BIODEGRADATION OF OILY SLUDGE VIA THE USE OF IMPELLERS AND A CHEMICAL DISPERSANT

Christina Lopez and Matthew Alexander, Ph.D.

Wayne H. King Department of Chemical & Natural Gas Engineering

Texas A&M University Kingsville — McNair Scholars Program

Texas A&M University Kingsville — Frank H. Dotterweich College of Engineering

ABSTRACT

The presence of oily sludge from factories and wastewater treatment are a detriment to the state of the environment, as it contains many harmful and toxic substances, including polycyclic aromatic hydrocarbons (PAH), cycloalkanes, benzene, and similar compounds [6]; benzene alone is a group 1A carcinogen, putting those in contact with it at risk for developing cancer [11]. Though this is not a new issue, there has been an increased need for the treatment of oily sludge as its production only increases as time goes on [10]. Numerous methods are used for the treatment of oily sludge and are continuously being modified and improving. The use of two-phase composting and the use of chemical hydrocarbon dispersants have both been proven effective in achieving significant removal of total petroleum hydrocarbons (TPH) present in sludge samples. Another method that this research in particular focuses on is the method of chemical dispersants and extended periods of agitation to achieve TPH removal. This research was an attempt to analyze the effectiveness of oily sludge dispersion and biodegradation in a controlled setting. A dispersant effectiveness test (DE) and biodegradation test were done using paddle and helical impellers, samples of West Texas Crude Oil (WTCO), Petroclean, and bacteria that was cultured in a bioreactor. The DE lasted 4 hours and the biodegradation took place over the course of 28 days. The results show the overall DE of each impeller, as well as the data results of the biodegradation-- which had the most consistent success with the helical samples, particularly the sample inoculated with bacteria.

INTRODUCTION

The presence of oily sludge in the environment has been a point of concern for years due to its adverse effects [6]. Extensive research has been done in order to determine the most effective ways in which the sludge can be safely and effectively biodegraded. This study focuses on comparing the results of biodegradation from bacterial inoculation by using oil samples that were dispersed at different speeds and with different styles of impellers, to see if it has any significant impact on the TPH removal in the samples. Prior literature [1][12] has shown a noticeable difference when using varying rotational speeds and some impeller variations. Further research regarding these methods is necessary in order to enhance the techniques currently in use in industry.

Fig. 1: above: image of 2.5-in. slanted turbine paddle impeller

Fig. 2: above: image of 3.0-in. helical impeller

METHODS

DISPERSION EFFECTIVENESS TEST

- Small amounts of an oil-dispersant solution (10:1:1 oil: dichloromethane: dispersant) were added to 1500 mL of ultra-pure water
- The solution was mixed for 4-hour long periods
- Every 0.5 hour a sample was taken and extracted using dichloromethane (DCM)
- The absorbance values were taken at 340, 370, and 400nm using a UV-spectrophotometer
- 2 different speeds and 2 different impeller types were used to determine which had better efficiency in dispersing the oil into the water

BIODEGRADATION

- 700mL sample of a nutrient-rich medium had a small amount of oil-dispersant solution dispersed into it for 2 hours using a helical impeller at 400rpm
- Sample was split into two 500mL Erlenmeyer flasks, where one was inoculated with bacteria from the Oppenheimer formula
- The same process was repeated using a paddle impeller at 150rpm
- The 4 flasks were left in a shaker bath at 100 rpm for 28 days with constant aeration
- Samples were taken for absorbance values 3 times a week
- 3 sets of 4 Petri dishes were used to check on the bacterial growth

RESULTS

DISPERSION EFFECTIVENESS

PADDLE @ 150 RPM

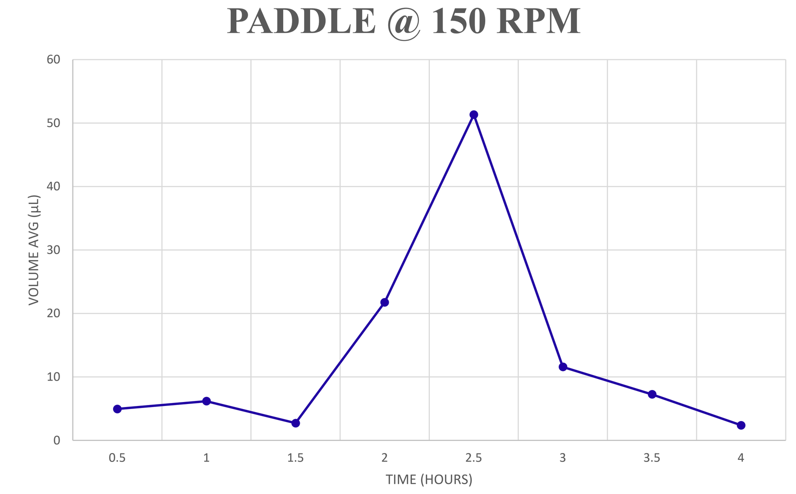

Fig. 3: graphical data of average volumes from absorbance values taken for DE with paddle impeller at 150 rpm

