

BIOREMEDIATION OF INDUSTRIAL PHENOL-CONTAMINATED

WASTEWATER USING INDIGENOUS BACTERIA

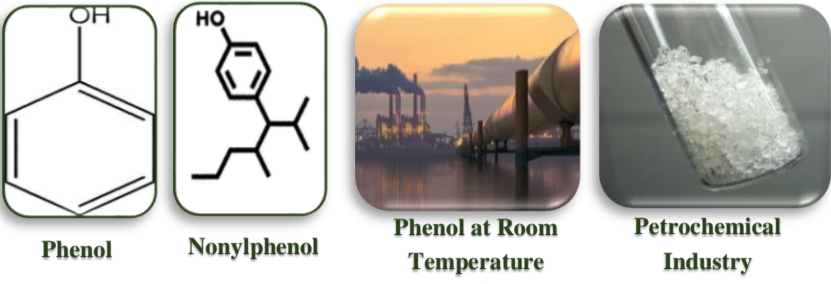
(¹) Nidal Mohammed Zabermaawi *, (¹) Fawzeyah Abdullah Alshehri, (²) Ebtesam El-Bestawy

(¹) * Corresponding Author: Department of Biological Sciences, Faculty of Sciences, King Abdulaziz University, Jeddah 21589, Saudi Arabia.

Email: nzabermaawi@Kau.edu.sa, Phone: +966505658458 ORCID: <https://orcid.org/0000-0003-1216-7003>

(²) Department of Environmental Studies, Institute of Graduate Studies and Research, Alexandria University,

163 Horria Ave. El-Shatby, P.O. Box 832, Alexandria, Egypt. Phone: +2/1224979468 E-mail: ebtesamelbestawy@alexu.edu.eg, ORCID: <https://orcid.org/0000-0002-5351-9696>



INTRODUCTION

Water is very important in petroleum and petrochemical production processes. Industrial wastewater contains a variety of organic compounds that must be treated effectively. Among the serious pollutants in the oil refinery and petrochemical industrial wastewater, phenol is considered a highly concerned. Phenol, also known as Hydroxybenzene, is an organic aromatic compound consists of the attached hydroxyl group to aromatic hydrocarbon group. It has hydroscopic properties in water and slightly in organic solvents that make them easily spilled or leaked into the surface water or inside ground water source. It is stable, more persistent in the environment and bio-accumulated in the food chain. Phenol is one of the most hazardous organic pollutant in the petrochemical wastewater. It is classified as a priority pollutant due to its high toxic effects on animal and human health even at low concentrations, as well as its widespread distribution and persistence in the environment. Several methods have been developed to remove phenol from wastewater, including microbial degradation, chemical oxidation, photocatalytic degradation, ultrasonic degradation, enzymatic polymerization, membrane separation, and solvent extraction and adsorption. Biological treatment of wastewater is advantageous over physical-chemical treatment because of its low cost, and as environmentally friendly approach.

AIM OF THE WORK

The present study aimed to investigate the ability and efficiency of biological treatment to remove and decontaminate phenol-contaminated wastewater using indigenous bacteria in a free-living batch-mode bioassay.

MATERIALS & METHODS

Wastewater samples were collected from poly-vinyl chloride production unit's effluent at a major petrochemical company in the industrial city, Jeddah, Saudi Arabia. Phenol-contaminated wastewater was characterized physically, chemically, and microbiologically to determine the degree of pollution, isolate and identify the most promising indigenous phenol-degrading bacteria and to choose the best treatment method. Ten indigenous microbial isolates (A1-A10) were isolated from the final drainage of phenol contaminated industrial wastewater of poly-vinyl chloride production unit on nutrient agar (NA) plates under aseptic conditions using the standard pour plate standard technique. Morphologically, isolates A5 and A6 proved being fungal isolates, therefore, they were excluded. The rest 8 isolates (A1, A2, A3, A4, A7, A8, A9 and A10) were screened and investigated as free-living, individual, or mixed cultures for bioremediation of phenol-contaminated wastewater in batch mode bioassays. Raw and treated effluents underwent wastewater characterization (temperature, pH, dissolved oxygen (DO), COD, BOD, total phenolics, TSS, TDS, and total viable count of bacteria (TVCB). The removal efficiencies of the tested parameters using the tested bacterial species were computed to identify the most promising strains for the bioremediation process. Three strains (A2, A4 and A9) showed the highest removal efficiency of phenol during the screening bioassay. Therefore, they were molecularly identified and chosen and used as individual or mixed free-living cultures in an 8-day batch mode remediation process.



