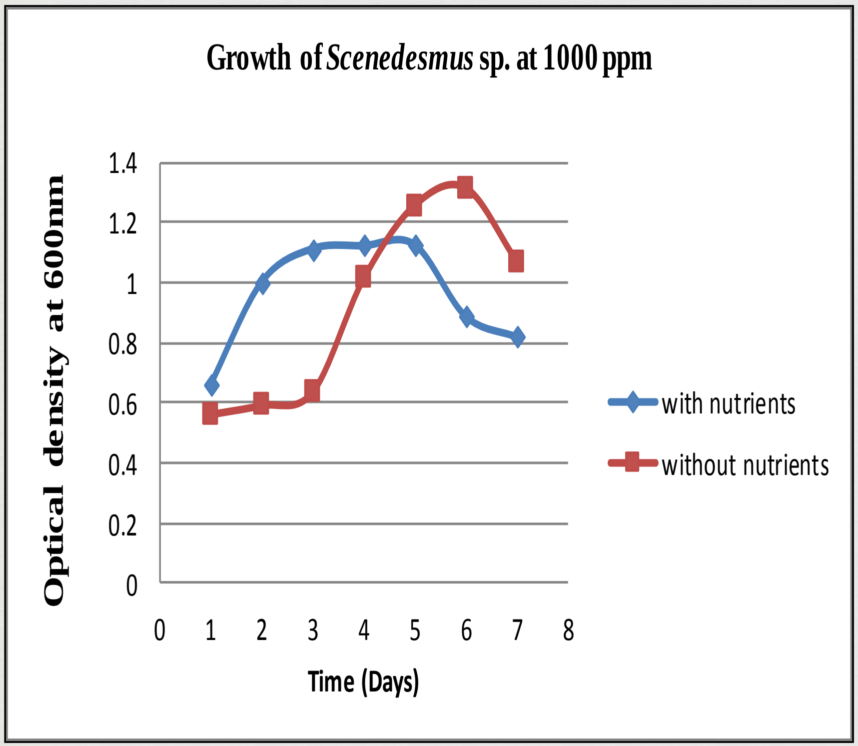
Experimentation

- The 15 day old culture was centrifuged and four different concentrations (1g, 2g, 3g and 4g per liter of raw effluent) of wet biomass with nutrients (Potassium bicarbonate: Urea in the ratio of 2:1) (Batch I) and without nutrients (Batch II) was inoculated into raw effluent
- Samples and controls were monitored for 7 days at ambient temperature and environmental conditions.
- The algal growth was monitored by analyzing optical density at 600 nm using UV-VIS spectrophotometer. Fluorescent Inverted Microscope was used to monitor physical changes in the algae.
- The phenolic concentration was analyzed using IS 3025 - Part no: 43 methods.

