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ScienceDirect
Environment International 33 (2007) 456–462
ENVIRONMENT INTERNATIONAL
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Liquid versus solid phase bioassays for dredged material toxicity assessment

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Available online 15 December 2006

Abstract

Since 1994 the results of the analyses of key chemical compounds (trace metals, polychlorinated biphenyls and polycyclic aromatic hydrocarbons) and the comparison with the corresponding sediment quality guidelines (SQGs) are used in decision-making for dredged material management in Spain. Nonetheless in the last decades a tiered testing approach is promoted for assessing the physical and chemical characteristics of dredged sediments and their potential biological effects in the environment. Bioassays have been used for sediment toxicity assessment in Spain but few or no experiences are reported on harbour sediments. We studied the incidence of toxicity in the 7d bioassay using rotifers (*Brachionus plicatilis*) and the 48h bioassay using sea urchin (*Paracentrotus lividus*) embryos over a series of experiments employing 22 different elutriates. The relative performance of this exposure phase was not comparable to data on the 10-d acute toxicity test using the burrowing amphipod *Corophium volutator* and the polychaete *Arenicola marina*, carried out on the whole sediments. These results evidence the importance of the exposure route and the test selected in decision-making, as the toxicity registered for the undiluted elutriates was largely due to the different solubility of sediment-bound contaminants. This work and other studies indicate that for many sediments, a complete battery of test is recommended together with physico-chemical analyses to decide whether dredged sediments are suitable for open water disposal or not.

Keywords: Ecotoxicity; Contaminated sediments; Elutriates; Dredged material characterisation

1. Introduction

Ports, rivers and water ways often need regular dredging to keep them open for navigation. Environmental concerns arise when dredged sediments are anoxic and particularly if they come from harbours or industrialized estuaries, since these sediments can be contaminated with different substances due to poor environmental policies in the past. When these dredged materials are excavated and relocated the contaminants can be transferred to the disposal grounds, where they can affect the local benthic community. Moreover during these operations sediments are oxygenated and dispersed and the contaminants may change their chemical speciation, cease to be adsorbed on to silt particles, and then enter food chains and do harm. Several countries are already applying laboratory bioassays for sediment quality assessment and/or dredged material management. One of the issues addressed by several regulatory bodies is the development of standard and sensitive methods since effects-based testing is still under development (den Besten et al., 2003; Peters et al., 2002). This study summarises the results of two different liquid phase tests for elutriate toxicity assessment: the sea-urchin embryo-larval bioassay, that is widely applied for sediment toxicity assessment including sediment elutriate and interstitial water (Beiras et al., 2001; Carr et al., 1996) and the 7-d bioassay using a population of the rotifer *Brachionus plicatilis*, previously used on sediment pore water and elutriates in Spain (DelValls et al., 1998; Riba et al., 2004a). The results are compared with standard 10-day static toxicity tests carried out on the whole sediments: the bioassay using the burrowing amphipod *Corophium volutator* (ASTM, 1991) and the bioassay using the polychaete *Arenicola marina* (Thain and Bifield, 2001). This design allows making direct intertest comparisons and, together with the physico-chemical characterisation of the sediments, to study the performance of

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doi:10.1016/j.envint.2006.10.008

elutriate tests for sediment toxicity assessment in the context of navigational dredging.

2. Material and methods

2.1. Sediment sampling and chemical characterization

Sediments were sampled in the ports of Huelva, Cádiz, Barcelona, Cartagena, Bilbao and Pasajes with a 0.025 m^2 Van Veen grab from approximately the top 20 cm of the sediment (Fig. 1). Sediments were pooled until enough volume was sampled (around 40 L) and were brought to the laboratory, where they were homogenized, sieved through a 2 mm mesh to eliminate debris and stored at 4 °C, darkness and closed hermetically no longer than two weeks prior to tests. Afterwards the sediments were subsampled for sediment chemical characterization, which followed Spanish recommendations for dredged materials (CEDEX, 1994). The analyses consisted of grain size distribution, organic matter content measured as loss of ignition and the concentration of As, Cd, Cr, Cu, Hg, Ni, Pb, Zn, the sum of 7 polychlorinated biphenyls and 12 polycyclic aromatic hydrocarbons. All metals were quantified using flame or furnace atomic absorption spectrometry except As and Hg, measured by hydride generation and cold vapor technique respectively. PCBs were determined by gas chromatography with electron capture detection (EPA 8080) and PAHs by HPLC with fluorescence detection (EPA 8310). Detailed information of the sediment characterization has been recently reported in Casado-Martínez et al. (2006a).

