Sediment and water quality in the Kam Tin River, Hong Kong

M. R. PEART[1], L. FOK[2] & J. CHEN[3]

1 Department of Geography, University of Hong Kong, Hong Kong, China
mrpeart@hku.hk
2 Department of Science and Environmental Studies, Hong Kong Institute of Education, Hong Kong, China
3Department of Civil Engineering; University of Hong Kong, Hong Kong, China

Abstract River water quality has reflected development pressures in Hong Kong. The Hong Kong Government has adopted a range of measures to improve water quality including the enactment of the Water Pollution Control Ordinance which specifies Water Quality Objectives (WQO) for rivers. One of the key WQO for the Kam Tin River, one of the largest rivers in Hong Kong, is an annual median suspended solids value of <20 mg/L. During the years of 2006 to 2011, regular weekly sampling at the Kam Tin monitoring station revealed dry season median values for suspended solids of 82.1, 84.4, 52.6, 74.3, 82.2 and 60.6 mg/L, respectively, well above the WQO limits. In the summer wet season the annual median values are 52.2, 43.4, 19.1, 21.6, 25.0 and 56.6 mg/L, respectively, which are much lower than those in the dry season and in general exceed the WQO limit. Monitoring at three additional stations indicates spatial variation in sediment concentrations in the basin. For 2006 to 2011 the median chlorophyll-*a* concentrations of 19.8 and 11.3 µg/L were observed at Kam Tin for dry and wet seasons, respectively. There is also a need to examine sediment quality in the basin as enrichment of Zn, Pb, Cu, Ni and As against the crustal average has been observed for storm period suspended sediment.

Key words water quality objective; suspended sediment; chlorophyll-*a*; sediment quality

INTRODUCTION

Hong Kong has many hundreds of streams and rivers which have a range of beneficial uses such as water supply, the support of ecosystems, the provision of drainage and waste disposal, along with recreation. Within streams and rivers, as noted by Ongley (1996), sediment transport is associated with a range of engineering and environmental issues. Engineering issues, for example, include river channel siltation, sedimentation in reservoirs, instability of river channels and deterioration of drinking water supply. More recent discussions of the significance of sediment in rivers are provided by, for example, Walling (2006, 2009), Owens *et al.* (2005) and Syvitski *et al.* (2005). These studies reveal sediment transport in rivers has significance in terms of many aspects of geomorphology, including denudation of the continents, the development of river channels and the coastal zone. Sediment also relates to the biological functioning of rivers (Kerr, 1995; Wood & Armitage, 1997; Walling, 2009) and has an important quality dimension (Webb & Walling, 1992; Ongley, 1996; Förstner & Owens, 2007) including geochemical transfer and cycling (Meybeck, 1982; Ongley, 1996; Horowitz *et al.*, 2007). The engineering, environmental and other aspects of sediment transport are of interest and concern in Hong Kong. For example, Li & Lee (1998) examined the effects of sediment carbon dynamics on shorebird conservation in Deep Bay and Dudgeon & Corlett (2004) document the impact of sediment upon stream ecology. Sewell (1999), Cheung *et al.* (2003) and Peart (2003) evidence the geochemical significance of sediment transport in rivers in Hong Kong. The Drainage Services Department attest to the importance of sediment in terms of flood control and drainage, whilst Wang *et al.* (2011) note that sedimentation in the tidal sections of rivers and drainage channels may cause serious problems for flood control. Berry (1955) documents the sedimentation problem in water-supply reservoirs in Hong Kong and Martin (2009) recognizes the role of sediment in causing blockage in catchwaters of the water catchment areas in Hong Kong. The impact of sediment on coastal zone geomorphology in Hong Kong is illustrated by the study of Wong & Li (1990) on Deep Bay, and by Owen & Shaw (2007) for pocket beaches. In terms of geochemistry in the coastal waters the studies of Li & Lee (1998), Cheung *et al.* (2003), Zhou *et al.* (2007) and Nicholson *et al.* (2010) are noteworthy.

These observations upon the importance and significance of sediment in the surface waters of Hong Kong should be placed in the context of environmental change. As Hill (2011) observes

"The hydrological system of Hong Kong, both within its urban areas and in the countryside, has been profoundly altered by human activities that stemmed from population growth and from the now declining industrial sector". Moreover, Wong & Wan (2009) suggest that Hong Kong's economic success, its rapid population growth, along the escalation of consumerism, have all in the last four decades "led to serious environmental degradation and pollution". Dudgeon (1996) notes the vulnerability of freshwater bodies in Hong Kong to disturbance and damage by anthropogenic impacts and Nicholson *et al.* (2010) document the effects of development in coastal waters.

