Marine Pollution Bulletin 63 (2011) 108–118

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Application of artificial mussels (AMs) under South African marine conditions: A validation study

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ARTICLE INFO

Keywords:
Artificial mussel
South Africa
Metals
Monitoring

ABSTRACT

Over the last three decades there has been a significant decline in the number of marine pollution monitoring-related studies in South Africa. Thus, the current study was conducted to assess the current state of metal contamination within the South African marine environment through the validation of the artificial mussel (AM). Indigenous reference mussels (*Perna perna*) were deployed alongside the passive device within the South African marine environment for a 6 week exposure period. Analysis of metal uptake (Cd, Cr, Cu, Pb and Zn) was determined by filtration and elution of the AM chelex resins, microwave digestion of the transplanted mussels, and determination of their metal concentrations by ICP-MS and ICP-OES analysis. Uptake patterns between the AM and transplanted mussels showed significant temporal and spatial correlation for the majority of the elements analysed. While the AM provided relevant and complementary information on the dissolved metal concentrations, limitations were also observed.

1. Introduction

The use of mussels for marine biomonitoring in South Africa can be traced back to 1974 (Cloete and Oliff, 1976). The existence of biomonitoring programmes to determine the fate and impacts of inorganic pollutants along the coastline was relatively short lived, with the last known report by the South African National Committee for Oceanographic Research (SANCOR, 1990). Today, the majority of marine pollution monitoring is conducted by academic institutions (Mills, 2005; Rajkumar, 2008) or by the South African Environmental Observation Network (SAEON) (Wepener, 2008; Degger and Wepener, 2009). Currently, no national marine pollution monitoring programme exists and with a 60% increase in population residency along the coastline (DEAT, 2008), conservation and sustainability practices cannot be realised unless a pollution monitoring programme is implemented to prevent environmental degradation.

While the use of bivalve organisms as bioindicators has several advantages over sediment and water, they are hindered by certain physical (temperature and salinity) and biological (size, reproductive state, age, gender) factors (Philips and Rainbow, 1994; Wu and Lau, 1996). In addition, different species have varying pollutant accumulation strategies and biogeographical distribution of all biomonitoring species is limited, making global and local spatial comparisons difficult, if not unachievable (Leung et al., 2008). Many studies have touched on the influence of these variables (Hennig, 1985; Rainbow, 1993; Leung et al., 2001, 2002), highlighting the probability of erroneous conclusions due to the masking of metal bioaccumulation concentrations as suggested by Philips and Rainbow (1994). Marine pollution studies would therefore benefit from the adoption and implementation of technology which provides uniformity of metal bioaccumulation results.

The artificial mussel (AM) was first developed by Wu et al. (2007) with the aim of providing a methodology which overcomes the limitations of biological bioindicators. The AM consists of plastic perspex tubing and artificial seawater suspending the ligand Chelex-100. Testing of this ligand by Wu and Lau (1996) demonstrated its potential to allow for direct and global comparisons due to its ability to overcome hydrographic limitations. This was reiterated by the field validation of the AM in Scotland and Iceland which showed the capability of the device to provide standardised results as well as a time-integrated estimate of metal concentrations in the marine environment without the influence of temperature and salinity (Leung et al., 2008). According to Wu et al. (2007) the AM has the capability to accumulate metal concentrations at environmentally relevant levels. The uptake and release of metals appear to be less affected by salinity and temperature in the AM as opposed to transplanted mussels and the device seems to overcome the problems associated with reproduction, growth and geographical limitations in transplanted mussels, thus enabling worldwide comparisons (Wu et al., 2007).

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0025-326X/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.marpolbul.2011.04.040

The objective of this paper is to determine the potential of the use of AMs under South African marine conditions at selected sites by conducting field validation tests.

2. Materials and methods

South Africa's Harbours access two oceans, the Indian and Atlantic with some of Africa's busiest ports (Marshall and Rajkumar, 2003). According to Wepener and Vermeulen (2005) extensive port development has occurred along the coastline and has the potential to negatively impact on the important ecological functions that they provide (Forbes et al., 1996). Consequently, port environments are put under pressure by contaminants associated with the shipping industry as well as discharges which are largely land derived (Taljaard, 2006). Due to their sheltered and polluted nature, harbours provide an ideal environment for validation of the passive device. Thus, AMs were deployed along with the indigenous brown mussel, *Perna perna*, within Saldanha Bay, Cape Town, Port Elizabeth and Richards Bay Harbour sites. The mussels for transplantation studies were obtained from the pristine reference site within the Tsitsikamma National Park (Fig. 1).

