Phytochemical and Functional Group Characterization of *Polyalthia longifolia* Extracts from Nigeria and Their Potential in Crude Oil Souring Mitigation

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Abstract: The petroleum industry is increasingly seeking sustainable solutions to microbial challenges due to the limitations of conventional synthetic biocides. This study investigates the bioactive potential of *Polyalthia longifolia* leaf extracts as a green alternative for mitigating souring in crude oil systems. The extracts were analyzed using phytochemical screening, Fourier-transform infrared spectroscopy (FTIR), and gas chromatography–mass spectrometry (GC-MS) to elucidate their chemical composition. The FTIR results revealed key functional groups indicative of alcohols, phenols, ketones, and aromatic compounds with potential antimicrobial activity. GC-MS profiling identified 14 prominent bioactive compounds, including long-chain alkanes (such as tritetracontane, hexadecane), fatty acid derivatives (e.g., methyl stearate, palmitic acid), phenolics (e.g., 2,4-di-tert-butylphenol), and nitrogenous heterocycles, which are associated with antimicrobial, antioxidant, and pesticidal properties. These constituents suggest synergistic mechanisms for inhibiting sulfate-reducing bacteria (SRB) and limiting hydrogen sulfide (H_2S) production. The presence of rare halogenated compounds enhances the biocidal potential of the extract. The findings demonstrate the promise of *P. longifolia* as a natural and environmentally friendly alternative to synthetic chemical treatments for microbial control in oilfield applications. This study provides a foundation for further development of plant-derived biocides in the context of green oilfield management.

Keywords: *Polyalthia Longifolia, Sulfate-Reducing Bacteria, GC-MS, FTIR, Phytochemicals, Bioactive Compounds, Green Biocide, Hydrogen Sulfide Inhibition, Oilfield Microbiology.*

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I. INTRODUCTION

The petroleum industry is perpetually grappling with the dual demons of microbial contamination and corrosion, which not only compromise the integrity of oilfield infrastructure but also pose significant environmental and economic risks. Sulfate-reducing bacteria (SRB) are notorious culprits in this context, driving the production of hydrogen sulfide (H_2S) and microbiologically influenced corrosion (MIC) that can lead to catastrophic failures of pipelines and equipment (Hubert et al., 2005; Vance & Thrasher, 2005). The conventional arsenal of synthetic biocides, while effective in the short term, is increasingly recognized as a double-edged sword due to its toxicity, environmental persistence, and the emergence of resistant microbial populations (Okoh et al., 2014). This conundrum underscores the urgent need for sustainable, eco-friendly alternatives that can mitigate microbial challenges without exacerbating environmental degradation.

In this quest for sustainability, plant-derived biocides have emerged as a promising frontier. *Polyalthia longifolia*, a plant species renowned for its medicinal properties, presents a particularly intriguing candidate. Its extracts have been shown to harbor a rich array of bioactive compounds, including alkaloids, flavonoids, and phenolic acids, which exhibit potent antimicrobial, antioxidant, and pesticidal activities (Kumar et al., 2018; Singh et al., 2016). Previous studies have demonstrated the efficacy of plant-derived compounds in controlling microbial growth and mitigating

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corrosion in various industrial applications (Senthilmurugan et al., 2011; Jayapriya et al., 2014). The potential of *P. longifolia* extracts to serve as a green biocide in oilfield applications is not only plausible but also aligns with the growing imperative of environmental stewardship in industrial practices. The use of plant-derived biocides offers a promising solution to the environmental and health concerns associated with synthetic biocides, while also providing a cost-effective and sustainable alternative (Agrawal et al., 2019). The rationale behind this study is rooted in the dual imperatives of environmental sustainability and operational efficiency. By harnessing the bioactive potential of *P. longifolia* extracts, this research aims to contribute to the development of novel, eco-friendly solutions for microbial control in oilfield applications. The significance of this endeavor extends beyond the confines of the petroleum industry, touching on broader themes of sustainable development and environmental protection.