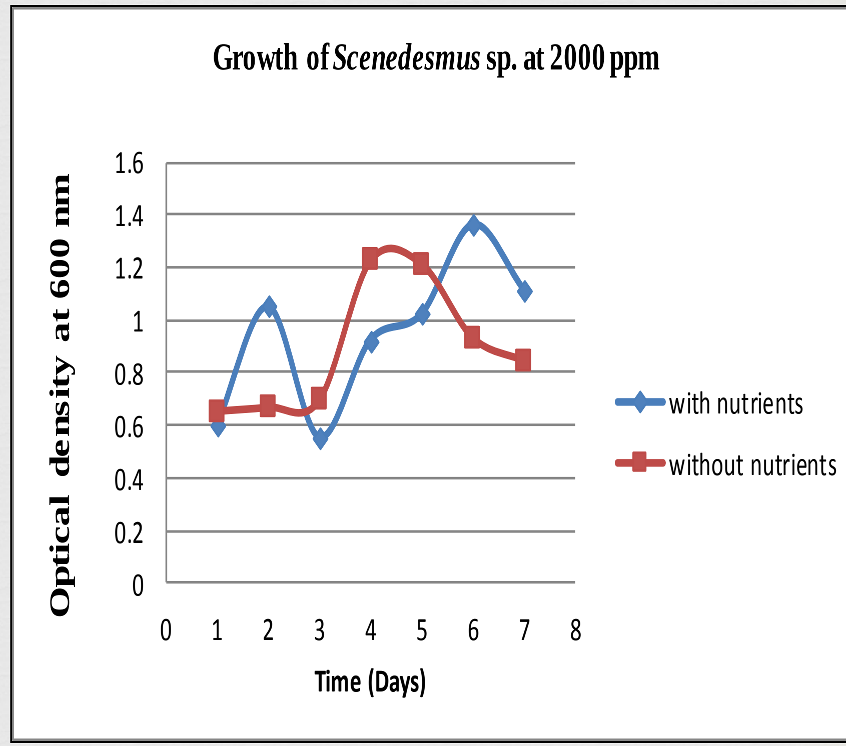
Result and Discussion

Effect of phenol on the growth of *Scenedesmus* sp.

