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Baseline

Combined effects of land reclamation, channel dredging upon the bioavailable concentration of polycyclic aromatic hydrocarbons (PAHs) in Victoria Harbour sediment, Hong Kong

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ABSTRACT

The up-to-date concentration of polycyclic aromatic hydrocarbons (PAHs) in sediment materials of Victoria Harbour was investigated so as to evaluate the pollution potential associated with the reclamation projects in Hong Kong. A total of 100 sediment samples were collected at 20 locations. Except the control point in reservoir, the PAHs concentrations were detectable levels all sites (131–628.3 ng/g, dw) and such values were higher than Dutch Target and Intervention Values (the New Dutch standard in 2016). The PAHs concentration indicating that construction waste and wastewater discharges were the main pollutant sources. Results of correlation in single cell gel electrophoresis assay (comet assay) studies also revealed that the PAHs concentration was highly correlated (<0.01) with DNA migration (i.e. the length of tail moment of fish cells) in 5 mg/ml of PAHs. The above observation indicates that the PAHs present in the sediment may substantially effect the marine ecosystem. Although the dredged sediment can be a useful sea-filling material for land reclamation; however, the continuing leaching of PAHs and its impact on the aquatic environment need to be studied further.

Rapid population growth and urbanization in Hong Kong has contributed to unsustainable coastal development such as reclamation which has deteriorated the marine ecosystem (Rao et al., 2014). Reclamation and site formation projects have generated increasing environmental concerns as these activities cause widespread redistribution and resuspension of sediment-associated contaminants (Cheung et al., 2005). Several studies showed that dredging or sediment suspension activities have affected aquatic fauna and marine ecosystem (Steger and Gardner, 2007; Magni et al., 2008; Jane et al., 2010; Sundstein et al., 2010; Vinther et al., 2012; Kolarević et al., 2016). Besides, several publications showed that polycyclic aromatic hydrocarbons (PAHs) are widespread and accumulate in aquatic systems (Cheung et al., 2007; Li et al., 2015). These carcinogenic substances tend to adsorb tightly to sediment thus affecting the survival of aquatic organisms. Due to frequent reclamation activities in Hong Kong, scarce up-to-date information of PAH concentration was rare on the sediment in Hong Kong Waters, the objective of this research was to report the PAHs in sediment and its ecotoxicological effects in an attempt to study an impact on the aquatic environment.

A total of 100 surface sediment samples (with five replicates from each site) were collected from nineteen coastal sites (Tai O, Mui Wo, Tung Chung, Chai Wan, North Point, Causeway Bay, West Point, Aberdeen, Lam Tin, Kai Tak, Hung Hom, Cheung Sha Wan, Tsuen Wan, Yuen Long, Sha Tin, Tai Po, Junk Bay, Tsing Yi, Sai Kung) and one control site (Port Shelter Reservoir) in Hong Kong (Fig. 1). All samples were collected using a grab sampler and packed immediately into aluminum foil and stored in a refrigerator (0 °C) and then transported to the laboratory where they were stored at −20 °C until further analysis. Sediment samples were freeze-dried, ground, and homogenized by sieving through a stainless steel 75 mesh (0.5 mm) sieve and stored in glass containers at −20 °C until extraction. Sieved samples (about 5 g) were extracted for 16–18 h with a mixture of acetone, dichloromethane (DCM), n-hexane (v:v:v 1:1:1, 120 ml) in Soxhlet extractors according to the EPA Standard Method 3540C. Florisil column clean-up was used for purification of the concentrated extract according to the EPA Standard Method 3620B. Deuterated PAH internal standards (acenaphthene-d10, phenanthrene-d10, chrysene-d12 and perylene-d12) were added into all extracts to the concentration of 320 ng/g prior to instrumental analysis for