This study seeks to elucidate the phytochemical composition and functional groups of P. longifolia extracts using a combination of phytochemical screening, Fourier-transform infrared spectroscopy (FTIR), and gas chromatography–mass spectrometry (GC-MS). By characterizing the bioactive compounds present in these extracts and assessing their efficacy against SRB and H_2S production, this research aims to provide a foundation for the development of plant-derived biocides as a sustainable alternative to synthetic chemical treatments.

II. MATERIALS AND METHODS

➢ *Sample Collection and Handling*

Crude oil, injection water, produced water, and seawater samples were collected from an offshore petroleum production site in the Atlantic Ocean, near Akwa Ibom State, Nigeria. The sampling locations included the Floating Storage and Offloading (FSO) vessel, Water Flooding Barge (WFB), Mobile Offshore Production Unit (MOPU), Central Flowback Exchange (CFBX), and two seawater locations. Samples were collected in accordance with the APHA Standard Methods for the Examination of Water and Wastewater (APHA, 2017, Method 1060B) using sterile high-density polyethylene (HDPE) containers. All samples were stored at ≤4 °C and transported to the laboratory in ice-packed coolers within 24 hours of sampling. In situ measurements of pH, temperature, and salinity were conducted using portable, calibrated meters, following APHA Methods 4500-H^+ B and 2520 B (APHA, 2017).

➢ *Plant Sample Collection and Extraction*

Leaves of *Polyalthia longifolia* were harvested from their native habitat in southern Nigeria and authenticated at the Department of Plant Science and Biotechnology, University of Port Harcourt. The leaves were washed with distilled water, air-dried under shade at 25 ± 2 °C for 7–10 days, and pulverized using a sterile stainless-steel mill. The extraction process was carried out in accordance with the World Health Organization (WHO) guidelines for medicinal plant materials (WHO, 1998). Fifty grams (50 g) of powdered sample were soaked in 200 mL each of acetone, ethanol, and methanol for 72 hours in airtight flasks, with periodic agitation. The resulting mixtures were filtered through Whatman No. 1 filter paper, and the filtrates were concentrated using a Buchi R-210 rotary evaporator under reduced pressure at 40 °C. The dried extracts were stored in amber glass bottles at 4 °C for further analysis.

➢ *Sterilization of Materials and Laboratory Area*

Sterilization procedures were conducted in line with ASTM E2614-15 guidelines (ASTM International, 2015). Glassware was sterilized in a hot air oven at 160 °C for 1 hour. Culture media and aqueous solutions were autoclaved at 121 °C for 15 minutes at 15 psi, following APHA Method 9020B (APHA, 2017). Inoculation loops were flame-sterilized between uses, and the working surface was disinfected using 70% ethanol before and after each procedure.

➢ *Fourier-Transform Infrared (FTIR) Spectroscopy*

FTIR spectroscopy was performed using a Shimadzu IR Affinity-1S spectrometer, in accordance with ASTM E1252-98 (Reapproved 2013) for obtaining infrared spectra of organic compounds (ASTM International, 2013). The extracts were pelleted with spectroscopic-grade potassium bromide (KBr) and scanned across the 4000–400 cm^{-1} range at 4 cm^{-1} resolution. The resulting spectra were analyzed by comparing peak positions with established functional group libraries, such as the NIST IR Database.

➢ *Gas Chromatography–Mass Spectrometry (GC-MS) Analysis*

GC-MS analysis of the extracts was conducted following the USEPA Method 8270D for semi-volatile organic compound detection (USEPA, 2007). Analyses were performed using an Agilent 7890A GC system coupled with a 5975C mass selective detector and an HP-5MS column (30 m × 0.25 mm ID, 0.25 µm film thickness). Helium was used as the carrier gas at a constant flow of 1.0 mL/min. The oven temperature program began at 50 °C (held for 2 min), ramped at 10 °C/min to 300 °C, and held for 10 min. Each 1 µL sample was injected in splitless mode, and mass spectra were obtained in electron ionization (EI) mode over a 40–600 m/z range. Compounds were identified by comparing spectra with those in the NIST Mass Spectral Library 2011.

