Marine Pollution Bulletin xxx (2014) xxx–xxx

Contents lists available at ScienceDirect

Marine Pollution Bulletin

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

# Structure and taxonomic composition of free-living nematode and macrofaunal assemblages in a eutrophic subtropical harbour, Hong Kong

W.Z. Xu [a], S.G. Cheung [a,b], Paul K.S. Shin [a,b,*]

[a] Department of Biology and Chemistry, City University of Hong Kong, Hong Kong
[b] State Key Laboratory in Marine Pollution, City University of Hong Kong, Hong Kong

ARTICLE INFO

*Keywords:*
Nematodes
Macrofauna
Diversity
Organic enrichment
Recovery
Subtropics

ABSTRACT

The spatial and seasonal taxonomic composition patterns of macrofauna and nematodes in a eutrophic subtropical harbour, previously suffered from sewage pollution, were studied in relation to a number of sediment parameters. In the polluted, inner-harbour area, levels of organic contents and heavy metals were high, whereas species number, abundance and diversity of nematodes and macrofauna were the lowest in comparison to the cleaner, outer-harbour area. Different taxonomic composition patterns of nematodes and macrofaunal assemblages were found between inner-harbour and outer-harbour area, which was highly correlated with sediment nutrient levels. Different responses of macrofaunal and nematode communities to sewage pollution suggested that macrofauna might be more tolerant than nematodes to eutrophic conditions due to their ability to modify the sediment. The present findings indicated the usefulness of studying both nematode and macrofaunal communities, in order to reveal different aspects of the benthic ecosystems in response to organic enrichment.



## 1. Introduction

Organic pollution is one of the most common disturbances within marine benthic communities. The direct consequence of organic enrichment in sediments is similar to the impacts of hypoxia, which leads to the reduction or disappearance of sensitive organisms (Vollenweider et al., 1992; Grall and Chauvaud, 2002). Organic input can also influence the abundance of the microorganisms which are used as food sources for the benthic fauna, which, in turn, affect the energy flow and food–web interactions of the biological communities (Coull and Chandler, 1992; Cheung et al., 2008).

Regarding communities of benthic invertebrates, macrofauna have been traditionally used to describe the state of the seabed environment, because of their high taxonomic diversity and abundance, wide range of physiological tolerance to various stresses, and diverse feeding guilds and life-history strategies, which allow them to respond to a range of environmental conditions (Gómez-Gesteira and Dauvin, 2000; Nilsson and Rosenberg, 2000; Pinn and Robertson, 2003). Moreover, macrofauna tend to have larger body size (>0.5 mm), are relatively less mobile and cannot easily escape from stresses generated from natural and/or anthropogenic disturbances. Thus, they can be routinely sampled and analyzed to reflect the local benthic status in biological monitoring programmes (Marín-Guirao et al., 2005; Dauvin et al., 2006). However, in recent years, the smaller-size meiofauna (<0.5 mm) has also been used for assessing effects of environmental changes in marine sediments (Moreno et al., 2008; Liu et al., 2011), principally because of their special characteristics of life cycles: ubiquitous distribution, small size, rapid generation time and lack of larval dispersion (Higgins and Thiel, 1988), which make them sensitive to such changes. Among the meiofauna, nematodes are particularly the richest species group, with great abundance and high structural and functional diversity (Heip et al., 1985).

The communities of macrofauna and nematodes can provide different information to reflect environmental status as the smaller-size nematodes exhibit an interstitial life style opposite to the surface dwelling behaviour of the larger macrofauna (Schwinghamer, 1981). However, only few studies have compared the responses of nematodes and macrofaunal communities to various types of perturbations thus far. From a large-scale mesocosm experiment, Austen and Widdicombe (2006) reported different responses of meio- and macrobenthos to physical disturbance and organic enrichment, which were attributed to the constraints of the experimental design and different ecology of these two faunal groups. A field study on benthic recolonization from dredged materials by Bolam et al. (2006) also noted the difference in the settlement patterns for meio- and macrofauna, principally because of

* Corresponding author at: Department of Biology and Chemistry, City University of Hong Kong, Hong Kong. Tel.: +852 3442 7720; fax: +852 3442 0522.
*E-mail address:* bhpshin@cityu.edu.hk (P.K.S. Shin).

0025-326X/$ - see front matter © 2014 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.marpolbul.2014.01.023

their different relationships with sediment characteristics. *In situ* field studies of the responses of these two benthic faunal groups to sewage pollution in subtropical areas are lacking.

Victoria Harbour in Hong Kong is one of the busiest and heavily populated ports in the world. Over three million people live along both sides of the harbour and discharge 1.7 million tonnes of preliminarily treated sewage daily, leading to severe organic pollution especially in the harbour proper. While the water quality has been improving since 2001, owing to the interception of most of the discharges for central treatment, the majority of the sediment in the central harbour area still contains high levels of organic matter (Liu et al., 2011). This study aimed to investigate the structure and taxonomic composition of free-living nematode and macrofaunal assemblages in Victoria Harbour, and compare the changes in their community structure between organically enriched, inner-harbour and relatively cleaner, outer-harbour area.

