Available online at www.sciencedirect.com
ScienceDirect
Environmental Pollution 156 (2008) 82–89
ENVIRONMENTAL POLLUTION
www.elsevier.com/locate/envpol

Evaluation of zoobenthic assemblages and recovery following petroleum spill in a coastal area of Río de la Plata estuarine system, South America

C.S. Ocon [a,b,*], A. Rodrigues Capítulo [a,b], A.C. Paggi [a,b]

[a] Instituto de Limnología ''Dr. Raúl A. Ringuelet'', UNLP-CONICET CC 712, 1900 La Plata, Argentina
[b] Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina

Received 3 April 2007; received in revised form 16 November 2007; accepted 23 December 2007

Oil spill impact was evaluated by zoobenthos response in an estuarine system.

Abstract

The objective of this work was to analyse zoobenthic assemblages in the coastal sector of the Río de La Plata, Argentina, after a petroleum spill. Sampling stations were located in representative sites of various landscapes. Structure, composition, physico-chemical parameters and seasonal changes were recorded in order to assess taxocenosis evolution during the period 1999–2003. Recovery signs were estimated by means of biotic indices and the presence of sensitive species. Tolerant species were dominant in heavily polluted sites, with low diversity and water quality values, according to the biotic indices used. In certain zones, sediment quality remains impoverished, with a visible oil film on the surface. However, during the last sampling, some points showed an increase in biotic indices, pointing to a slight improvement in environmental conditions.

Keywords: Petroleum spill; Zoobenthic macroinvertebrates; Biotic indices; Río de la Plata estuary; South America

1. Introduction

Pollution of the marine environment with oil is potentially one of the most devastating impacts on coastal, estuarine, and inter-tidal regions (Pezeshki et al., 2000). Crude oil represents a complex mixture of both organic and inorganic components which can interfere with oxygen exchange between water and atmosphere, diminishing light penetration and suffocating organisms. Besides, a soluble part in water is very toxic for various forms of aquatic life. In the same way, hydrocarbons are harmful to coastal vegetation causing its deterioration or loss. The coastal marshes are important ecosystems because of their high biological productivity and role as nurseries for coastal fisheries, habitat for wildlife, flood mitigation, shoreline protection from erosion, and water quality enhancement (Lin and Mendelssohn, 1998).

Benthic macroinvertebrates have been extensively used in water quality assessment, since their community structure shows changes in physical and chemical parameters related to anthropogenic disturbances, integrating the environmental factors along time. Several studies (Elmgren et al., 1983; Harrel, 1985; Poulton et al., 1997, 1998; Pontasch and Brusven, 1998; Peterson, 2000; Lytle and Peckarsky, 2001; Colombo et al., 2005a; Gomez Gesteira and Dauvin, 2005; Junoy et al., 2005) have been conducted on the effect of oil spills on zoobenthic organisms.

Macroinvertebrate sensitive species may be directly or indirectly impaired by lethal or sublethal effects of pollutants. This in turn may alter the species abundance or community composition. Specific toxicant could exert lethal effects over certain species with no visible effects on others. According to Gomez Gesteira and Dauvin (2005), the community's

* Corresponding author. Instituto de Limnología "Dr. Raúl A. Ringuelet", UNLP-CONICET CC 712, 1900 La Plata, Argentina. Tel.: +54 11 4275 8564; fax: +54 11 4275 7799.
E-mail address: carolina@ilpla.edu.ar (C.S. Ocon).

0269-7491/$ - see front matter
doi:10.1016/j.envpol.2007.12.035

response includes very high initial mortalities in sensitive species and their subsequent disappearance. This process is followed by a significant increase in the abundance of opportunistic species.

The Río de la Plata drains the second largest basin of South America, "Del Plata," which has an area of 3,170,000 km^2. Its coastal area is affected by anthropogenic disturbances (Paggi et al., 2006) and natural phenomena related to estuarine characteristics. Benthic fauna distribution is influenced by hydrologic conditions, salinity, and sediment size. According to Rodrigues Capítulo et al. (1997), the more abundant macroinvertebrates are Oligochaeta and Nematoda, mainly in sites with high organic matter concentration. Another numerically important group is Mollusca, but its distribution is more closely related to substratum and physico-chemical characteristics. In January 1999, the collision of two ships (one of them carrying crude oil) led to a spill (approximately 1000 tons) affecting the middle zone of this estuarine system.

In order to assess the Río de la Plata estuary water quality, zoobenthic community structure and composition were analysed. Seasonal changes and taxocenosis evolution were registered through time, in order to evaluate recovery signs. Biotic indices and physico-chemical parameters were also assessed.

2. Material and methods

2.1. Study area

The Río de la Plata is located on the eastern coast of South America, between 34°S, 36°20′S latitude and 55°W, 58°30′W longitudes. The river flows into the Atlantic Ocean with a total average discharge of 20,000–25,000 $m^3 s^{-1}$ (Urien, 1972). It is a funnel shaped (30,000 km^2), 320 km in length, with an open mouth of 230 km along the line Punta Rasa–Punta del Este (Framiñan and Brown, 1996; Guerrero et al., 1997). In this system there are three zones with fluvial-marine characteristics such as salinity, geology, hydrology and biology (Boschi, 1988). The top and middle stretches have characteristics typical of rivers while downstream portions present a gradual increase in salinity. However, being an estuarial system with tidal influence, saline intrusions are frequent in those sections, mainly during summer (AGOSBA-OSN-SIHN, 1994).