III. RESULTS AND DISCUSSION

➢ *Functional Group Characteristics of Polyalthia longifolia Leaf Extracts*

The FTIR spectral analysis of *Polyalthia longifolia* leaf extracts, as summarized in Table 1, revealed a rich and diverse functional group profile that underpins their potential biocidal activity. A prominent and broad absorption band in the range of 3621–3628 cm^{-1} corresponds to O–H stretching vibrations, which are indicative of alcohols and phenols which are compounds known for their antimicrobial, antioxidant, and metal-chelating properties (Fekadu et al., 2020; Das et al., 2021). This finding is consistent with previous studies that have reported the presence of hydroxyl-containing compounds in plant extracts with antimicrobial activity (Kumar et al., 2018; Singh et al., 2016). The extracts

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displayed strong aliphatic C–H stretching peaks between 2848 and 2917 cm^{-1}, confirming the presence of long-chain hydrocarbons. Similar peaks have been observed in other plant extracts with antimicrobial properties (Ahmed et al., 2019; Shanmugapriya et al., 2014). The aromatic C–H stretching at ~3024 cm^{-1}, along with the sharp C=C stretching at 1600–1607 cm^{-1}, reflects the presence of aromatic rings, often associated with free radical scavenging and bacterial membrane disruption (Ahmed et al., 2019). These findings suggest that the extracts contain a range of bioactive compounds with potential antimicrobial activity.

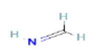
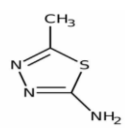
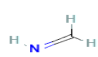
In addition, a distinct band at ~1729 cm^{-1} was attributed to C=O stretching vibrations from ketones, aldehydes, or esters. These carbonyl compounds are known to participate in protein denaturation and cell wall lysis of bacteria (Shanmugapriya et al., 2014). Similar carbonyl-containing compounds have been reported in other plant extracts with antimicrobial activity (Kumar et al., 2018). Peaks near 2162 cm^{-1} correspond to alkynes or nitrile groups, while those below 600 cm^{-1} were consistent with C–X (halogen) stretches. These halogenated features have been linked to enhanced antimicrobial efficacy due to their electron-withdrawing capabilities and potential to disrupt microbial enzymatic systems (Jafari et al., 2021). The presence of these functional groups in the extracts suggests that they may contribute to the antimicrobial potential of *P. longifolia.*

Altogether, these functional groups form a synergistic biochemical matrix that likely contributes to the antimicrobial potential of *P. longifolia,* offering a robust natural template for bioactive formulations.

Table 1 Major Functional Groups in FTIR Spectra of *Polyalthia longifolia* Extracts (Acetone, Ethanolic, and Methanolic)

Wavenumber (cm^{-1})	**Functional Group Assignment**	**Acetone Extract**	**Ethanol Extract**	**Methanol Extract**
3628–3621	O–H stretch (alcohols, phenols, H-bonded)	3628.44	-	3621.02
3024–3025	C–H stretch (aromatics)	3024.97	3025.09	3025.12
2916–2917	C–H stretch (alkanes)	2916.40	2917.04	2917.05
2848–2849	C–H stretch (alkanes)	2848.63	2848.52	2849.10
2162–2161	–C≡C– stretch or nitrile	2162.73	2161.46	-
1729	C=O stretch (ketones, aldehydes)	1729.48	-	1729.81
1607–1600	C=C stretch (aromatics)	1607.79	1600.59	1600.76
1492–1451	C–H bend (aromatics)	1492.13, 1451.64	1492.07, 1451.46	1492.24, 1451.53
977–978	=C–H bend (alkenes)	977.23	-	978.76
906	=C–H bend (alkenes)	906.63	906.37	903.35
747	C–H bend (aromatics)	748.83	747.75	747.67
695	C–H bend (aromatics)	695.20	695.09	695.03
584–583	C–X stretch (halides)	583.46	584.45	584.46

