FOSSIL FUEL POLLUTION IN WADI GAZA AND BIODEGRADATION OF PETROLEUM MODEL COMPOUNDS BY CYANOBACTERIAL MATS

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Abstract

Coastal and sea water pollution is one of several serious problems currently affecting the Gaza Strip. Sediments and cyanobacterial mats in Wadi Gaza are exposed to various levels of pollution mainly with diesel oil. Screening experiments show that petroleum model compounds (pristane, n-octadecane, phenanthrene, and dibenzothiophene) are efficiently biodegraded by cyanobacterial mats from Wadi Gaza. Within forty days, the aromatic compounds disappeared completely, and the aliphatic compounds were degraded to a large extent.

Keywords: Pollution; petroleum hydrocarbons; cyanobacterial mats; biodegradation.

Introduction

The Gaza Strip along the eastern Mediterranean Sea is a coastal area of about 365 km^2 (45 km long and 6-12 km wide). Coastal and sea water pollution is one of several serious problems currently affecting the Gaza Strip (1). At present, significant oil pollution exists along the Eastern Mediterranean coast (2). Wadi Gaza is the only surface water in Gaza Strip. It is used for disposal of sewage water, solid waste, and agricultural and industrial waste water (3). The eastern part of the wadi is influenced by untreated waste-water discharge. The effluent from the Gaza City treatment plant is discharged into Wadi Gaza and then disappears in the dunes and partly reaches the sea (4). Cyanobacterial mats (CBM) develop in the western part of the wadi close to the coast of the Mediterranean Sea. They are naturally exposed to fluctuating salinity due to seasonal sea-water intrusion and fresh-water run-off. In recent years there was increasing concern over the fate of petroleum hydrocarbons in marine ecosystems since several of these compounds are known to exhibit toxic, mutagenic or carcinogenic properties (5,6). We investigated the pollution in Wadi Gaza and carried out a screening experiments for biodegradation of petroleum model compounds by natural CBM.

Materials and methods

Cyanobacterial mats and freeze-dried sediments from Wadi Gaza were extracted with dichloromethane (DCM)-methanol-water 1:2:0.8 (v/v/v) and DCM, respectively. The sediment extracts were separated into aliphatic, aromatic and NSO fractions and analyzed by gas chromatography (GC) and GC-mass spectrometry. CBM from Wadi Gaza were inoculated into 100 ml autoclaved sea water with ammonium chloride (1 mM) and phosphate (8 μM). Pristane, *n*-octadecane, phenanthrene, and dibenzothiophene as petroleum model compounds (PMC) were added by means of organo-clay complexes (OCC; adsorbed on benzyl- trimethylammonium montmorillonite). 50 mg OCC containing 1.65 mg of each compound were added. The experiments were carried out in Erlenmeyer flasks incubated on a rotary shaker (70 rpm, 28°C) under 12 h light /12 h dark conditions. Uninoculated flasks containing medium and OCC served as controls to estimate PMC loss during the incubation period. PMC were extracted with DCM-methanol-water 1:2:0.8 (v/v/v) and quantified by GC.

Results and discussion

The analyses show that the sediments are contaminated with petroleum to variable levels. The aliphatic fractions are dominated by *n*-alkanes up to *n*-C_{35} (Figure 1). *n*-Alkane distributions with maxima between *n*-C_{19} and *n*-C_{21} are attributed to pollution by diesel oil. A predominance of *n*-C_{27}, *n*-C_{29} and *n*-C_{31} is due to the contribution of higher plants growing along the wadi. Elevated concentrations of the C_{17} *n*-alkane partly originate from cyanobacteria. The contribution of diesel oil or other petroleum derivatives is further indicated by the presence of fossil fuel biomarkers, *e.g.* pristane, phytane, and extended 17α,21β-hopanes in the aliphatic hydrocarbon fractions, and methyl- and ethylphenanthrenes and methyl- and ethyldibenzothiophenes in the aromatic hydrocarbon fractions. Increased pristane/C_{17} ratios show that slight biodegradation occurred. In a screening experiment the cyanobacterial mats from Wadi Gaza degraded the aromatic hydrocarbons within forty days. Also the aliphatic compounds were degraded to a large extent (Figure 2). This shows that natural cyanobacterial mats from polluted environments are well adapted to efficiently degrade pollutants. Biodegradation can be considered as potential tool for the cleaning of oil-contaminated marine and coastal environments. Further investigations will be carried out in the field to be relevant for oil spill incidents.

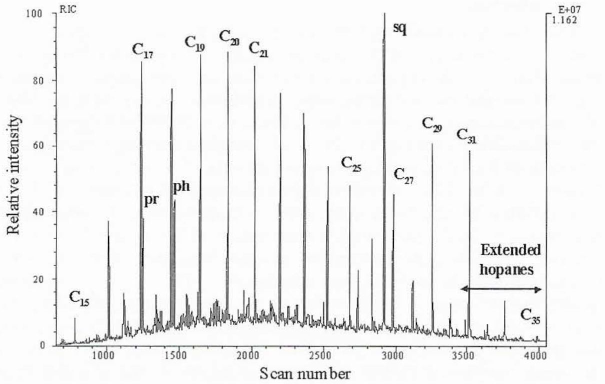

Figure 1. Representative gas chromatogram of an aliphatic hydrocarbon fraction of Wadi Gaza sediment polluted with diesel oil. Major peaks are n-alkanes (carbon numbers are indicated). Pr: pristane, ph: phytane, sq: squalane (internal standard).

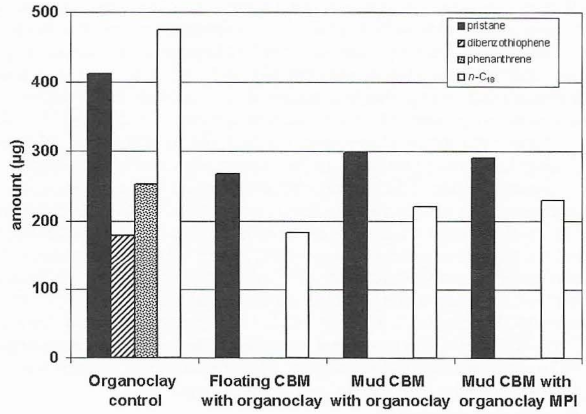

Figure 2. Biodegradation experiment with floating and benthic cyanobacterial mats from Wadi Gaza. Aromatic petroleum model compounds (added by means of organo-clay complexes) were degraded completely after 40 days.

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