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Baseline survey of marine sediments collected from the State of Kuwait: PAHs, PCBs, brominated flame retardants and metal contamination

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ABSTRACT

A geographically extensive baseline survey of sediment contamination was undertaken at twenty nine locations around Kuwait. Samples were assessed in relation to a wide range of industrial pollutants, including metals, PAHs, PCBs, PBDEs and HBCDs. The data generated indicated that levels of pollutants were generally low and below commonly applied sediment quality guidelines (SQGs). However, naturally high background concentrations of certain metals present in sediment from the region may prohibit the direct assessment against some of the routinely applied SQGs. Hot spots of contamination were identified for PAHs, PCBs and PBDEs, that were mainly associated with the Shuaiba Industrial Area, located south of the city, and known to contain a diverse mix of both light and heavy industry.

1. Introduction

The State of Kuwait has witnessed major economic, social and industrial development following the discovery and exploitation of its vast oil reserves (Al-Abdulghani et al., 2013). Similar to other countries, which comprise the Gulf Co-operative Council (GCC), the rapid expansion of Kuwait's industrial sector has mainly occurred around its coasts (Al-Rifaie et al., 2007; Al-Abdulghani et al., 2013). As a consequence a variety of contaminants have been discharged directly into the marine environment, including petroleum hydrocarbons, trace metals, nutrients (from raw domestic sewage), and contaminated brine from desalination plants, which are essential for freshwater production in the region (Readman et al., 1992; Al-Ghadban et al., 2002; Al-Sarawi et al., this issue). Analysis of sediment and biota have shown the marine environment around Kuwait to be contaminated with a range of aliphatic and polycyclic aromatic hydrocarbons (PAHs) and organochlorine contaminants (Beg et al., 2009; de Mora et al., 2010; Al-Sarawi et al., this issue). Power generating industries and desalination plants are also known to be point sources of contamination and elevated levels of heavy metals, which in some instances exceeded human consumption safety limits, have been observed in clams (*Amiantis umbonella*) collected from Kuwait Bay (Tarique et al., 2012, 2013). A large number of industrial outfalls, storm water culverts and earth channels are situated along the coastline of Kuwait and discharge directly into the sea. It is known that these release raw sewage and untreated industrial water to the marine environment (Ghannoum et al., 1991; Al-Ghadban et al., 2002; Bu-Olayan and Thomas, 2014; Lyons et al., this issue). Domestic sewage in Kuwait has a high organic content and is often septic because of low flows, long retention times, high ambient temperatures and concomitant anaerobicity (Al-Ghadban et al., 2002).

Past events, such as the 1991 Gulf War, have further contributed to environmental pressures associated with rapid industrialization. During this period it is estimated that 9–10.8 million barrels of oil were released into the coastal waters of Kuwait from sabotaged tankers and pipelines at the Al-Ahmadi terminal (Al-Abdali et al., 1996; Readman et al., 1996). As a consequence the environment was exposed to an array of contaminants, which included petroleum hydrocarbons from burning oil wells and polychlorinated biphenyls (PCBs) and heavy metals from damaged industrial facilities (Massoud et al., 1998; Al-Sarawi et al., 2002). These impacts are exacerbated by other sources of marine pollution that include atmospheric fallout from dust storms and particulate matter transported from the Shatt Al-Arab river (Al-Ghadban et al., 2002; Al-Ghadban and El-Sammak, 2005). It is also known that natural oil

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seepage occurs at a number of sub-sea locations and these are also thought to be important point sources of contamination at various locations around the coast (Al-Ghadban et al., 2002).

Here we describe the results from a survey which collected sediment from twenty nine locations situated within Kuwait Bay (including Sulaibikhat Bay) and along the Gulf coastline towards the Shuaiba Industrial Area (SIA) to the south of the city (Fig. 1). Sediments were analysed for PAHs, metals and an array of organohalogen compounds.

