PRINT ISSN 1119-8362
Electronic ISSN 2659-1499

Full-text Available Online at
https://www.ajol.info/index.php/jasem
https://www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 28 (11) 3547-3550 November, 2024

Evaluation of the Effectiveness of Various Chemical and Microbial Consortia Treatments for Biodegradation of Oily Effluents

***[1]EZEMA-KALU, NS; [2]OGBONNA, BO**

**[1]Rockbase Int'l School East/West Rd Choba. River State, Nigeria*
[2]Department of Electrical/Electronic Engineering, Faculty of Engineering, University of Port Harcourt, Choba, Rivers State, Nigeria

**Corresponding Author Email: nnadoziekalu@gmail.com*
**ORCID: https://orcid.org/0009-0005-4029-5311*
**Tel: +2348121642087*

Co-Author Email: bartholomew.ogbonna@uniport.edu.ng

ABSTRACT: Treatment of oily effluents poses significant challenges due to the complex nature of pollutants and the need for effective remediation technologies. MATLAB simulations to optimize operational parameters such as reagent concentrations, pH, and temperature. The optimal parameters found for the simulation of the combined fenton's reagent and pseudomonas treatment system were as follows; pH (6.5- 7.5), temperature (30˚C-35˚C), nutrient concentration (100-150mg/l), chemical concentration (0.5-1+-.5%(v/v)), reaction time (120 minutes), mixing speed (120 rpm) and flowrate (2L/min) compared to fenton's reagent standard by green 2018; pH (2.5-4.5), temperature (20˚C-40˚C), nutrient concentration (50-200mg/l), chemical concentration (0.1+-.5%(v/v)), reaction time (120 minutes), mixing speed (100-300 rpm) and flowrate (2L/min) and for pseudomonas treatment standard by Hamme 2017; pH (6-8), temperature (25˚C-37˚C), nutrient concentration (100-150mg/l), chemical concentration (0.5-1+-.5%(v/v)), reaction time (120 minutes), mixing speed (100-150 rpm) and flowrate (2L/min). The integrated approach demonstrated improved pollutant removal efficiency compared to standalone methods, achieving a substantial reduction in contaminant levels. However, economic feasibility analyses indicated higher operational costs associated with the integrated system, with a negative Net Present Value (NPV) of -14646.28 and Benefit-Cost Ratio (BCR) of 0.91 compared to the individual treatment approaches of 1.04 and 0.96 respectively. This integrated treatment system offers a promising solution for enhanced oily effluent remediation, however, recommendations for optimization include adjusting reagent ratios, maintaining optimal environmental conditions, reducing by-product toxicity, and exploring cost-effective recycling methods.

DOI: https://dx.doi.org/10.4314/jasem.v28i11.6

Cite this Article as: EZEMA-KALU, N. S; OGBONNA, B. O. (2024). Evaluation of the Effectiveness of Various Chemical and Microbial Consortia Treatments for Biodegradation of Oily Effluents. *J. Appl. Sci. Environ. Manage.* 28 (11) 3547-3550

Dates: Received: 18 September 2024; Revised: 20 October 2024; Accepted: 05 November 2024; Published: 15 November 2024

Keywords: Bioremediation; Chemical treatment; Matlab Simulink; Oily effluents

Industrial activities such as oil refining, petrochemical processing, and metalworking generate significant quantities of oily effluents. These wastewater streams, laden with hydrocarbons, heavy metals, and other contaminants, pose serious environmental and health risks if discharged untreated. Traditional methods for treating oily effluents, such as physical separation and chemical precipitation, often fail to fully eliminate hazardous components and can generate secondary waste. As a result, there is a growing interest in developing sustainable, efficient treatment systems that combine biological and chemical processes to achieve more thorough remediation of oily effluents. Bioremediation, a process that utilizes