1000 ppm

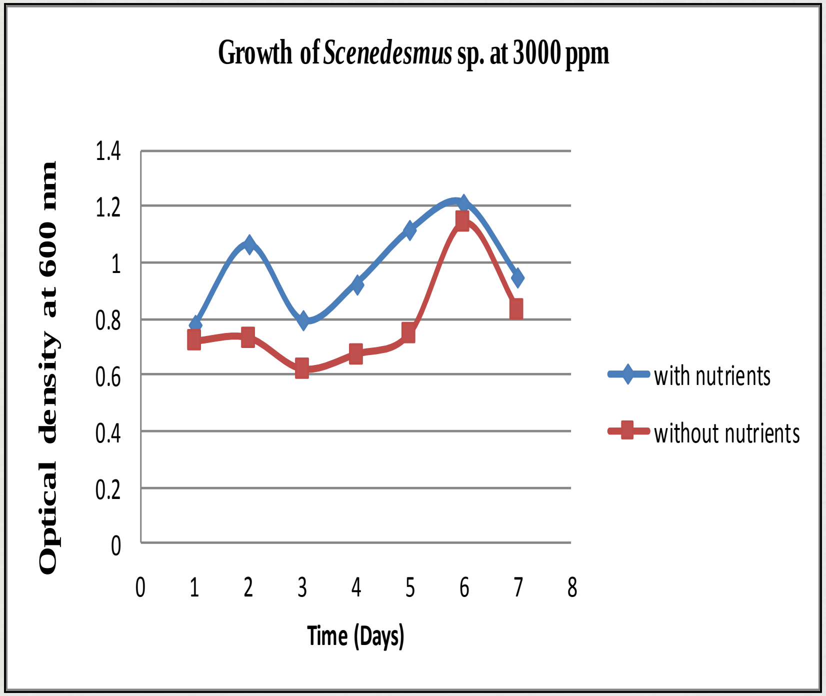


2000 ppm

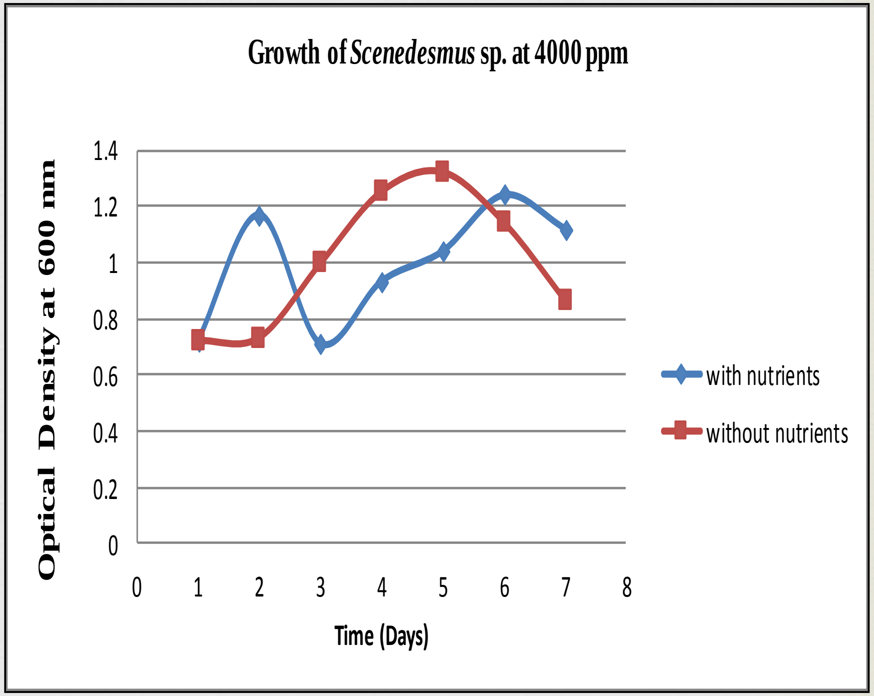


Effect of phenol on the growth of *Scenedesmus* sp.