2.1. Temporal analysis

Temporal analysis was conducted between March and April 2009. This period was specifically selected to avoid spawning phases of the transplanted mussels, which take place during May to October (McQuaid, 2005). At each site 75 AMs and 100 *P. perna* (20–30 mm) were secured within plastic cages ($26 \times 21 \times 14$ cm, mesh size 0.3 cm^2) and attached to navigational buoys at a depth of 2 m. After a 4 week exposure period, five AMs together with 10 mussels were retrieved from each site for metal analysis. Sampling was repeated every 7 days over a 6 week period to assess the metal uptake profiles.

2.2. Spatial analysis

Spatial comparison took place during March and April 2009. Similar to the temporal study, 10 AMs and 20 *P. perna* (20–30 mm) were deployed in plastic cages and secured to navigational buoys and exposed for 4 weeks. Samples were then retrieved following a 6 week exposure period. To maintain randomness, five AMs and 10 *P. perna* were then selected for metal analysis.

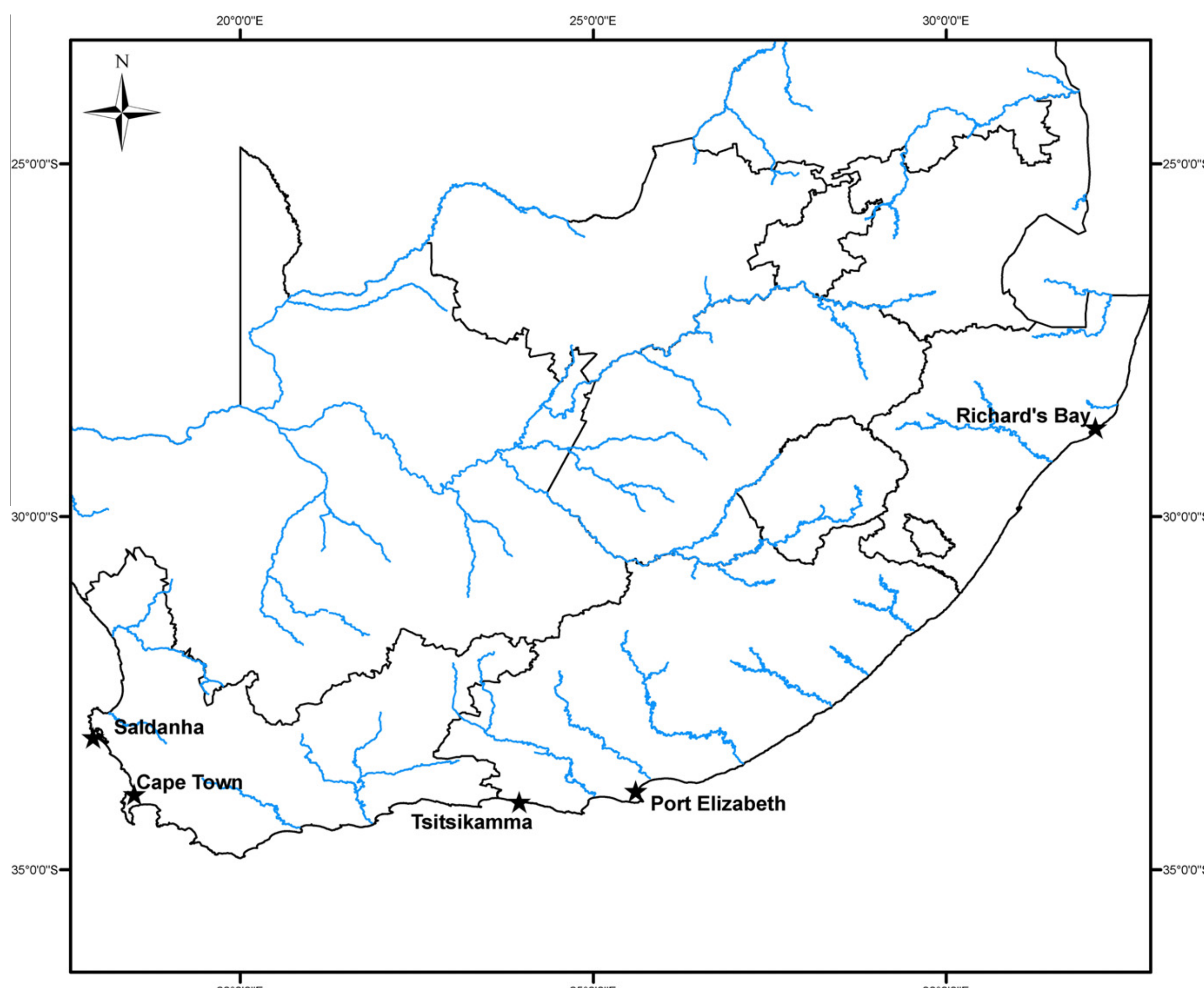

Fig. 1. Study sites selected along the South African coastline.