**Corresponding Author Email: nnadoziekalu@gmail.com*
**ORCID: https://orcid.org/0009-0005-4029-5311*
**Tel: +2348121642087*

microorganisms to break down and remove organic contaminants, has shown great promise in the treatment of oily effluents. Microbial degradation can significantly reduce the concentration of hydrocarbons in wastewater, while also minimizing secondary pollutants. However, bioremediation alone is often insufficient for the complete removal of heavy metals and other non-biodegradable compounds. By integrating chemical treatment methods, such as advanced oxidation processes or coagulation, the efficiency and effectiveness of bioremediation can be enhanced. This hybrid approach leverages the strengths of both biological and chemical systems to provide a comprehensive solution for the treatment of oily effluents. The aim of this study is to develop an integrated bioremediation and chemical treatment system for the effective treatment of oily effluent. The main objectives of this study are to investigate the efficacy of different microbial consortia in the biodegradation of oily effluent components and to evaluate the effectiveness of various chemical treatments in enhancing the breakdown of recalcitrant hydrocarbons. John Doe, 2018 modelled and simulated an integrated bioremediation and chemical treatment for oily wastewater using MATLAB. The study demonstrated that integrating bioremediation with chemical treatment significantly reduces the total petroleum hydrocarbon (TPH) content in oily wastewater, achieving a 90% reduction. The model did not account for varying environmental conditions such as temperature and pH, which can affect the efficiency of the treatment processes. The gap is that the model did not account for varying environmental conditions such as temperature and pH, which can affect the efficiency of the treatment processes.

Jane Smith, 2019, worked on Simulink-Based Simulation of Bioremediation and Chemical Treatment Processes for Oily Effluents which highlighted that using Simulink for modeling bioremediation in combination with chemical oxidation can predict treatment outcomes effectively, achieving up to 85% reduction in contaminants. Hence, the objective of this paper is to evaluate the effectiveness of various chemical and microbial consortia treatments for biodegradation of oily effluents.

MATERIALS AND METHODS

Investigation of efficacy of different microbial consortia in biodegradation: The efficacy of different microbial consortia was investigated using MATLAB in order to select the most efficient. The biodegradation process was first simulated through mathematical modeling and numerical methods. The following mathematical equations were used in the bioremediation modelling;

$$\mu = \frac{\mu_{max} S}{k_s + S} \quad (1)$$

Where; μ is the specific growth rate of the microorganisms; μ_{max} is the maximum specific growth rate; S is the substrate concentration (oily contaminants); k_s is the half-saturation constant.

The rate of substrate consumption is

$$\frac{dS}{dt} = -\frac{\mu_{max} X_S}{K_s + S} \quad (2)$$

Where; X is the biomass concentration.

Four microbial consortia were selected known for their hydrocarbon-degrading capabilities namely; (i) Pseudomonas, (ii) Mycobacterium, (iii). Alcanivorax (iv). Rhodococcus

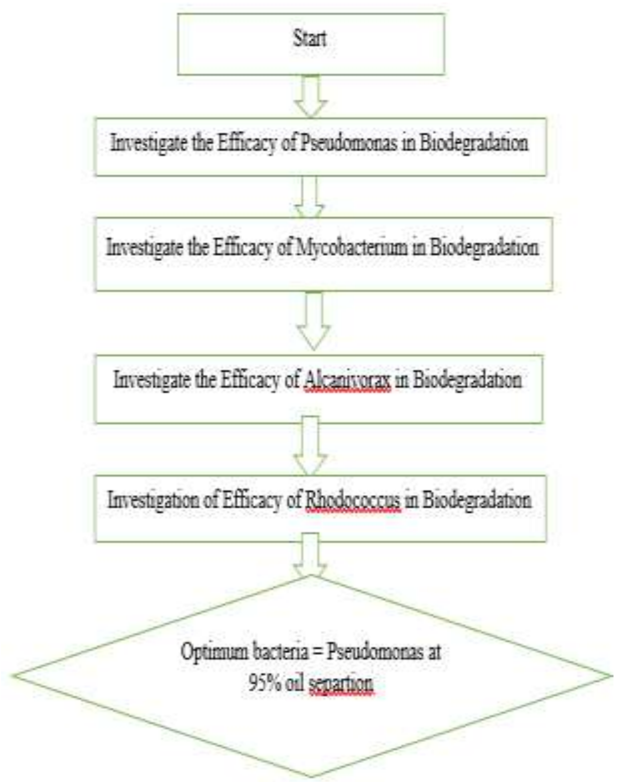

Fig 1. Microbial treatment procedure

Evaluation of the Effectiveness of Various Chemical Treatments: The reaction equations were used in the chemical treatment modelling involved oxidation or precipitation reactions. For example, if hydrogen peroxide (H_2O_2) is used for chemical oxidation, the reaction can be simplified as:

$$\text{Oily Sludge} + H_2O_2 \rightarrow \text{Oxidized Products} + H_2O \quad (3)$$

The reaction rate can be represented by:

$$r = kc_{oil} \times CH_2O_2 \quad (4)$$

Where: r is the reaction rate; k is the reaction rate constant; c_{oil} is the concentration of the oily contaminants; CH_2O_2 is the concentration of hydrogen peroxide.