It is against this background that monitoring of suspended sediment in a small (44 km^2) drainage basin in the northwest New Territories of Hong Kong is made.

STUDY AREA AND METHODS

The Kam Tin basin (44 km^2) is located in the northwest New Territories of Hong Kong and it has two main branches, one in the north and one to the south with a mainstream length of around 50 km. The drainage system has its origins on the western slopes of the Tai Mo Shan and flows into Deep Bay (Fig. 1). Topographically there is a sharp contrast between the flat lowland alluvial plain and the steep slopes of the uplands. The steep uplands have no settlement and their vegetative cover consists of grass, shrubland and woodland with the former types dominant. The occurrence of hill fire affects the type of vegetation cover in some upland areas. The lowland plain has a long history of settlement and a community existed at Kam Tin from the Hau Chau period (951–959 AD) and the earliest significant settlement in Yuen Long can be traced back to the Sung Dynasty (960–1279 AD). With the development of Hong Kong the lowland plain has come under increasing pressure with agricultural land being converted to low density housing, transport infrastructure, open-storage and so forth. There also exist some small factory units and a military base, whilst river training for the mitigation of flooding has been undertaken.

Hong Kong is influenced by the Asian monsoon system with a distinct seasonal climate, namely hot-wet summers and relatively cool-dry winters. About 70% of the annual precipitation at the Hong Kong Observatory fell in the summer months (May to September) between 1961 and 1990. For 1971–2000 annual average rainfall was 2387.7 mm, and annual mean air temperature was 23.1°C. The monthly mean temperatures were between 16.1°C and 21.4°C for November to March, and 22.5°C to 28.7°C for April to October.

The geology of the Kam Tin basin is dominated by volcanic rocks of the Shing Mun and Tai Mo Shan Formation, and intrusive granodiorites. On the lowland plain thick deposits of alluvium dominate, whilst colluvial materials are associated with the upland slopes and streams.

Figure 1 shows that four sites have been sampled. The KARC and RDH are very small basins (<0.1 km^2) and located in the uplands. They contain no settlement. The Kam Tin site is located downstream on the lowland plain on the northern main channel near the village of Kam Tin. The fourth site (SHELL) is located near the settlement of Wong Chuk Yuen at the junction of the steep upland and the lowland plain and contains housing, agriculture, open-storage and small industrial units, as well as upland contributing areas, and is an intermediate type between the two upland basins and the Kam Tin sampling site in the lowlands.

Sampling for suspended sediment has provided data for the period 2006–2011 at the four sites. Regular weekly samples collected manually with a volume of 400 to 500 mL have been obtained to determine suspended sediment concentrations and concurrently large volume (2–5 L) samples were collected for the determination of chlorophyll-*a* at the KARC, RDH and Kam Tin sites. At the SHELL site regular monthly sampling was conducted. At a regular four-weekly interval an additional 500 mL sample was collected for the determination of specific electrical conductance and nutrient content of the water at all four sampling sites.

Upon return to the laboratory the suspended sediment was separated by filtration using pre-weighed GF/C filter papers and the suspended sediment concentration was determined by oven drying (at 103–105°C) to a constant weight. For chlorophyll-*a* the samples were filtered through a