RESULTS

1. Screening Bioassay

The obtained results show that all strains can consume the phenol from the water with different abilities (Table 1), where A4 being the most efficient after 24 hours compared to the other tested strains. A4 also showed the highest phenol RE% after the 2nd and 3rd exposure days. A2 and A9 showed the highest RE of phenol after 4 exposure days. But in general, strain A9 showed the highest ability among all tested strains. Therefore, the three strains (A2, A4, and A9) were selected for further treatment investigations.

Table 1. The Highest Removal Efficiencies (RE%) and Lowest Residual Concentrations (RC) of Phenol in the Raw and Treated Wastewater at Different Exposure Times During the Screening Bioassay

Strain	RC (mg/L)	RE%	Exposure (Days)	
			Raw Wastewater Initial Phenol Concentration: 2.229098806 mg/L	
A1	0.39414	82.3257	5	
A2	0.296	86.71**	5	
A3	0.3507	84.273	3	
A4	0.329	85.247*	3	
A7	0.3724	83.299	2, 3	
A8	0.3507	84.273	4	
A9	0.253	88.655**	4	
A10	0.405	81.839	8	

A2, A4 and A9 were molecularly identified (Table 2). The 16S rDNA sequences of three isolates were extracted partially and aligned with those sequences of Ribosomal Database available in the National Center for Biotechnology Information (NCBI) GenBank

2. Batch Mode Remediation Process Using the Promising Candidates

Results obtained from the batch treatment for 5 days concluded that the mixed culture (A2, A4 and A9) is the most active and efficient for removing the included contaminants from phenol-contaminated effluent. It could achieve 98.85, 31.08, 45.83, and 45.83% removal of phenol, COD, BOD, and TDS, respectively. All the parameters' residues were below their MPLs (0.05, 80, 60 and 2000 mg/L) and complying very well with the Egyptian environmental regulations for the safe discharge except TSS with 63.5% (by A4), IC. 266 mg/L and residue of 97 mg/L, which is 1.94-fold higher than its MPL (50 mg/L). The current study's findings confirmed that the proposed treatment system using the selected cultures, strain A9, in particular, is a highly active, promising, renewable, and inexpensive biotechnology for the treatment of a wide range of contaminated industrial wastewater.

Table 2: Similarity% of the Most Active Isolates with their Closest Neighbors

Code	Strain	Similarity %	Accession No.
A2	<i>Stutzerimonas chloritidis</i> mutans strain AW-1	99.88	PQ333147
A4	<i>Stutzerimonas stutzeri</i> ATCC 17588 - LMG 11199	99.84	PQ333146
A9	<i>Arthrobacter ruber</i> strain MDB1-42	100.0	PQ 333145