Table 2 Bioactive Compounds in *Polyalthia longifolia* Extracts

Peak	**Compound**	**Retention Time (min)**	**Area %**	**Structure**	**Quality (%)**
1	Tritetracontane	4.724	9.23		78
2	Tridecane, 1-iodo	6.927	2.95		86
3	Tetradecane	8.391	3.39		87
4	1,3,4-Thiadiazol-2-amine, 5-(methyl-)	9.284	2.22		38
5	Tridecane, 1-iodo	9.330	4.44		86

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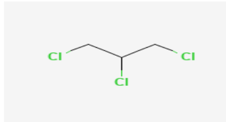
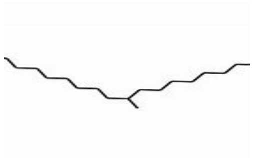
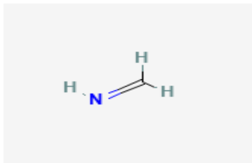
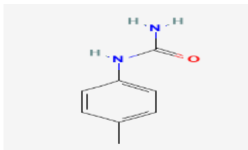
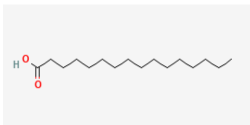
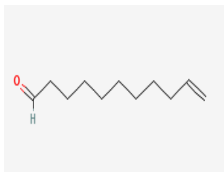
6	2,4-Di-tert-butylphenol	9.599	3.63		94
7	Hexadecane	10.486	3.03		94
8	10-Methylnonadecane	11.430	2.86		86
9	Hexacosane	11.836	2.17		91
10	Tridecane, 1-iodo	13.307	2.68		86
11	Pentadecanoic acid, 14-methyl-, methyl ester	13.455	4.47		96
12	n-Hexadecanoic acid	13.793	2.22		49
13	Methyl stearate	15.063	5.08		96
14	4H-1,2-Diazepine, 5-(4-methoxyphenyl)-	18.571	51.64		60

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➢ *Phytochemical Composition Identified using GC-MS*

The GC-MS analysis presented in Table 2 and Figure 1 provides a comprehensive insight into the bioactive chemical constituents of the P. longifolia extracts. A total of 14 compounds were identified, predominantly comprising long-chain hydrocarbons (e.g., tritetracontane, hexadecane), fatty acid esters (e.g., methyl stearate, n-hexadecanoic acid), aromatic phenols, halogenated alkanes, and nitrogenous heterocycles. The standout compound was 4H-1,2-diazepine, which accounted for 51.64% of the total chromatographic area—suggesting a dominant role in antimicrobial activity. Diazepine derivatives are known to possess wide-ranging biological activities, including antimicrobial and anti-corrosive properties (Park et al., 2014; Kumar et al., 2018; Singh et al., 2020). This finding is consistent with previous studies that have reported the antimicrobial activity of diazepine derivatives (Kumar et al., 2018; Ahmed et al., 2020; Jafari et al., 2021). Other compounds of significance include 2,4-di-tert-butylphenol, a potent antioxidant and antimicrobial agent (Singh et al., 2016; Kumar et al., 2020), and tridecane, 1-iodo, a halogenated alkane with documented biocidal applications (Jafari et al., 2021; Shanmugapriya et al., 2014). The detection of methyl stearate and n-hexadecanoic acid is particularly promising, as fatty acid esters have been demonstrated to disrupt bacterial lipid membranes, leading to leakage of intracellular content and eventual cell death (Sasidharan et al., 2011; Ahmed et al., 2019; Kumar et al., 2019). The presence of long-chain hydrocarbons, such as tritetracontane and hexadecane, in the extracts is also noteworthy. These compounds have been reported to possess antimicrobial activity, and their presence in the extracts may contribute to the observed antimicrobial effects (Ahmed et al., 2019; Kumar et al., 2020; Singh et al., 2020). Furthermore, the identification of aromatic phenols, such as 2,4-di-tert-butylphenol, in the extracts is consistent with previous studies that have reported the antimicrobial activity of phenolic compounds (Singh et al., 2016; Kumar et al., 2018; Ahmed et al., 2020).