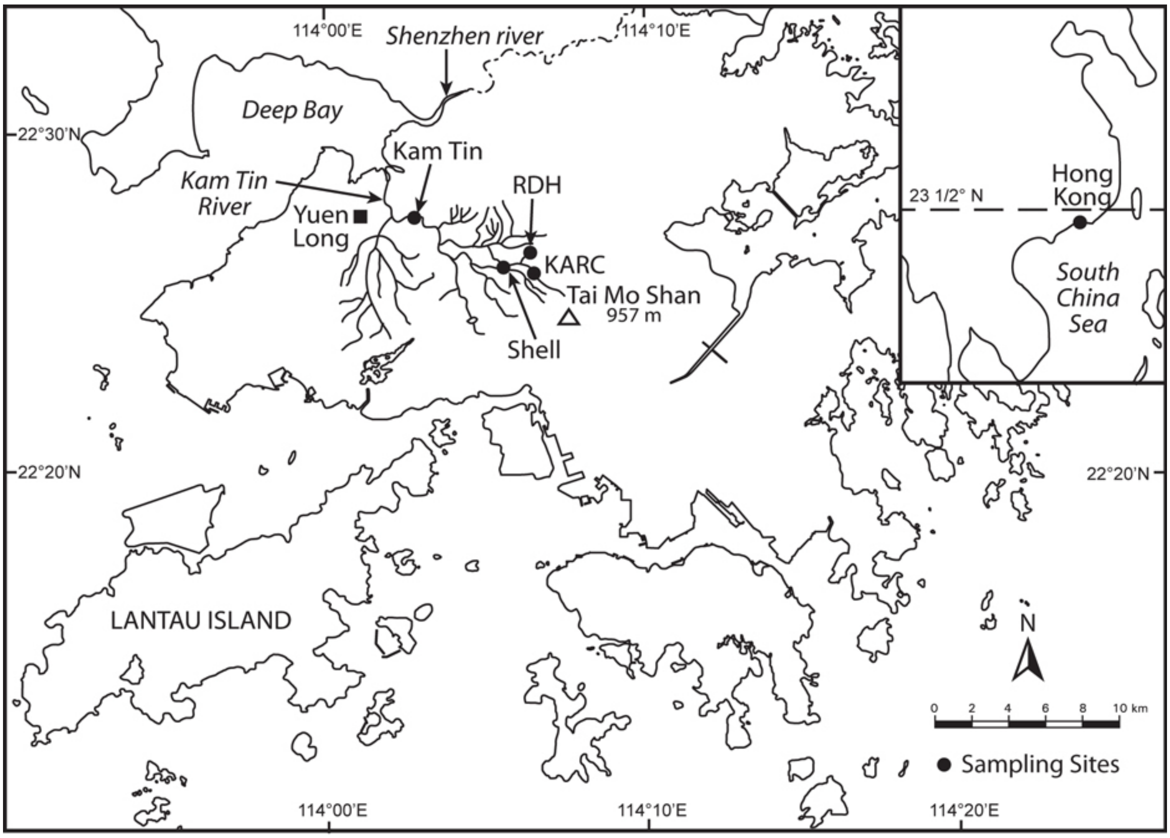

Fig. 1 Location of the Kam Tin basin and sample sites.

GF/C filter paper with acetone being used to extract the chlorophyll-*a* and a spectrophotometer measured extinction at 665 nm. The method is based upon Golterman (1970) and Lorenzen (1967). PO_4^{-3} and NH_3-N were determined on samples filtered through 0.45 μm, using colorimetric methods based upon La Motte test kits. The specific electrical conductance was determined on a Schott Gerate Conductivity meter (model CG855) with automatic temperature compensation to 25°C.

At the Kam Tin site the collection of large volume (>30 L) bulk water sediment samples under stormflow conditions during 2001–2003 provided an opportunity to examine suspended matter geochemistry; 17 samples were collected and a combination of settling and filtration were utilized to separate the sediment. Aliquots of the suspended sediment samples were submitted to a commercial laboratory, Actlabs in Canada, for analysis using its "Total IDENT Code 4E" (Research) package; As, Cu, Zn and Ni had detection limits of 1 ppm, whilst for Pb it was 5 ppm.

RESULTS

Table 1 presents the annual dry and wet season annual median suspended sediment concentration data for the four sampling sites in the Kam Tin river basin. A clear contrast exists between the two non-developed upland drainage basins, where the annual dry season median values are in the range 3–6 mg/L, and the downstream Kam Tin site on the developed plain which exhibits much higher median suspended sediment concentrations ranging from 53 to 84 mg/L. Dry season annual median suspended sediment concentrations ranged from 7 to 29 mg/L at the SHELL site. The SHELL site also shows a decline in median sediment concentrations for the period 2006–2011. In the dry season for the six years of data, the highest annual median suspended sediment concentration is 2.1, 1.9, 4.0 and 1.6 times higher than the lowest at KARC, RDH, SHELL and Kam Tin, respectively. Despite the much higher suspended sediment concentrations the inter-year variation of median suspended sediment concentrations at the Kam Tin station is similar to that of the other sites.

Table 1 Annual suspended sediment concentration data for the four sampling sites (mg/L); n is sample size.

Dry season	2006	2007	2008	2009	2010	2011
KARC						
median	6.1	3.5	4.1	2.9	3.9	4.6
n.	26	22	27	27	26	25
RDH						
median	3.3	5.8	3.1	4.9	4.1	4.1
n.	23	21	23	18	26	24
SHELL						
median	28.7	22.0	14.0	10.0	7.2	11.6
n.	6	5	7	7	6	6
KAM TIN						
median	82.1	84.4	52.6	74.3	82.2	60.6
n.	26	22	27	27	26	25
Wet season	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
KARC						
median	5.4	6.3	4.5	2.7	4.1	3.3
n.	24	26	26	28	25	26
RDH						
median	5.7	5.5	5.6	2.9	8.3	1.8
n.	20	26	26	23	24	14
SHELL						
median	9.6	22.3	7.3	3.5	5.4	7.5
n.	5	5	5	5	6	6
KAM TIN						
median	52.2	43.4	19.1	21.6	25.0	56.6
n.	24	26	26	28	25	26

In terms of the annual wet season median suspended sediment concentrations the downstream Kam Tin sampling site has median values ranging from 19 to 57 mg/L, which are much higher than the other three sampling locations. They are also noticeably lower than in the dry season. The two upland basins (KARC and RDH) have very low annual median suspended sediment concentrations (2–8 mg/L) in the dry season. The SHELL station (apart from 2007) is also characterized by low wet season annual median values (4–22 mg/L) compared to the dry season. In the wet season the highest annual median is 2.3, 4.6, 6.4 and 3.0 times that of the lowest at the KARC, RDH, SHELL and Kam Tin sites, respectively, without great variation.