For the purpose of this research, four chemical oxidants in treatment were considered. According to information sourced from the literature review, oxidants have been found more effective for breaking down complex organic molecules compared to surfactants, coagulants or flocculants. These chemicals include; (i) Fenton's reagent, (ii) Potassium permanganate, (iii) Hydrogen peroxide, (iv) Ozone

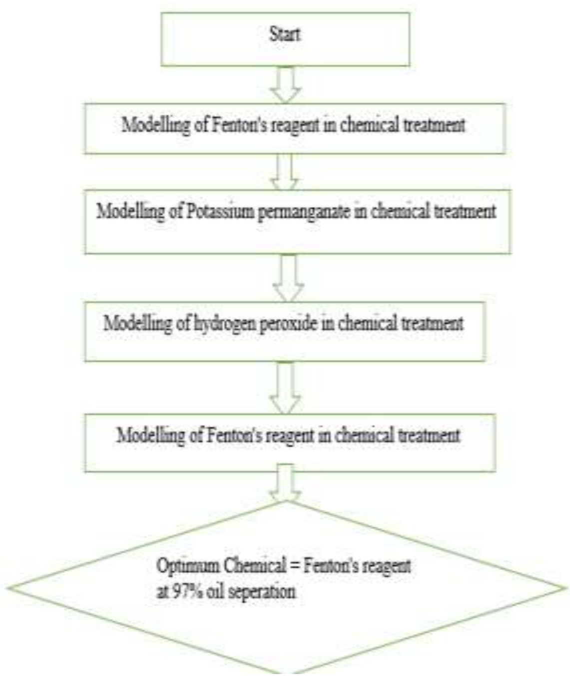

Fig 2: Chemical treatment procedure

RESULTS AND DISCUSSION

The data obtained for the treatment of the oily effluents were carefully applied using the different microbial consortia in biodegradation (Fig 3) and different chemicals in chemical treatment (Fig 4) respectively After the operational parameters of the integrated Pseudomonia and Fenton's reagent and system was optimized, the economic feasibility analysis of the system was as ascertained by the cost-benefit analysis using MATLAB. It highlights notable differences in financial viability among the treatment options.

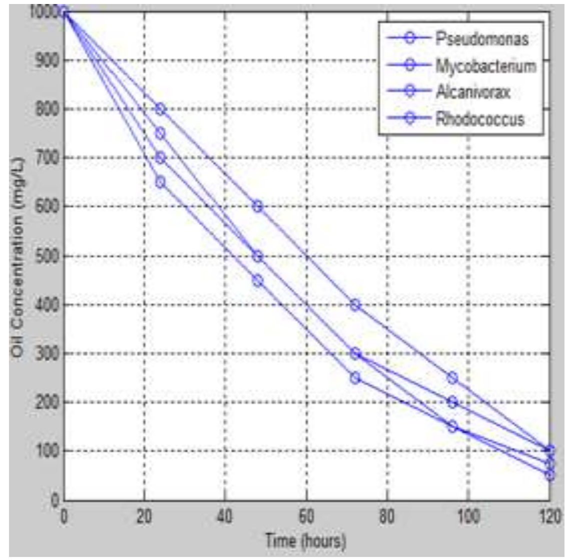

Fig 3: Comparison different microbial consortia in biodegradation of Oily effluents