2. Material and Methods

2.1. Sampling and characterisation of marine sediment from Kuwait

Samples were collected during 2013/2014 using a hand-held van Veen grab deployed from research vessels provided by the Kuwait Environment Public Authority (KEPA), Kuwait Institute of Scientific Research (KISR) and Public Authority for Agriculture and Fish Resources (PAAFR). The top layer of each grab sample was collected using a stainless steel scoop and immediately transferred to a *n*-hexane rinsed 500 ml glass jar. Samples were kept on ice before transferring to <−20 °C for storage prior to analysis. Particle size analysis (PSA) was completed on each sample. Laser diffraction analysis of the <1 mm fraction of each sample was undertaken, with the remaining sediment wet split at 63 μm. The >63 μm fraction was dry sieved at 0.5 Phi intervals down to 4 Phi (63 μm). The <63 μm fraction was freeze-dried and weighed. The sieve and laser diffraction data were merged to form a complete particle distribution for each sample. Quality assurance tests include comparing weights of samples before sieving, during sieving and after sieving. Totals are checked and any results with any anomalies were re-sieved. Certified reference materials (CRMs) were analysed regularly with the laser-sizer, as well as an in-house reference material (IHRM) which was analysed at the start of every day that analysis was completed. PSA ring tests are completed as part of the National Marine Biological Analytical Quality Control (NMBAQC) scheme. Total organic carbon (TOC) was completed on both the <63 μm fraction (prepared as described within PSA methodology) and <2 mm fraction. For the <2 mm fraction, sediment samples were air-dried after removal of >2 mm fraction. The <2 mm sediment was ground and both <63 μm fraction and <2 mm fractions analysed. Inorganic carbon was removed using a sulphurous acid digest. TOC was measured using a Carlo Erba EA1108 Elemental analyser. Quality control was carried out with 3 repeats for 1 in 10 samples (with rsd% of <10%), additionally a CRM was included for 1 in 10 samples and 3 replicates of IHRM were completed for each batch. Limits of detection were <0.02% for organic and

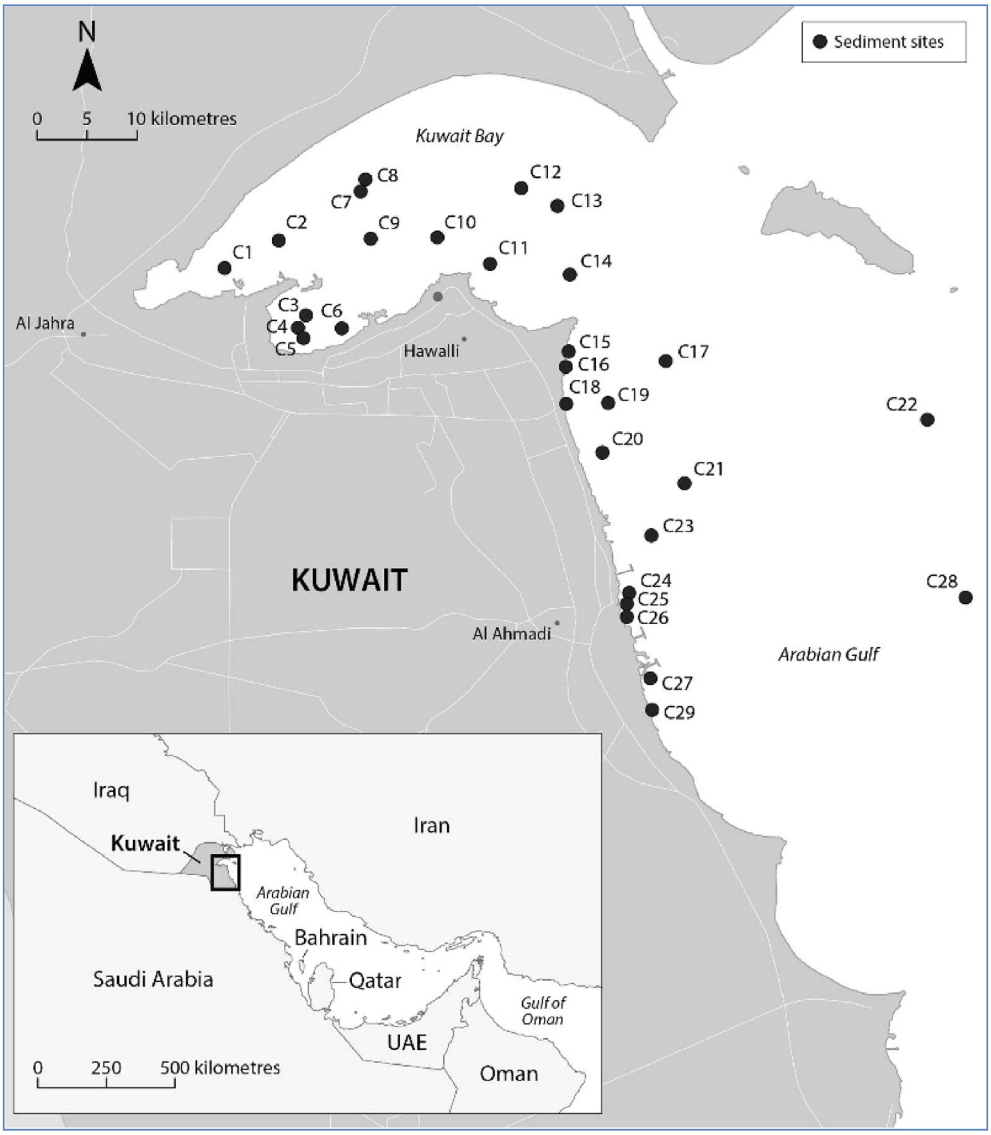

Fig. 1. Sediment sampling locations.

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