PADDLE @400 RPM

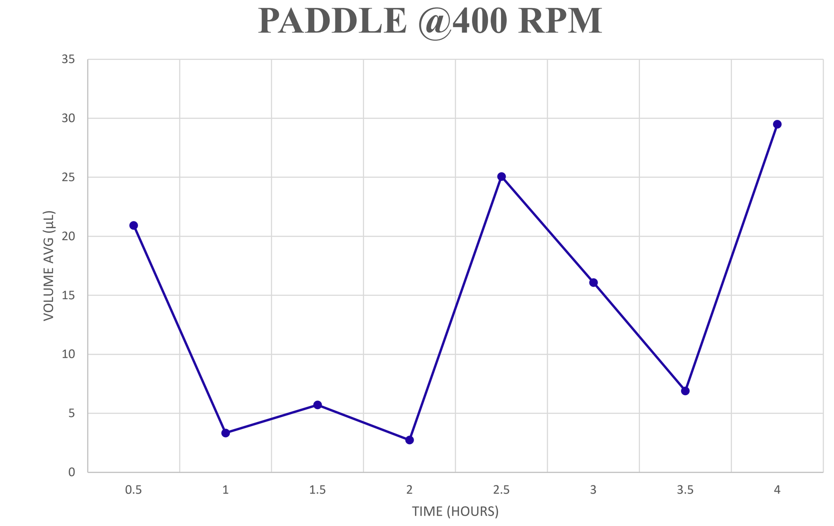

Fig. 4: graphical data of average volumes from absorbance values taken for DE with paddle impeller at 400 rpm

HELICAL @ 150RPM

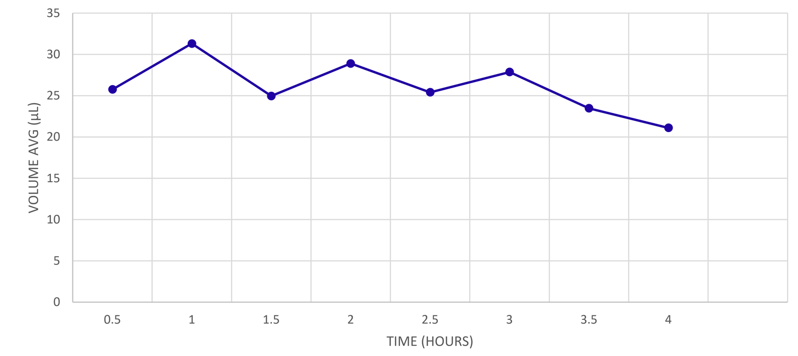

Fig. 5: graphical data of average volumes from absorbance values taken for DE with helical impeller at 150 rpm

HELICAL @ 400 RPM

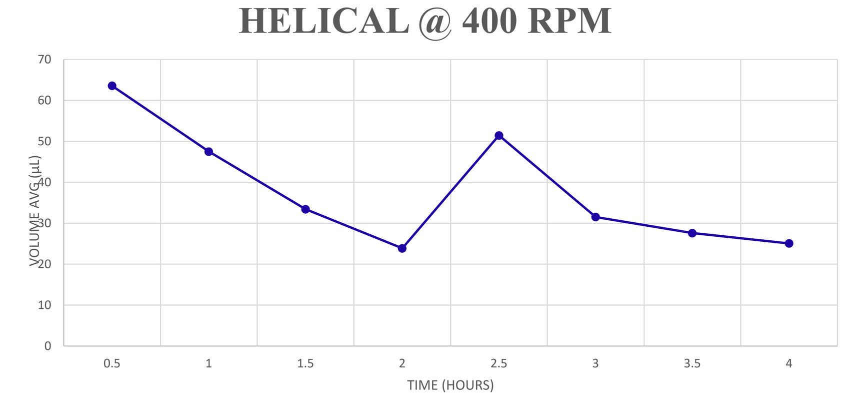

Fig. 6: graphical data of average volumes from absorbance values taken for DE with helical impeller at 400 rpm

Fig. 7: left, DE test in which large amounts of the oil-dispersant solution are clinging onto the flask

Fig. 8: right, DE test where flask was treated with an oleophobic coating prior; small amounts of oil-dispersant solution still clinging to flask