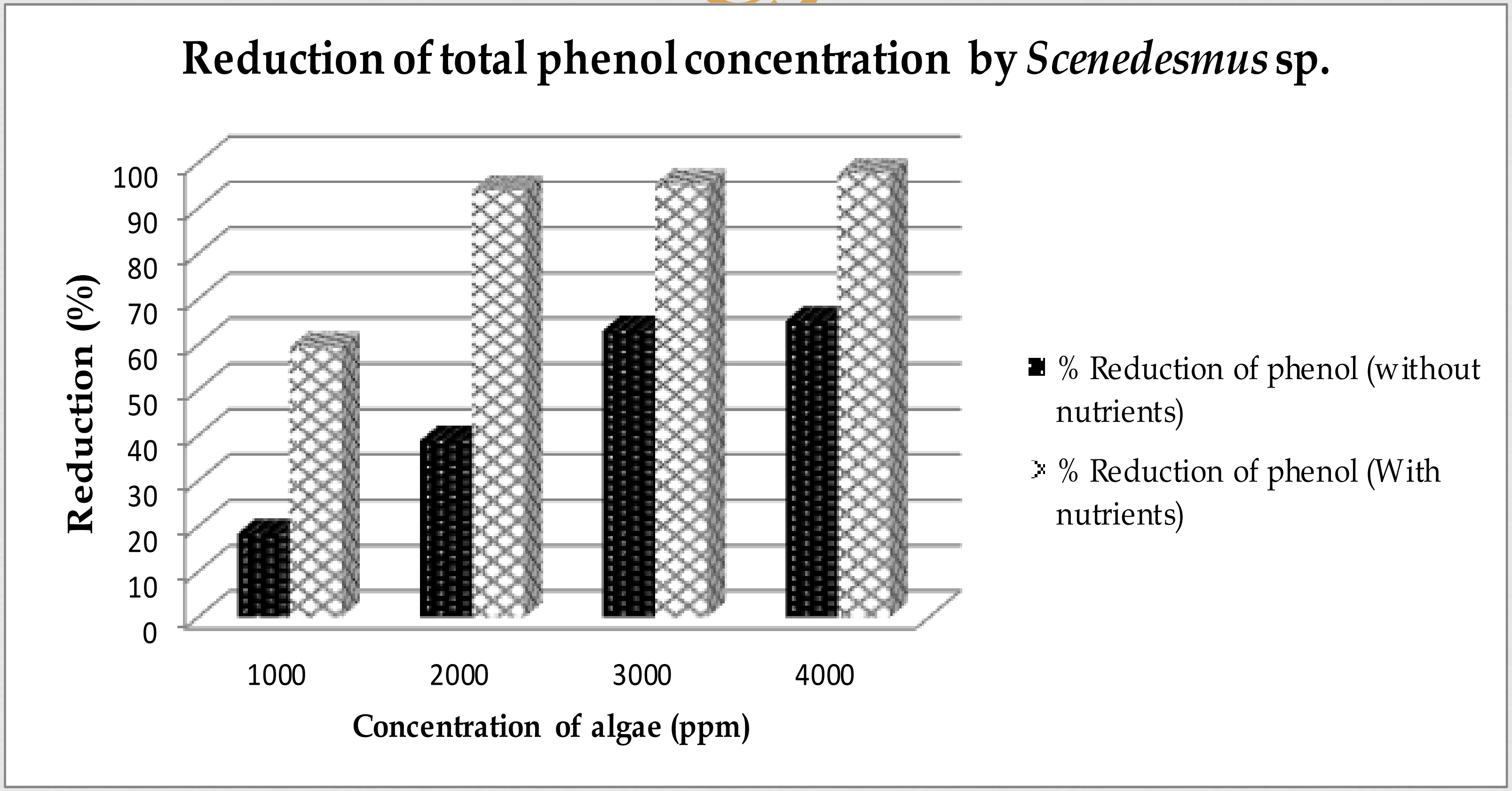
3000 ppm



4000 ppm

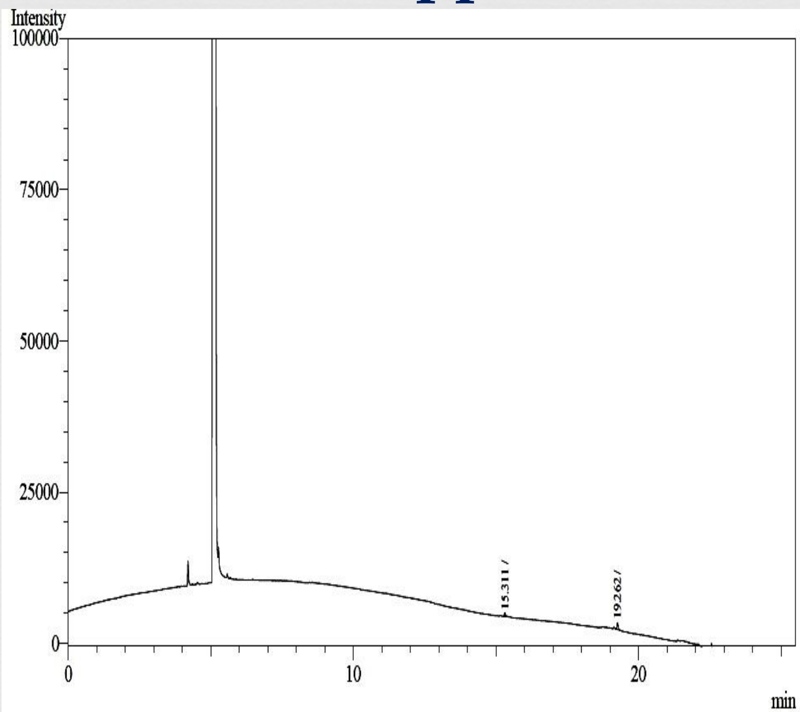


Reduction of Total phenol

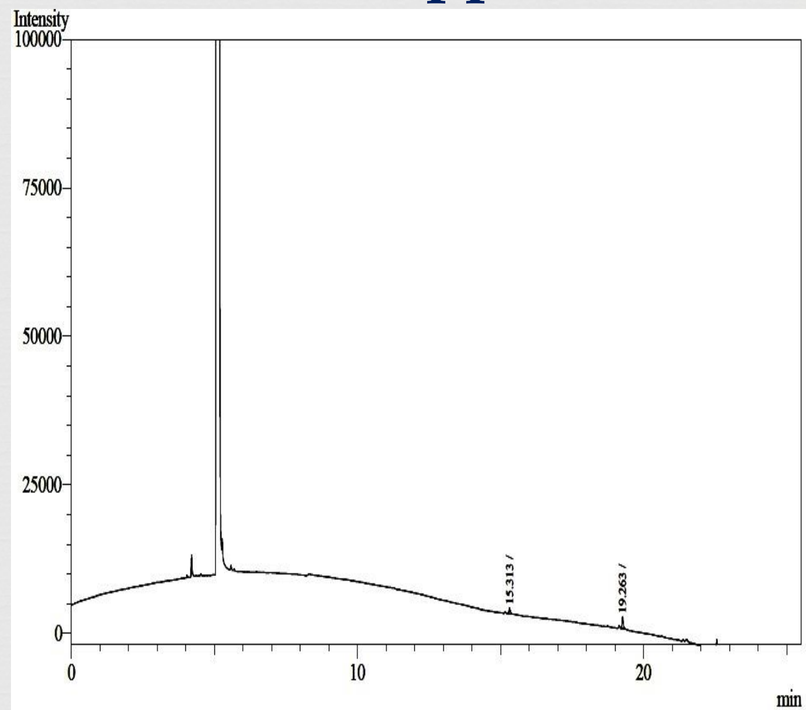


Degradation of Phenol(with nutrients)