## 2. Material and methods

### 2.1. Field sampling and treatment of samples

Sediment samples were collected at five sites, in which two were located outside the harbour and three inside the harbour area (Fig. 1). Field sampling at these sites was conducted once in January and August 2010, representing the dry, winter and wet, summer seasons in subtropical Hong Kong (Morton and Morton, 1983). A Global Position System was used to fix the position of these sampling sites. At each sampling site, nine sediment samples were collected with a 0.1 $m^2$ van Veen grab. Three sediment samples were used for free-living nematode analysis, in which samples were taken using a cut-off syringe ($D$ = 3 cm $\times$ $L$ = 8 cm) from each replicate grab sample. Another three sediment samples were used for macrofaunal analysis, in which sediment was gently rinsed through a stack of sieves with 1 mm mesh on top and 0.5 mm mesh at the bottom. Residues retained on the sieves were transferred into plastic bottles. All the animal samples were fixed with 4% buffered formalin immediately on board and followed by staining with 1% Rose Bengal. Surface sediment for particle size and chemical analyses, including total organic carbon (TOC), total Kjeldahl nitrogen (TKN), total phosphorus (TP) and heavy metals (Cu, Cd, Zn, Pb, Mn, Fe, Co, Ni), were collected from another three grab samples. All sediment samples for chemical analyses were stored in an ice box on board and transferred to the laboratory for further processing.

### 2.2. Laboratory processing

Upon arrival to the laboratory, the sediment samples, except those for particle size analysis, were frozen at −20 °C for 24 h followed by freeze-drying. The freeze-dried sediments were homogenized to <0.25 mm with a mechanical homogenizer and stored in a desiccator for further analyses. TOC in sediment was measured by Walkley–Black wet titration method (Walkley and Black, 1934). TKN and TP in sediments were extracted by Kjeldahl acid digestion, followed by measurement using a Flow Injection Analyzer. Particle size distribution was determined with the wet sieving method (Buchanan, 1984). The concentration of heavy metals was determined, after microwave digestion, by inductively coupled plasma-mass spectrometry. Md was expressed in phi ($\phi$) notation, where $\phi = -\log_2$ (particle diameter in mm) (Krumbein and Pettijohn, 1938), TOC in % and TKN, TP and heavy metals (except Fe) in mg/kg on dried weight basis, whereas Fe was expressed in g/kg.

Meiofauna were extracted from the sediment by the Ludox™ centrifugation technique (Heip et al., 1985), using a 31 μm sieve as the lower size limit and a 500 μm sieve as the upper size limit. Each sample was washed into a lined petri dish and meiofauna were sorted and counted under a stereoscopic microscope. Specimens of nematodes were then slowly evaporated in anhydrous glycerol, mounted on permanent slides, and identified to species or genus level using a compound microscope with bright-field illumination (Liu et al., 2007, 2011). Macrofaunal samples were sorted from sediment residues and animals collected were identified to the lowest possible taxonomic level and enumerated. For soft-bodied animals, only the anterior fragments were recorded to avoid double counting of individuals.

### 2.3. Data analysis

#### 2.3.1. Sediment parameters

Twelve sediment parameters including sediment median diameter (Md) and concentrations of TOC, TKN, TP and heavy metals (Cu, Cd, Zn, Pb, Mn, Fe, Co, Ni) were examined using normalized principal component analysis (PCA) to compare the differences in sediment parameters at the five sampling sites (Pielou, 1984).

#### 2.3.2. Benthic fauna

The total numbers of individuals and species were calculated per 0.1 $m^2$ for macrofauna and per 10 $cm^2$ for nematodes, with three replicates per sampling site. The diversity of nematode and

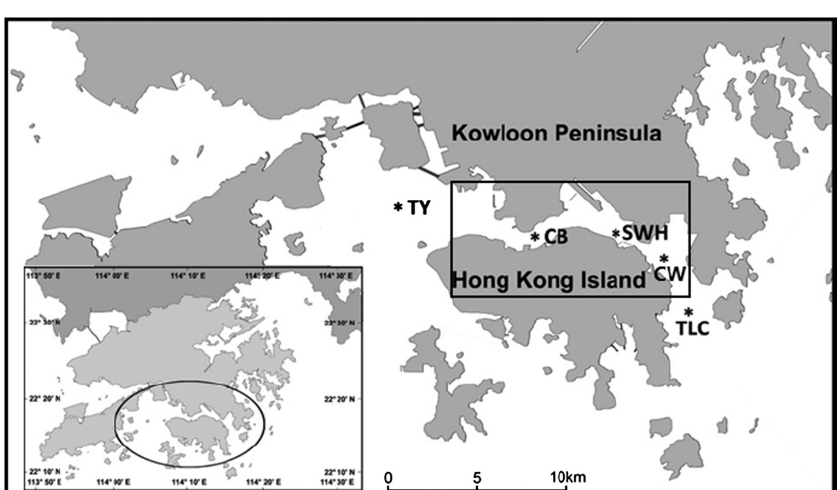


**Fig. 1.** Map of Victoria Harbour, showing five sampling sites (TLC: Tung Lung Chau; CW: Chai Wan; SWH: Sai Wan Ho; CB: Causeway Bay; TY: Tsing Yi). The outer-harbour sites TLC and TY are relatively clean whereas inner-harbour sites CW, SWH and CB are organically enriched (Shin et al., 2008). □ Inner-harbour area.

Please cite this article in press as: Xu, W.Z., et al. Structure and taxonomic composition of free-living nematode and macrofaunal assemblages in a eutrophic subtropical harbour, Hong Kong. Mar. Pollut. Bull. (2014), http://dx.doi.org/10.1016/j.marpolbul.2014.01.023