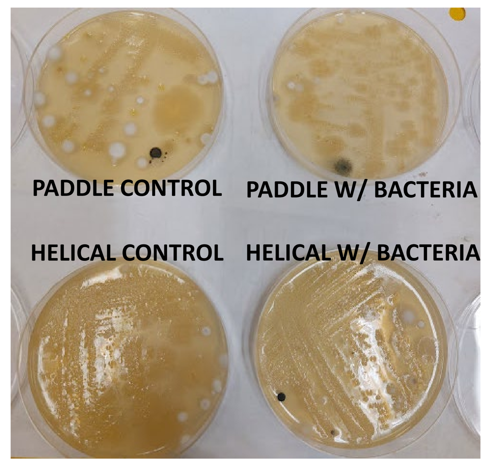

Fig. 9: one of the sets of petri dishes two weeks after initial inoculation

BIODEGRADATION

PADDLE CONTROL

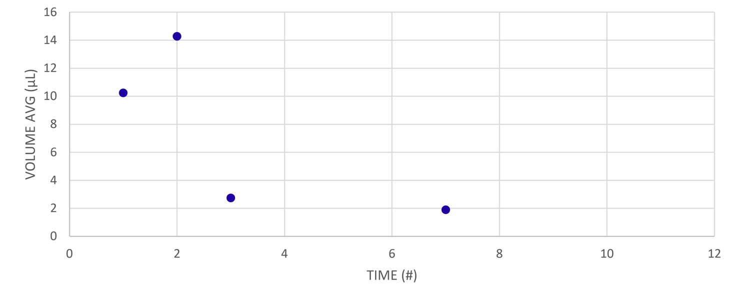

Fig. 10: graphical data of average volumes from absorbance values taken from paddle control sample; measurements were taken 3x a week for 2 weeks

PADDLE BACTERIA

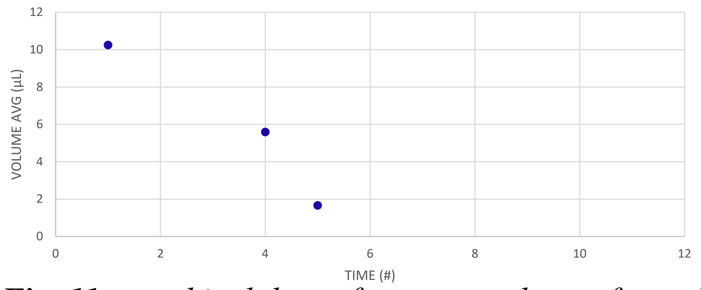

Fig. 11: graphical data of average volumes from absorbance values taken from paddle sample inoculated with bacteria; measurements were taken 3x a week for 2 weeks

HELICAL CONTROL

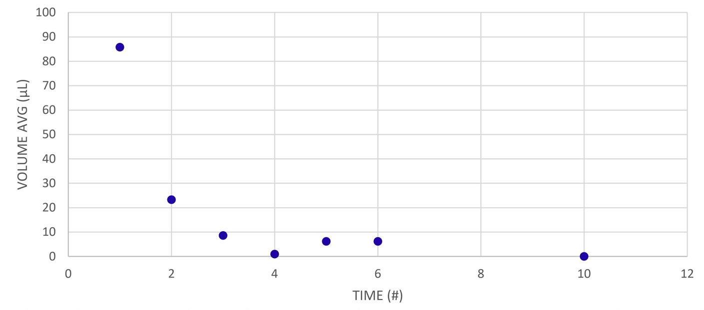

Fig. 12: graphical data of average volumes from absorbance values taken from helical control sample; measurements were taken 3x a week for 2 weeks

HELICAL BACTERIA

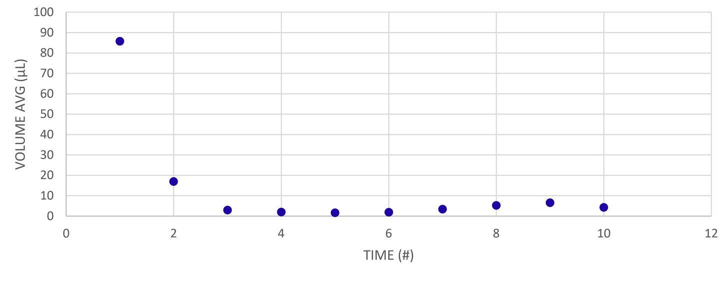

Fig. 13: graphical data of average volumes from absorbance values taken from helical sample inoculated with bacteria; measurements were taken 3x a week for 2 weeks

DISCUSSION

LIMITATIONS

- Time constraint: 10-week research periods
- Trial and error: numerous methods were used for DE tests in an attempt to obtain the most accurate data
  - Oil sticking to container during mixing
  - Oleophobic coating used
- Unusable data presented in the form of negative absorbance values
- Possible cross-contamination in biodegradation bioreactors
  - Example: petri dishes, see ***Fig. 9***

CONCLUSIONS

DISPERSION EFFECTIVENESS

- Correlation between rotational speed and impeller type
  - ***Fig. 6:*** highest speed with helical impeller had the most consistent rate of absorbance value changes as time went on
- ***Fig. 3*** and ***Fig. 6*** both see a spike in absorbance values at the 2.5-hour mark before dropping for the last 1.5 hours

BIODEGRADATION

- Correlation between helical impeller and dispersion power displayed
- ***Fig. 10- Fig.13:*** data follows a more consistent downward slope for the helical impellers; paddle data goes awry and is missing points due to having negative absorbance readings
- No major differences between helical control and helical inoculated with the bacteria

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