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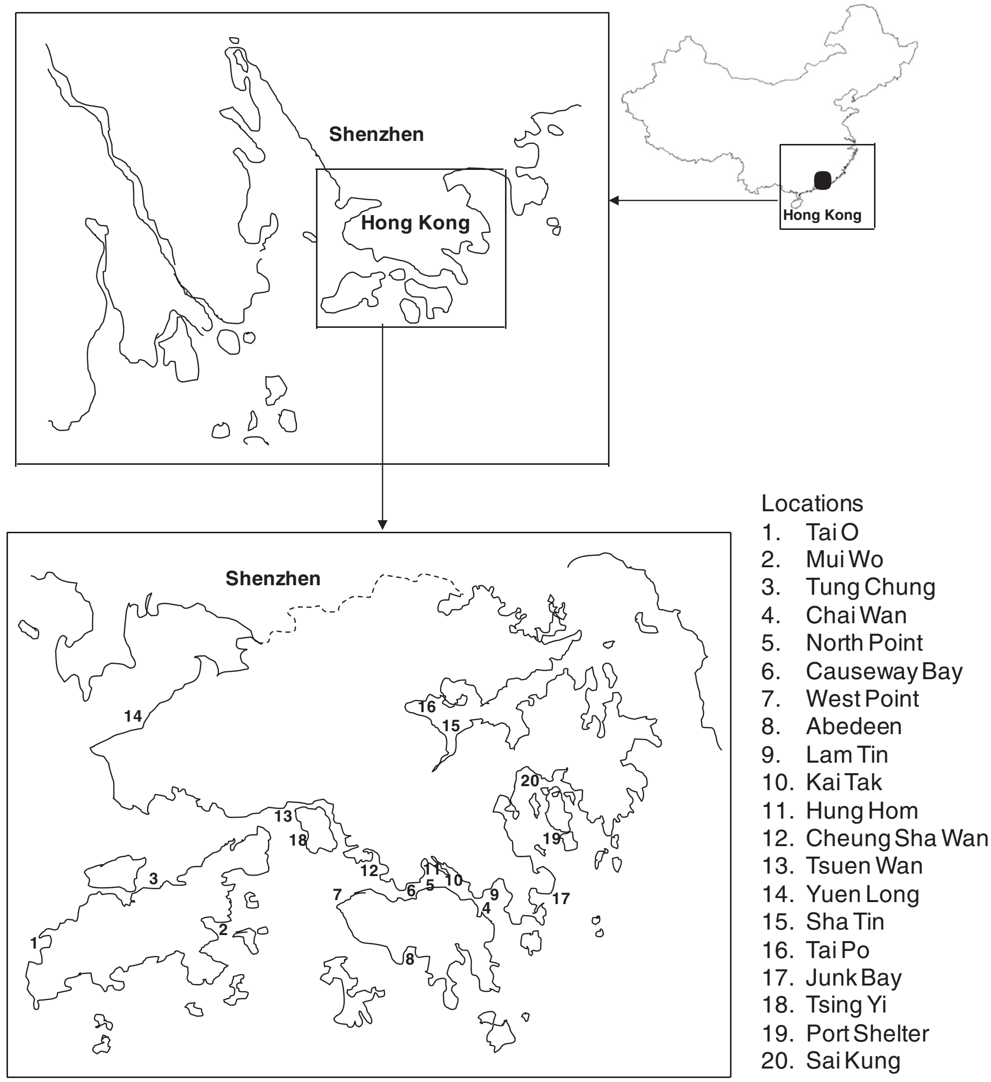

Fig. 1. Sampling locations.

quantitation by a Hewlett Packard (HP) 6890 N gas chromatograph (GC) coupled with a HP-5973 mass selective detector (MSD) and a 30 m × 0.25 mm × 0.25 mm DB-5 capillary column (J & W Scientific Co. Ltd., USA) using the EPA Standard Method 8270C. The PAH standards (AccuStandard, New Haven, CT) consisted of 16 USEPA priority PAHs: naphthalene (Nap), acenaphthylene (Acel), acenaphthene (Ace), fluorene (Fl), phenanthrene (Phe), anthracene (An), fluoranthene (FlA), pyrene (Py), benz(a)anthracene (BaA), chrysene (Chry), benzo(a)pyrene (BaP), benzo(b)fluoranthene (BbF), benzo(k)fluoranthene (BkF), indeno(1,2,3-cd)pyrene (IP), dibenz(a,h)anthracene (DahA) and benzo(g,h,i) perylene (BghiP). As the peaks of benzo(b)fluoranthene (BbF) and benzo(k)fluoranthene (BkF) were extremely close and difficult to be distinguished, these two compounds were thus combined as one, namely B(b + k)F. Concentrations based on individually resolved peaks were summed to obtain the total PAH concentrations. All the results were reported in ng/g, dw (dry weight).

Single cell gel electrophoresis assay (comet assay) was used to investigate the effect of leachable PAHs upon the DNA damage of fish cell. *T. philippinarum* (clam) were collected from six sites (Port Shelter, Tai Po, West Point, Causeway bay, Tai O and Tsing Yi) in four seasons (spring, summer, autumn and winter). The isolated cells were treated with ten successive levels of PAHs (0-5 mg/ml of PAHs). Slides were examined to investigate the extent of DNA strand breakage according to USEPA method. The cell migration percentage were compared within the same PAHs concentration by one-way ANOVA. Analysis of correlation coefficients between tail moment mean, and PAHs concentration was conducted using Pearson's Correlation Coefficient.

PAHs concentrations in surface sediment are shown in Table 1. The concentration range of PAHs in surface sediments among the 20 sampling locations were 26.1–638.3 ng/g (dw). Nearly all of the target compounds were detected in the sediment samples except for B(ghi)P, D(ab)A and B(b + k)F. Nap, Phe, Py and BaA had relatively higher proportions among all the compounds. Among all the sampling sites, the PAHs concentrations of sediment sampled at TY (i.e. 638.3 ng/g, dw) were the highest and the lowest concentrations were found at PS (i.e. 26.1 ng/g, dw). The PCA is performed on the PAHs components collected in twenty sampling sites (Fig. 2). Sites of greater similarities are plotted closer together, while sites of low similarity are further apart. The PCA figure showed two distinct groups according to their PAH concentrations and components. There is one majority of grouped sites as similar in composition of PAHs, with the sediment sample taken in TY coastal area (i.e. NT-6) was dissimilar. Compared with sediments of worldwide, the PAH contamination levels in Hong Kong were higher than Dutch value (i.e. 40 mg/kg) (VROM, 2016), Daya Bay (a key aquaculture area in China, 42.5–158.2 ng/g, mean 126.2 ng/g, dw, Yan et al., 2009), Gulf of Aden, Yemen (2.2–604 ng/g, mean 82.4 ng/g, dw, Mostafa et al., 2009) and Potter Cove, Antarctica (37–252 ng/g, dw, Curtosi et al., 2009), and lower than Zhelin Bay (an important bay for marine