2.2. Liquid phase bioassays

2.2.1. Sediment elutriates

Sediment elutriates were obtained using a modification of the US EPA method (1998). Sediments were homogenized and mixed with clean seawater in a proportion 1:4 v/v (sediment:water) for 30 min at approximately 20 °C. The mixture was left to settle overnight and then the supernatant was siphoned. The sediment elutriates were kept at 4 °C and darkness until they were used in the toxicity tests but no longer than one week. The day the tests were initiated elutriates were transferred to the test chambers manually and they were left to reach the test temperature without additional aeration before the addition of the test organisms.

2.2.2. Rotifer population decay bioassay

Test parameters and conditions followed the protocol developed by DelValls et al. (1996) and are summarized in Table 1. This test evaluates the decrease in a population of the rotifer *B. plicatilis* exposed to the sediment elutriates for 7 days. The test organisms were maintained for 48 h on starving conditions prior to tests to empty the guts and the population decrease was registered throughout the test duration counting 100 organisms under an optical loupe three times a day. The number of surviving organisms was used to calculate the time needed for a decrease of 50% of the initial population under starving conditions (LT50) using a modification of the probit method (DelValls et al., 1996). A negative toxicity control was included on each batch of samples consisting on the same seawater used for culturing the test organisms and to obtain the sediment elutriates. The results were corrected for the corresponding control to compare different batch of experiments.

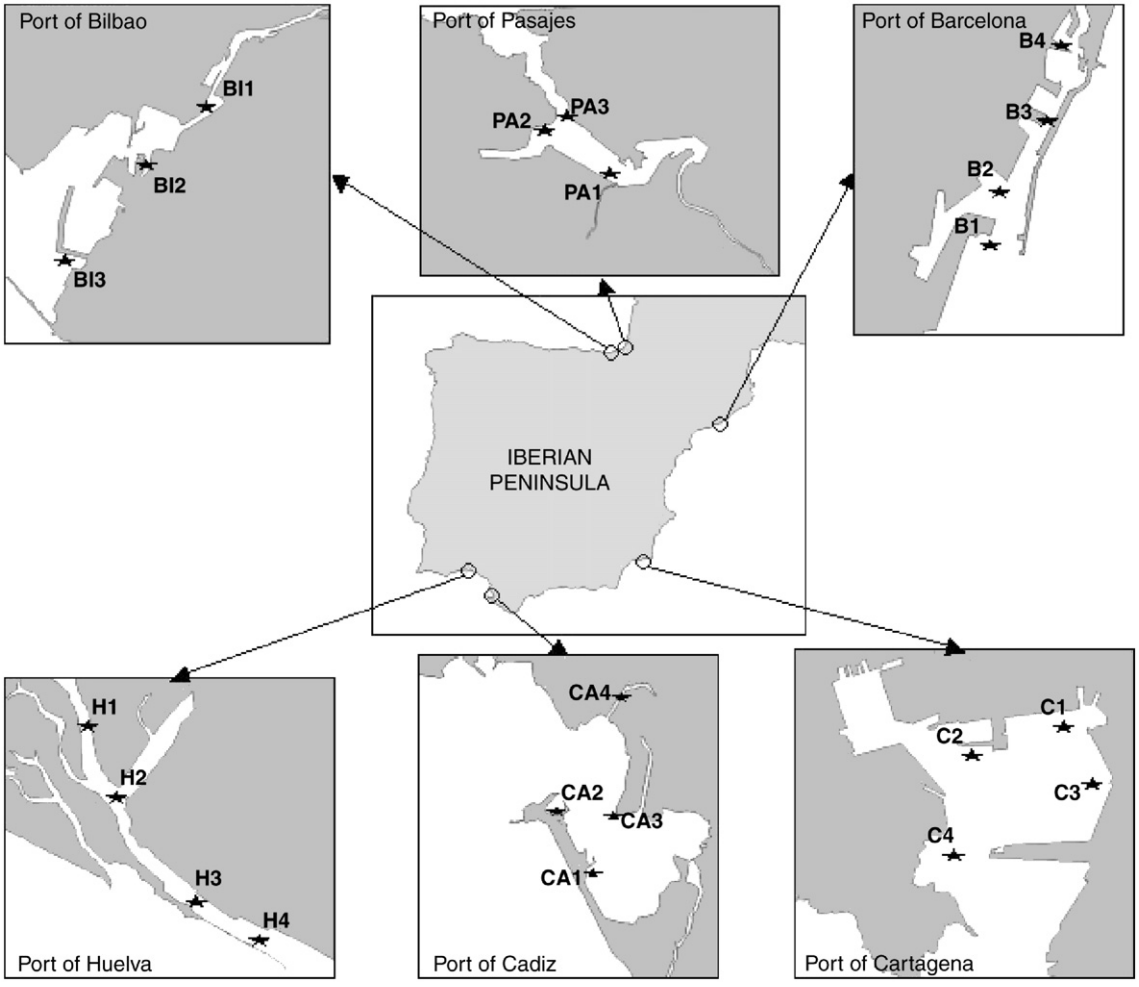

Fig. 1.