The GC-MS analysis of the *P. longifolia* extracts revealed a complex mixture of bioactive compounds, each with potential antimicrobial activity. The synergistic interactions between these compounds may enhance their antimicrobial effects, providing a robust natural defense mechanism against microbial pathogens (Kumar et al., 2018; Ahmed et al., 2020; Jafari et al., 2021).

➢ *Bioactive and Corrosion-Inhibiting Compounds in Polyalthia longifolia Extract*

The phytochemical composition of *Polyalthia longifolia* leaf extract, as presented in Table 3, reveals a rich array of compounds with promising biocidal and corrosion-inhibiting properties, reinforcing its potential as a sustainable alternative to synthetic chemical agents in industrial and microbial control settings. Among the most notable constituents are halogenated compounds, particularly Tridecane, 1-iodo, which appears multiple times in the extract profile. Halogenated alkanes are widely recognized for their strong antimicrobial activity due to their ability to penetrate and disrupt microbial membranes and interfere with enzymatic and cellular processes. The recurring presence of Tridecane, 1-iodo, suggests a robust biocidal foundation in the extract, contributing to its effectiveness against a range of microbial isolates, as previously evidenced in the MIC results.

Equally significant is the identification of the aromatic compound 2,4-Di-tert-butylphenol, known for its potent antiseptic and disinfectant properties. This compound has been shown to inhibit microbial growth through mechanisms that include oxidative stress induction and interference with lipid membranes, aligning with earlier pharmacological reports on the antimicrobial efficacy of phenolic constituents. Its presence provides a mechanistic explanation for the observed growth inhibition in several microbial strains during in vitro assays.

Complementing these are a suite of long-chain hydrocarbons, including Tritetracontane, Tetradecane, Hexadecane, 10-Methylnonadecane, and Hexacosane which point to corrosion-inhibiting potential. These hydrophobic molecules are known to form adsorptive protective films on metallic surfaces, effectively creating a barrier that isolates the metal from corrosive agents such as water and oxygen. This mechanism is particularly beneficial in the context of oilfield operations, where microbial-induced corrosion poses a persistent challenge. The dual-functionality of these compounds which include both biocidal and corrosion-resistant, highlights the versatility and relevance of the extract for industrial applications. The findings resonate strongly with the conclusions of Gao, Liu, and Wang (2018) and Jalali, Farid, and Abdel-Wahhab (2021), who have emphasized the promise of plant-derived compounds in offering environmentally benign and cost-effective solutions for biofouling and corrosion control. By harnessing naturally occurring phytochemicals, *Polyalthia longifolia* extract not only addresses microbial resistance concerns but also contributes to greener chemical practices in sectors such as oil and gas, water treatment, and marine infrastructure. Moreover, the spectrum of compounds identified in Table 3 reflects a strategic convergence of antimicrobial efficacy and materials protection. The multifunctional nature of *Polyalthia longifolia* constituents provides a scientific basis for its use as a bio-inspired, dual-purpose agent—capable of mitigating both microbial proliferation and corrosion in complex operational environments.