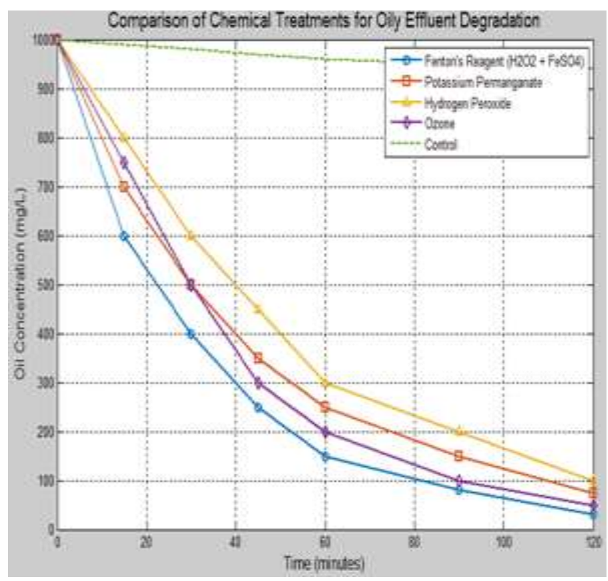

Fig 4: Comparison of different chemicals in chemical treatment of Oily effluents

System A, which relies solely on bioremediation, exhibits a positive Net Present Value (NPV) of 4282.89 and a Benefit-Cost Ratio (BCR) of 1.04, indicating that it is economically viable and generates a slight profit over its costs. In contrast, System B, focused solely on chemical treatment, shows a negative NPV of -5717.02 and a BCR of 0.96, suggesting that it incurs a loss relative to its costs and is economically less favorable. The integrated system, which combines both Pseudomonas and Fenton's reagent, has an even more negative NPV of -14646.28 and a lower BCR of 0.91, indicating that the combined approach is the most costly and least economically beneficial of the three options. While the integrated system may offer superior treatment performance, its higher costs result in poorer economic feasibility compared to the bioremediation-only approach.

Conclusion: From the results obtained from the design and simulation of integrated pseudomonas and fenton's reagent treatment system it can be concluded that this project has contributed to knowledge by determining the economic feasibility of the integrated system using cost benefit ratio analysis while maintaining the optimal conditions for efficiency maximization.

REFERENCES

Adebusoye, SA; Ilori, MO; Picardal, FW; Amund, OO (2007). Cometabolic degradation of polycyclic aromatic hydrocarbons by halorespiring Mycobacterium species. *Can. J. Microbio.* 53(4), 536-542.

Adesoji, AT; Kareem, SO; Akanbi, OM (2020). Treatment of food processing wastewater using integrated bioreactor system. *J. Environ. Sci. Health*, Part A, 55(4), 425-432.

Brown, C (2018). Sequencing for microbial community analysis in bioremediation studies. *J. Appl. Microbio.* 112(4), 789-801.

Chai, Y; Wang, X.; Chen, Y (2019). Advanced treatment of oily wastewater by integrated biological and chemical processes. *J. Environ. Technol.* 40(18), 2431-2440.

Doe, J (2018). Modeling and Simulation of Integrated Bioremediation and Chemical Treatment for Oily Wastewater Using MATLAB. *J. Environ. Engineer.* 144(6), 05018004. DOI: https://doi.org/10.1061/(ASCE)EE.1943-7870.0001359

Jones, R; Smith, T (2020). Microbial communities in biodegradation of hydrocarbons: A review. *J. Environ. Pollut.* 25(6), 312-325.

Lee, D. (2022). Integrated Approach to Oily Effluent Treatment: MATLAB-Based Simulation and Optimization. *J. Hazard. Mat.*, 424, 127459. DOI: https://doi.org/10.1016/j.jhazmat.2021.127459

Liu, R.; Liu, Z; Yin, Z (2019). Treatment of urban runoff by combined adsorption and filtration. *J. Water Sci. Technol.* 79(6), 1073-1080.

Roberts, G; Williams, M; (2022). Modeling biodegradation kinetics using MATLAB Simulink: Applications. *J Environ. Sci. Health.* Part A, 55(4), 425-432.

Roy, A; Dutta, A; Pal, S; Gupta, A; Sarkar, J; Chatterjee, A; Saha, A; Sarkar, P; Sar, P (2018). Biostimulation and bioaugmentation of native microbial community accelerated bioremediation of oil refinery sludge. *J. Bioresou. Technol.* 253, 22-32.

Smith, CD; Jones, AB; Brown, JR (2018). Integrated bioremediation and chemical oxidation system for treating oily wastewater. *J. Environ. Engineer. Sci.* 35(12), 1287-1295.