1000 ppm



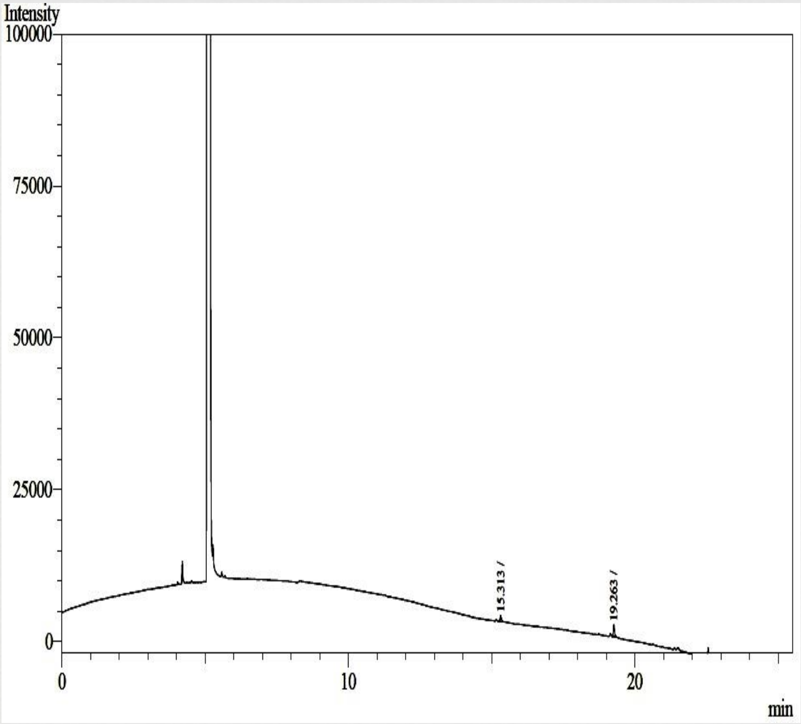
2000 ppm



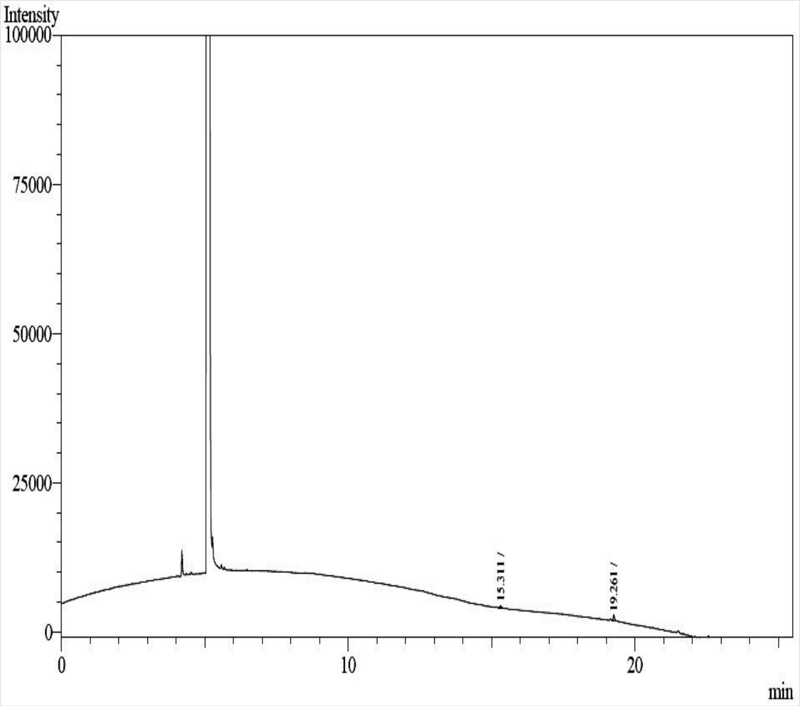
ppm- mg of algal wet biomass / liter of effluent

