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

IWWATV-2015

Dr. A.K. Bakthavatsalam,  
Professor of Energy & Head of T&P,  
NIT-Tiruchirappalli,  
Tamilnadu,  
India.
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 H₂, CO, CH₄ and volatile hydrocarbons together with small quantities of non-calorific gases such as CO₂ and N₂.

- Byproduct from the producer gas plant includes coal tar and ammonia.

In producer gas plant,

- 200m³/Day of water is used for coal gasification and gas cleaning system.
- 150m³/Day of water returns as phenolic effluent.
- This waste water contains phenolic compounds, tar and oil. Around 0.05m³ of tar is collected per day using tar oil separator.
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

<table>
<thead>
<tr>
<th>Types of phenol</th>
<th>Name of microalgae</th>
<th>Reference</th>
</tr>
</thead>
</table>
Process flow chart of gas cooling system of producer gas plant

Cold Industrial water

Precooler (Direct cooling counter flow system)

Hot producer gas from gasifier

Purified producer gas

ESP

Tar free Producer Gas

Tar storage tank

Gas booster

Consumer

Tar disposal

Hot phenolic water and Tar

Tar Clarifier

Effluent Treatment Plant

Dr. AKB / NITT / India
Characterization of raw effluent

Parameters and the standard testing procedures

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test procedure</th>
<th>Range limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>IS: 3025 (Part-4):1983/ APHA 22nd ed. -2120B-2012</td>
<td>1 to 50 Hazen</td>
</tr>
<tr>
<td>Oil &amp; Grease</td>
<td>IS: 3025 (Part-39): 1991/ APHA 22nd ed. -5520-2012</td>
<td>5 to 1000 mg/l</td>
</tr>
<tr>
<td>TDS</td>
<td>IS: 3025 (Part-16):1984/ APHA 22nd ed. -2541-2012</td>
<td>1 to 20000 mg/l</td>
</tr>
<tr>
<td>TSS</td>
<td>IS: 3025 (Part-17):1984/ APHA 22nd ed. -2540-2012</td>
<td>1 to 1000 mg/l</td>
</tr>
<tr>
<td>Phenolic Compounds (as C₆H₅OH)</td>
<td>IS: 3025 (Part-43): 1992/RA2003</td>
<td>0.02 to 150 mg/l</td>
</tr>
<tr>
<td>Biochemical Oxygen Demand (BOD)</td>
<td>IS: 3025 (Part-44): 1993/ APHA 22nd ed. -5210B-2012</td>
<td>1 to 10000 mg/l</td>
</tr>
<tr>
<td>Chemical Oxygen Demand (COD)</td>
<td>IS: 3025 (Part-58): 2006/ APHA 22nd ed. -5220-2012</td>
<td>1 to 20000 mg/l</td>
</tr>
</tbody>
</table>
Initial concentration of conventional parameters and Total phenol concentration of raw effluent
(Total Phenol concentration was determined by IS 3025 part no 43)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total suspended solids</td>
<td>mg/l</td>
<td>244.75 ± 48.7</td>
</tr>
<tr>
<td>Total dissolved solids</td>
<td>mg/l</td>
<td>827.4 ± 92.1</td>
</tr>
<tr>
<td>Biological oxygen demand</td>
<td>mg/l</td>
<td>62.5 ± 12.3</td>
</tr>
<tr>
<td>Chemical oxygen demand</td>
<td>mg/l</td>
<td>2116 ± 119.9</td>
</tr>
<tr>
<td>Oil &amp; grease</td>
<td>mg/l</td>
<td>97.25 ± 13.5</td>
</tr>
<tr>
<td>Phenolic concentration</td>
<td>mg/l</td>
<td>1024 ± 21.8</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>8-9.2</td>
</tr>
<tr>
<td>Color</td>
<td></td>
<td>Dark Brown</td>
</tr>
</tbody>
</table>
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:
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**

Growth of *Scenedesmus* sp. at 1000 ppm

Growth of *Scenedesmus* sp. at 2000 ppm

Optical density at 600 nm

Time (Days)
Effect of phenol on the growth of *Scenedesmus* sp.

**3000 ppm**

**4000 ppm**

![Growth of Scenedesmus sp. at 3000 ppm](image1)

![Growth of Scenedesmus sp. at 4000 ppm](image2)
Reduction of Total phenol

Reduction of total phenol concentration by *Scenedesmus* sp.

- % Reduction of phenol (without nutrients)
- % Reduction of phenol (With nutrients)
Degradation of Phenol (with nutrients)

1000 ppm

2000 ppm

ppm - mg of algal wet biomass / liter of effluent

5/29/2015

Dr. AKB / NITT / India
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

![Graph showing the effect of Scenedesmus sp. on OC, IC & TC (with nutrients)]

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

![Graph showing the effect of Scenedesmus sp. on OC, IC & TC (without nutrients)]
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.
Authors would like to thank the National Institute of Technology, Trichy and the World Bank funded Technical Education Quality Improvement Program (TEQIP).
References


References-contd…..


Thank you