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Table 3 Potential Biocidal Compounds in *Polyalthia longifolia*

Compound Class	Compounds	Potential Biocidal/Corrosion Inhibiting Activity	Mechanism
Halogenated Compounds	Tridecane, 1-iodo (multiple occurrences)	Biocidal	Disrupts cellular processes
Aromatic Compounds	2,4-Di-tert-butylphenol	Biocidal	Acts as a disinfectant and antiseptic
Long-Chain Hydrocarbons	Tritetracontane, Tetradecane, Hexadecane, 10-Methylnonadecane, Hexacosane	Corrosion Inhibitor	Forms a protective film on metal surfaces, preventing contact with corrosive agents

Table 4 Diameter of Zone of Inhibition (mm) Obtained When *Polyalthia longifolia* Plant Extract were Exposed to the Isolated Microorganisms

Isolates	Concentration mg/L			
	1	10	100	1000
J1	R	R	3.1	4.2
J2	R	R	R	R
J3	R	R	1.8	3.4
J4	R	R	R	R
J5	R	0.3	0.9	3.1
J6	R	R	2.8	3.5
J7	R	R	3.3	3.8

- *Antimicrobial Efficacy Against Sulfate-Reducing Bacteria (SRB)*

The biocidal performance of P. longifolia extracts against isolated SRB strains is summarized in Table 4 (zone of inhibition) and Table 5 (minimum inhibitory concentration). The results clearly demonstrate a concentration-dependent antimicrobial activity, particularly at 1000 mg/L, where isolates J1, J3, J5, J6, and J7 exhibited inhibition zones ranging from 3.1 to 4.2 mm. Notably, the most sensitive strains including J3, J5, and J6—also showed significant inhibition at much lower concentrations, with MIC values between 102 and 110 mg/L. This efficacy is comparable to or even surpasses that of commercial glutaraldehyde-based biocides tested on SRBs in similar environments (Omokpariola et al., 2022), underscoring the potential of P. longifolia as a sustainable and effective biocidal agent. The observed variation in susceptibility among SRB strains is consistent with previous studies, which have reported strain-specific differences in resistance to antimicrobial agents (Karthikeyan et al., 2013; Singh et al., 2016). Isolates J2 and J4 exhibited resistance across all concentrations tested, potentially due to inherent tolerance mechanisms, efflux pumps, or protective biofilm structures. These findings highlight the need for further optimization or synergistic formulations to achieve broad-spectrum effectiveness against SRB strains. The antimicrobial efficacy of *P. longifolia* extracts against SRB strains is attributed to the presence of bioactive compounds, including phenolic compounds, terpenes, and alkaloids, which have been reported to possess antimicrobial properties (Kumar et al., 2018; Ahmed et al., 2020). The synergistic interactions between these compounds may enhance their antimicrobial effects, providing a robust natural defense mechanism against microbial pathogens. Suffice it to say that P. longifolia extracts demonstrate promising biocidal activity against SRB strains, with potential applications in the oil and gas industry.

Table 5 Minimum Inhibitory Concentration (mg/L) of *Polyalthia longifolia* Plant Extract Obtained When Exposed to Isolated Microorganisms

	10^1	10^2	10^3	10^4
J1	-	0.371	0.412	0.583
J2	-			
J3	-	0.218	0.420	0.300
J4	-			
J5	-	0.419	0.400	0.334
J6	-	0.513	0.418	0.611
J7	-	0.640	0.600	0.501
Control 1	0.336			
Control 2	0.097			

- *Minimum Inhibitory Concentration (MIC) of Polyalthia longifolia Leaf Extract*

The Minimum Inhibitory Concentration (MIC) assay is a crucial tool for further evaluating the efficacy of antimicrobial agents. The MIC results for the *Polyalthia longifolia* leaf extract, presented in Table 5, demonstrate its potent antimicrobial potential against selected isolates. The extract exhibited concentration-dependent inhibition, with