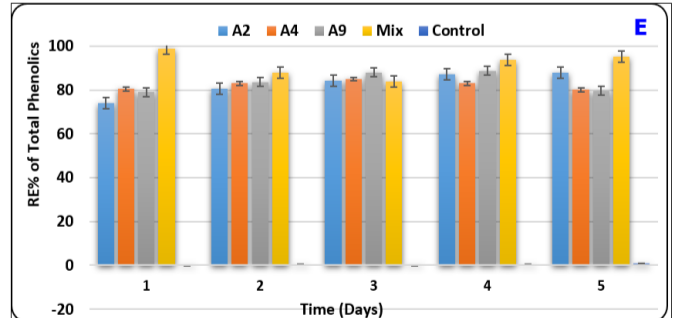
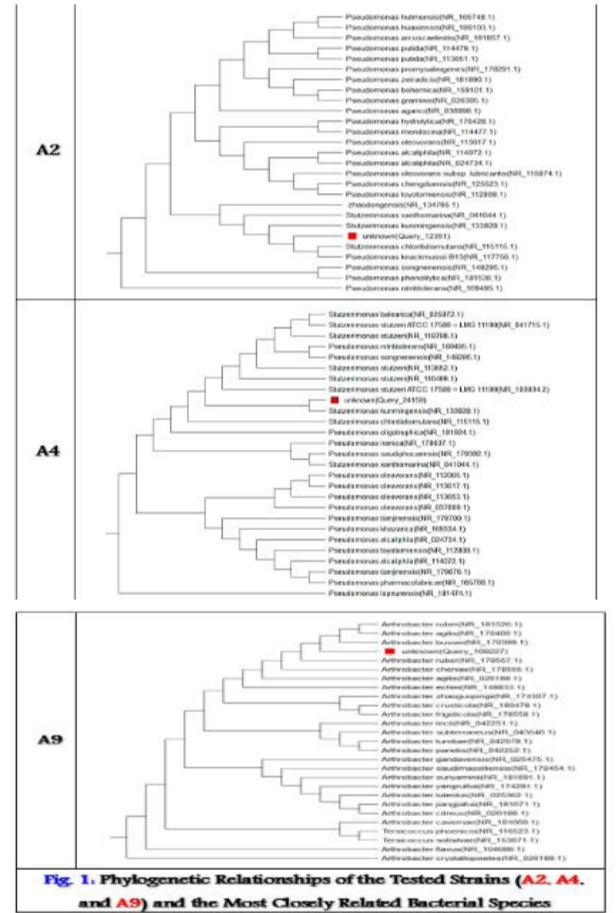
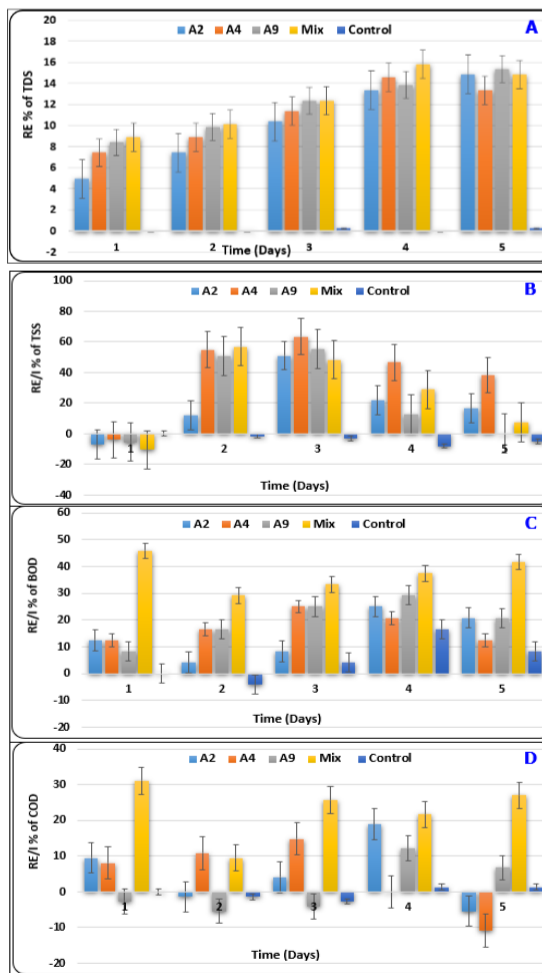


Fig. 3. RE% of TDS (A); RE/1% of TSS (B); BOD (C); COD (D) and the Total Phenolics (E) in the Raw and Treated Wastewater at Different Exposure Times during the Batch Bioassay Using Unmodified Bacteria (Reading are Averages of 3 Replicates ± SE)

CONCLUSION

Biological remediation using phenol degrading- bacteria is highly effective, low-cost, and readily available technology for phenol removal. The use of bacteria for the biodegradation of toxic pollutants presents an attractive chance to decontaminate the environment, produce high quality effluents, complying with the environmental regulations for the safe drainage into open environment.