Degradation of Phenol (with nutrients)

3000 ppm



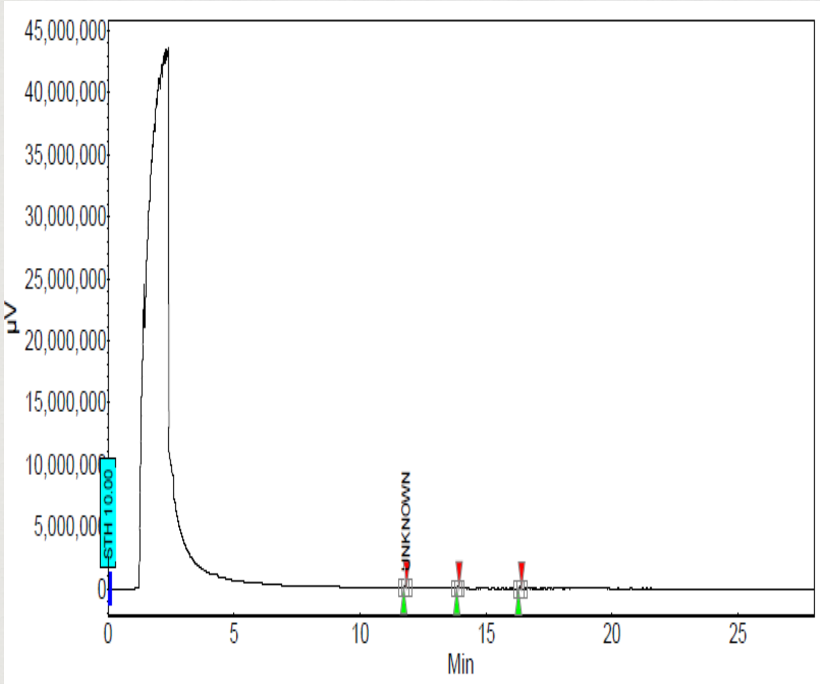
4000 ppm



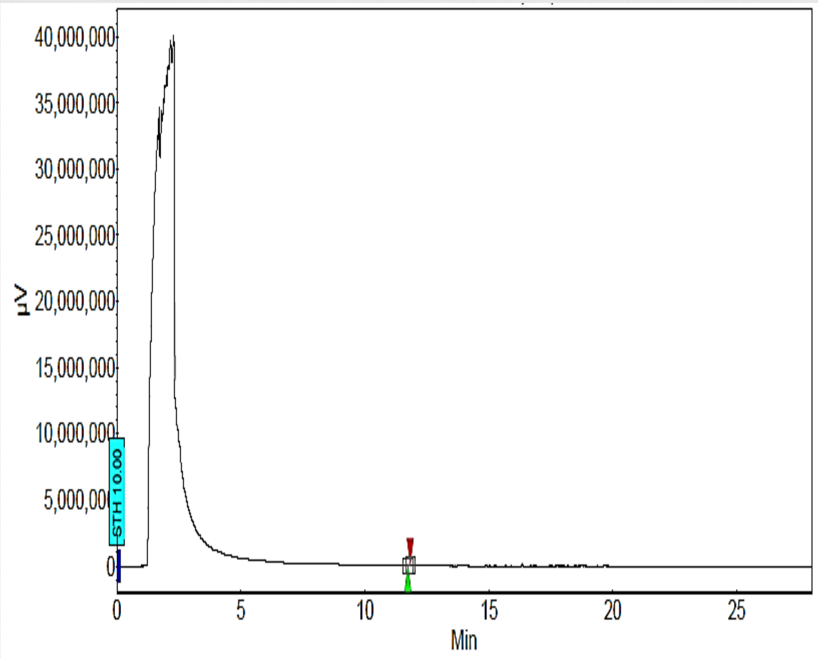
ppm- mg of algal wet biomass / liter of effluent

Degradation of Phenol (without nutrients)

