Analytical Techniques for Tracking the Bioremediation of Hydrocarbons in Sludge and Soil Polluted By Petroleum

Pankaj K Ghosh*

Department of Analytical Sciences Division, Indian Institute of Petroleum, Council of Scientific and Industrial Research, Uttarakhand, India

Abstract

P^c¦[|^˘{ @ˆå¦[&æ¦à[} &[}cæ{å}æcå[} [~•[å¦æ}å•|˘å*^]¦^•^}c••å*}å,&æ}c^}çå¦[}{^}cæ|&@æ||^}*^•å˘^c[c@^ persistence and toxicity of these pollutants. Bioremediation, utilizing microbial processes to degrade hydrocarbons, @æ• ^{^¦*^å æ• æ]¦[{å•å}*æ}å^}çå¦[}{^}cæ||^ ~¦å^}å¦æ]]¦[æ&@. T@å• æ¦cå&¦^ ¦^çå^¸•çæ¦å[˘•æ}æ¦ˆcå&æ|c^&@}åˇˇ^• ^{]|[^ˆå c[{[}åc[¦æ}å æ••^•• c@^ àå[¦^{^åàæcå[} [~@ˆå¦[&æ¦à[}-&[}cæ{å}æc^å•[å¦æ}å•|˘å*^. T^&@}åˇˇ^• •˘&@ æ• chromatography, spectroscopy, molecular biology methods, and isotopic analysis are discussed in detail, highlighting c@^å¦ æ]]¦å&æcå[}•, •c¦^}*c@•, æ}å |å{åcæcå[}• å}c¦æ&\å}* c@^ àå[¦^{^åàæcå[}]¦[*¦^••. T@^ å}c^*¦æcå[} [~{˘|cå]|^c^&@}åˇˇ^•]¦[çåå^• æ &[{]¦^@^}•åç^˘}å^¦•cæ}åå}* |æc^•, æ}å c@^ [ç^¦æ|| ^ ^&çç^}•• [~àå[¦^{^åàæcå[} •c¦æc^*å^•. Fˇc˘¦^]¦•••æ¦&@ å}å¦^&å[}• æ¦^ æ|•[• ˘**^•c^å c[ ]^}@æ}&^ c@^ ^ &å^}&ˆ æ}å æ]]¦å&æàå¦åˆ [~c@•^•• æ}æ¦ˆcå&æ| c[[|• å} ^}çå¦[}{^}cæ| {[}åc[¦å}* æ}å {æ}æ*^{^}c.

Keywords: Bioremediation; Hydrocarbons; Soil contamination; Sludge contamination

Introduction

Petroleum hydrocarbons are major environmental pollutants, causing soil and sludge contamination through accidental spills, industrial activities, and improper disposal practices [1]. e persistence of hydrocarbons in the environment poses risks to ecosystem health and human well-being, necessitating e ective remediation strategies. Bioremediation, which harnesses the metabolic capabilities of microorganisms to degrade hydrocarbons into harmless by-products, has gained attention due to its cost-e ectiveness and sustainability compared to traditional remediation methods like excavation and incineration [2]. Monitoring the e ciency and progress of bioremediation processes is crucial for assessing remediation success and environmental safety. Various analytical techniques are employed for this purpose; Gas chromatography (GC) and high-performance liquid chromatography (HPLC) are widely used to quantify hydrocarbon concentrations in contaminated samples [3]. ese techniques o er high sensitivity and speci city, enabling accurate monitoring of pollutant degradation over time. GC-intl

Corresponding author: Pankaj K Ghosh Department of Analytical Sciences Dåçå•å[}, I}åïæ} I}•cåc˘c^ [~P^c¦[|^˘{, C[˘}åå| [~S&åˆ}cå,&æ}å I}å˘•c¦åæ| R^•^æ¦&@, Uccæ¦æ\@æ}å, I}åïæ, E-{æå|:].@[•@335@*{æå|.&[{

of microbial activity and the origin of carbon sources. Isotope ratio mass spectrometry (IRMS) and compound-speci c isotope analysis (CSIA) are powerful tools for assessing the biodegradation of petroleum hydrocarbons and distinguishing between biotic and abiotic degradation processes [12-14].