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Review Article

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Sea Urchin Bioassays in Toxicity Testing: II. Sediment Evaluation

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Abstract

Bioassays on sea urchin early life stages have been used extensively in evaluating the pollution impact on seawater, coastal sediments, and other matrices as soil, freshwater sediment, and industry effluents. Here we review the literature in this field to determine whether testing whole sediment *vs*. pore water or elutriates by sea urchin bioassays provides a better estimation of actual risk. The present review of our results and from independent groups suggests that testing whole sediment as opposed to other substrates is better suitable, especially when a topographic evaluation of sediment toxicity is required, such as in enclosed bays or in lagoons. Unrestricted to marine sediment, the available methods in testing whole sediment provide an opportunity to test inland, freshwater or terrestrial materials, useful when answering complex mixture questions common to various monitoring and research programs, or for environmental assessment evaluations, or for remediation/ mitigation planning exercises.

Keywords

Sea urchin; Sediment; Pore water; Elutriate; Effluent; Soil

Introduction

Among environmentally occurring complex mixtures, marine sediments have been the focus of extensive research and monitoring efforts when concerned with ecosystem health status of coastal waters following pollutant releases and dredging operations [1,2]. Sea urchin bioassays are a recognized and broadly utilized component of our toolbox when assessing sediment contaminants and impacts to altered health status. After the pioneering report by Kobayashi in 1971 [3] focused on the evaluation of water quality in Seto Bay (Japan), sediment evaluations were recognized as being important when assessing the adverse effects of marine pollution on resident biota. The methodologies were further developed, standardized and regulated by several environmental protection agencies [4-11] due to their importance in answering important ecotoxicity questions.

The present review is aimed at providing a survey of the current body of literature on the use of bioassays on sea urchin early life stages in sediment toxicity testing, along with a critical evaluation of the methods utilized in sediment toxicity evaluations. The background literature and prospective use of non-marine substrates in answering similar questions are also outlined.

Methods in Sediment Toxicity Testing

Evaluating sediment quality is a complex procedure commonly ascribed to the so-called "triad" encompassing (i.) analytical determination of pollutants in sediment and resultant bioaccumulation in sediment-dwelling biota; (ii.) evaluation of biodiversity and population density of said biota in sediment and (iii.) *in vitro*, *in vivo*, or mesocosm toxicity bioassays in some selected bio indicator benthic biota [1,2,4-6,12].

Among bioassays in sediment toxicity testing, three sediment preparation methods have been utilized, i.e. by testing pore water (PW), elutriates (EL), or whole sediment (WS). For particular purposes, other substrates may be utilized, such as spiked sediment or overlying water.

Pore water, also termed interstitial water, is the water occupying space between sediment or soil particles [2] and is obtained by centrifugation or filtration of WS. Its presence and potential utilization is conditioned by sediment/soil granulometry due to its limited availability in sandy substrates.

Elutriate is the water extracted from shaking of WS with water (usually in ratio 1:4). The mixture is allowed to settle and the liquid phase is centrifuged and/or filtered [2,13]. The EL test was designed for evaluating the potential effects of water-soluble constituents of dredged material [14].

Whole sediment may be tested with or without minimal manipulation, such as freezing and thawing while maintaining both water and solid phase of the original sediment sample [2].

Following the recommendations of most environmental protection agencies [4-11], a frequently adopted practice in sediment toxicity testing includes a combination of both EL (and PW) and of WS by using different test organisms. For example, amphipods or polychaetes are commonly suggested when testing WS, while sea urchin and/or oyster embryos are recommended in EL or PW tests [15-19].

Thus, most of the available literature on sediment toxicity testing in sea urchin early life stages relies on EL or PW testing. As shown in Table 1, sea urchin embryo and sperm bioassays have been (and currently are) performed in an extensive number of investigations on sediment toxicity by means of EL or PW preparations [19-43]. It should be noted that a number of these reports showed PW-induced fading results [26-28], or openly recognized inconsistencies between the results of contaminant analyses and the outcomes of sea urchin bioassays [41-43].

The use of WS in toxicity evaluations has been applied in a number of studies of sea urchin embryo and sperm bioassays on marine and freshwater sediments, and on soil samples [44-55], as presented in Table 2. Most of this literature has been reported by our group [44,47-55] through active research projects of Toulon Bay (France) in 1990 [44] and later in a series of coastal sites in Europe under two European Commission-supported projects (BIOMAR I and BIOMAR II Projects, #ENV5V-CT94-0550 and #ENV4-CT96-0300) [47], and finally after more recent studies of sediments in Mytilene

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