1000 ppm



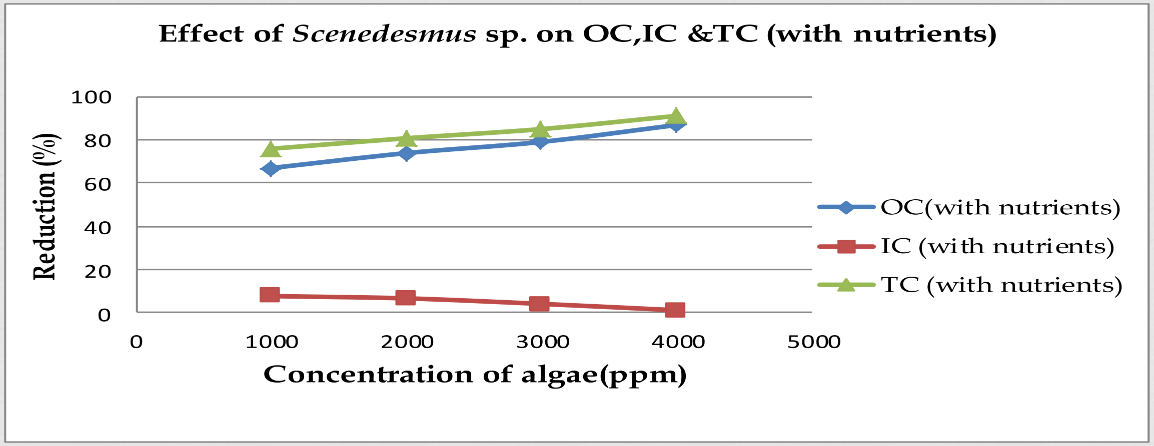
4000 ppm



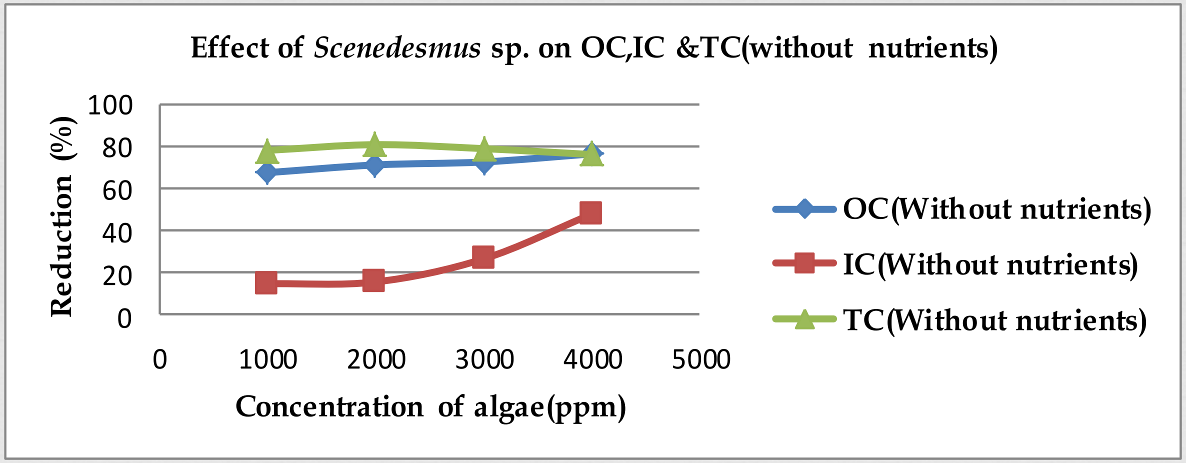
ppm- mg of algal wet biomass / liter of effluent

Reduction of carbon content

Effect of *Scenedesmus* sp. on the carbon content (Organic Carbon (OC), Inorganic Carbon (IC), Total Carbon (TC)) of batch-I



Effect of *Scenedesmus* sp. on the carbon content (Organic Carbon (TOC), Inorganic Carbon (IC), Total Carbon (TC)) of batch-II



Conclusion

- Phycoremediation of waste water treatment integrated with conventional methods present great opportunities to the water and wastewater treatment technologies.
- *Scenedesmus* sp. degrades more than 90 % of total phenol in the effluent.
- Degradation study was performed in the ambient conditions.
- Removal of contaminants present in the effluent other than phenol could also be noticed when the *Scenedesmus* sp. was externally supplied with nutrients.

Acknowledgements

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Thank you