According to Urien (1972), the South Coastal Fringe is a morphological unit located in a coastal sector extending from the coastline to the 6–9 m isobath. This unit represents three zones: continental, marginal, and marine environments, according to sediment type and salinity. The study site is located in the continental sector with lotic characteristics; however, it is affected by oceanic phenomenon such as tides. The tides' and winds' effects can invert the flow direction of the river, and also increase its level. These conditions influence its physical, chemical and biological characteristics (Bazan and Arraga, 1993).

Grasses such as Senecio bonariensis, Pontederia cordata, Echinodorus grandiflorus, Typha latifolia, Scyrpus giganteus, Eleochares montana or bonariensis and few arboreal species are the dominant riparian vegetation. On the coastal line Scirpus californicus is the dominant species (Cabrera, 1971). In January 1999, the study area was affected by a petroleum spill extending from Punta Blanca to Punta Piedras (Fig. 1). Eighteen sampling stations were placed in representative sites of different landscapes: (a) open beach (without riparian vegetation): La Balandra (LB), Punta Blanca (PB), Campos de Alberdi (CA), Playa Nueva 1 (PN1), Pearson external and internal (Pe and Pi); (b) stream mouths: Marcelo external (Me), Gauchito Gil external and internal (GGe and GGi), Ricardo (R), Alborada (A), Juan Blanco external and internal (JBe and JBi); and (c) bulrush zones: Juncal 1 (J1), Juncal 2 external and internal (J2i and J2e), Playa Nueva 2 (PN2), Marcelo internal (Mi).

2.2. Macroinvertebrates

Samples were taken seasonally (every 3 months) from 1999 to 2001 and twice in 2002 and 2003 (a single sampling in spring). Benthic replicate samples (three grabs per site) were taken with an Ekman grab (100 cm^2). The total number of analysed samples was 756. Macroinvertebrates were fixed *in situ* with formaldehyde (5%). The organisms were sorted, identified and numbered in the laboratory using a stereomicroscope (Olympus SZ-40) and a compound microscope (Olympus CH-2).

Shannon and Weaver (1963) and Margalef (1955) diversity indexes, species richness, and evenness were estimated. The Biotic Index for Pampean Rivers (IBPamp) by Rodrigues Capítulo et al. (2001) and Macroinvertebrate Index for Pampean Rivers (IMRP) by Rodrigues Capítulo et al. (1995) were applied to assess the water quality.

2.3. Physico-chemical parameters

Conductivity (μS/cm) and pH were measured in the field with portable instruments (Cole Parmer conductimeter and Hanna HI 8633 pH-meter, respectively). The presence of hydrocarbons in sediments was visually determined. NO_2^--N (phenol-disulphonic acid method), NO_3^--N (Zambelli reactive method), NH_4^+ (4500 NH_3C method), and total phosphorus (4500-P) were analysed in the laboratory according to APHA (1992). The macroscopic observation of hydrocarbons in sediments allows for their classification in three quality degrees: 1 = sediment with visible hydrocarbons film, 2 = sediment with diffuse oil slicks, 3 = sediment without observable presence of hydrocarbons.

A comparison was made between biological data (IMRP, richness and diversity) obtained in this assessment and hydrocarbon data (aromatic and aliphatic compounds) obtained by Colombo et al. (2005a) in the same date and study area. Reference (LB-P) and affected sites (GG-R) were analysed 6, 13, and 42 months after the oil spill.

2.4. Statistical analysis

Canonical Correspondence Analysis (CCA) was used to evaluate relationships between benthic organisms' sensitivity and physico-chemical parameters for each sampling station. Environmental variables were automatically excluded from the analysis if multicolinearity was observed by a variance inflation factor was greater than 10 and were manually excluded when $p > 0.05$. Significant relationships were tested with a Monte Carlo Test using 199 permutations according to Ter Braak (1986).

All biological and physico-chemical variables (except pH) were log transformed prior to the analyses in order to reduce scale variation effects.

Principal Components Analysis (PCA) was applied to evaluate the trends along time for the three different landscapes under consideration. The analysis also included benthic organism's sensitivity, sediment quality and biotic index values.

3. Results

3.1. Macroinvertebrates

The most abundant macroinvertebrates in the study area and their sensitivities are detailed in Table 1. The benthic fauna was dominated by Nematoda, Oligochaeta (Naididae and Tubificidae), Mollusca, and Crustacea. The tolerant taxa were Oligochaeta (Naididae and Tubificidae), Nematoda, and Chironomidae (Insecta, Diptera), generally linked to low DO contents and high organic matter percentages in sediments. The sensitive organisms that were present in sampling sites were *Claudicuma platensis* (Cumacea), *Sinelobus stanfordi* (Tanaidacea), *Dilocarcinus argentinianus* (Decapoda Trichodactylidae), and *Pseudosphaeroma platense* (Isopoda). These