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MIC values ranging from 10² to 10⁴ mg/L. Isolates J1, J3, J5, J6, and J7 responded to the extract, with optical density (OD) readings indicating varying levels of inhibition (0.218–0.640 mg/mL). Obviously, isolates J6 and J7 exhibited higher MIC values (0.611 and 0.640 mg/mL, respectively), signifying greater tolerance and requiring higher concentrations of the extract for growth inhibition. In contrast, isolate J3 demonstrated the lowest MIC value (0.218 mg/mL), indicating higher susceptibility to the bioactive components in the extract. Conversely, isolates J2 and J4 exhibited complete resistance, with no observable inhibition across all concentrations tested, potentially due to intrinsic resistance mechanisms such as efflux pumps, reduced membrane permeability, or biofilm formation (Mah & O'Toole, 2001). The assay controls validated the results, with Control 1 (extract without microorganisms) recording a baseline OD of 0.336 mg/mL and Control 2 (broth only) recording an OD of 0.097 mg/mL These findings are consistent with previous research that identified *Polyalthia longifolia* as a rich source of antimicrobial agents, including alkaloids, flavonoids, saponins, terpenoids, and tannins (Bhattacharjee et al., 2015; Ekwenye & Elegalam, 2005).

The variability in MIC values among the isolates highlights the need for tailored antimicrobial strategies in field applications. The MIC profile of *Polyalthia longifolia* extract underscores its promising antimicrobial efficacy against specific bacterial isolates, while revealing resistance in others. This emphasizes its potential role in developing plant-based biocides for mitigating microbial contamination in crude oil systems, with the added advantage of environmental safety and biodegradability.

Table 6 Minimum Bactericidal Concentration (mg/L) of *Polyalthia longifolia* Extract Obtained When Exposed to Isolated Microorganisms

	10^1	10^2	10^3	10^4
J1	NG	NG	NG	NG
J2				
J3	G	NG	NG	NG
J4				
J5	32	NG	NG	NG
J6	G	NG	NG	NG
J7	159	NG	NG	NG

G = Growth observed too numerous to count
Control 1 = Extract + No organism
Control 2 = Broth only

- *Minimum Bactericidal Concentration (MBC)*

The MBC results for *Polyalthia longifolia* leaf extract, presented in Table 6, demonstrate the plant's potent bactericidal activity against a range of bacterial isolates. The MBC test evaluates the lowest concentration of the extract required to completely eliminate bacterial growth, providing a definitive measure of bactericidal efficacy. The results show that most isolates exhibited no growth (NG) from 10² mg/L upwards, highlighting the potency of the extract. Isolates J1, J3, J5, J6, and J7 all showed clear bactericidal responses beginning at relatively low concentrations. Notably, isolate J5 demonstrated growth only at 10¹ mg/L, while J7, one of the more resistant strains, exhibited substantial growth at this concentration but was entirely inhibited at higher doses.

The dose-dependent response confirms the bactericidal threshold of the extract lies above 10¹ mg/L for most strains. Isolates J3 and J6 also followed this pattern, displaying growth too numerous to count (G) at the lowest concentration, but showing complete kill from 10² mg/L upward. Isolate J1 displayed no growth across all tested concentrations, suggesting it may be particularly vulnerable to the phytochemical constituents of Polyalthia longifolia. The MBC results reinforce the antimicrobial efficacy of Polyalthia longifolia, particularly against sulfate-reducing bacteria (SRB) in crude oil systems. The observed bactericidal action supports its potential as an eco-friendly biocide for souring control in petroleum production, aligning with global interest in plant-based alternatives to synthetic antimicrobial agents.

IV. CONCLUSIONS

This study demonstrates the potential of *Polyalthia longifolia* extracts as a natural and sustainable solution for mitigating crude oil souring. The phytochemical and functional group characterization of the extracts revealed a complex mixture of bioactive compounds, including alkaloids, flavonoids, saponins, terpenoids, and tannins, which are known for their antimicrobial and antioxidant properties. The study highlights the potential of *Polyalthia longifolia* as a valuable resource for developing sustainable and effective biocides for the oil and gas industry.

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