Table 2 presents median and mean values of suspended sediment concentration (SSC) values for the period 2006–2011 for the four sampling sites. The mean exceeds the median and both measures of central tendency exhibit lower values in the summer wet season at all four sampling sites, thereby reflecting the seasonal contrast exhibited by the individual years (Table 1). Furthermore, the mean values of suspended sediment in both the dry and wet seasons at the Kam Tin site are much higher than the other three sites, especially the two undisturbed upland basins (KARC and RDH). Indeed the data reveals that the annual wet and dry season median and mean values are proportional to basin area with the highest values being observed in the largest basin at the Kam Tin sampling site and *vice versa*. The standard deviations presented in Table 2 show a considerable variation in the suspended sediment concentrations. This variability may reflect both the supply and availability of suspended matter and discharge controlling transport of the sediment.

Table 2 also presented dry and wet season median values of chlorophyll-*a* for the period 2006–2011 for the four study sites along with information on nutrient content of the water. In respect of chlorophyll-*a* two points of interest emerge. Firstly, the two upland streams have much

Table 2 Water quality data for the four sampling sites in the KAM TIN basin for 2006–2011; n is sample size.

Dry season	SSC (mg/L)	Chlor.-*a* (µg/L)	PO_4^{-3} (mg/L)	NH_3-N (mg/L)	Conductivity (µS/cm)
KARC					
mean	6.4 ± 8.3				
median	4.1	0.25	0.02	0.00	37.2
n.	153	149	66	66	66
RDH					
mean	9.9 ± 21.3				
median	4.1	0.93	0.05	0.02	49.4
n.	135	129	60	60	60
SHELL					
mean	28.8 ± 34.1				
median	14.5	6.75	12.70	8.90	268.0
n.	37	39	65	65	65
KAM TIN					
mean	88.0 ± 63.7				
median	74.7	19.77	12.60	20.35	457.5
n.	153	153	66	66	66
Wet season	**SSC (mg/L)**	**Chlor.-*a* (µg/L)**	**PO_4^{-3} (mg/L)**	**NH_3-N (mg/L)**	**Conductivity (µS/cm)**
KARC					
mean	5.8 ± 5.2				
median	4.1	0.16	0.02	0.00	34.8
n.	155	149	63	63	63
RDH					
mean	8.2 ± 10.0				
median	5.5	0.25	0.07	0.03	46.0
n.	133	118	50	50	50
SHELL					
mean	14.4 ± 17.4				
median	6.8	1.35	2.98	1.68	147.2
n.	32	31	59	59	59
KAM TIN					
mean	60.8 ± 123.8				
median	33.0	11.28	5.87	8.15	308.0
n.	155	150	63	63	63

lower concentrations, compared to the SHELL and Kam Tin sites that are impacted by human activities. Secondly, a distinct contrast exists in chlorophyll-*a* concentrations between dry season and wet season at all the four sites, with noticeably lower wet season concentrations. For example at Kam Tin the dry season median value is 19.8 ug/L, whilst the wet season is 11.3 µg/L, only 57% that of the dry season. In the upland stream RDH the wet season median is only 27% of the dry season. The contribution made by algae, etc., to the suspended matter at the Kam Tin site is evidenced in Fig. 2 which plots chlorophyll-*a* against suspended sediment concentration. The scattergraphs for the Kam Tin site reveal a variable contribution of phytoplankton and algae to the suspended sediment concentrations. The correlation coefficients between chlorophyll-*a* and suspended sediment are $r = 0.31$ and 0.55 for the dry and wet seasons, respectively.

A number of metals in the suspended sediment samples obtained under storm flow conditions at the downstream Kam Tin sampling site were analysed. The median concentrations for the 17 samples for As, Cu, Pb, Zn, Ni are 14, 188, 89, 477 and 20 ppm, respectively. For As, Cu, Pb, Zn and Ni, the median absolute deviations (MAD) are 3, 142, 13, 305 and 1.5 ppm, respectively. The data indicate that the chemical composition of suspended sediment is also an important consideration in the study of sediment in rivers in addition to the physical impact of sediment.

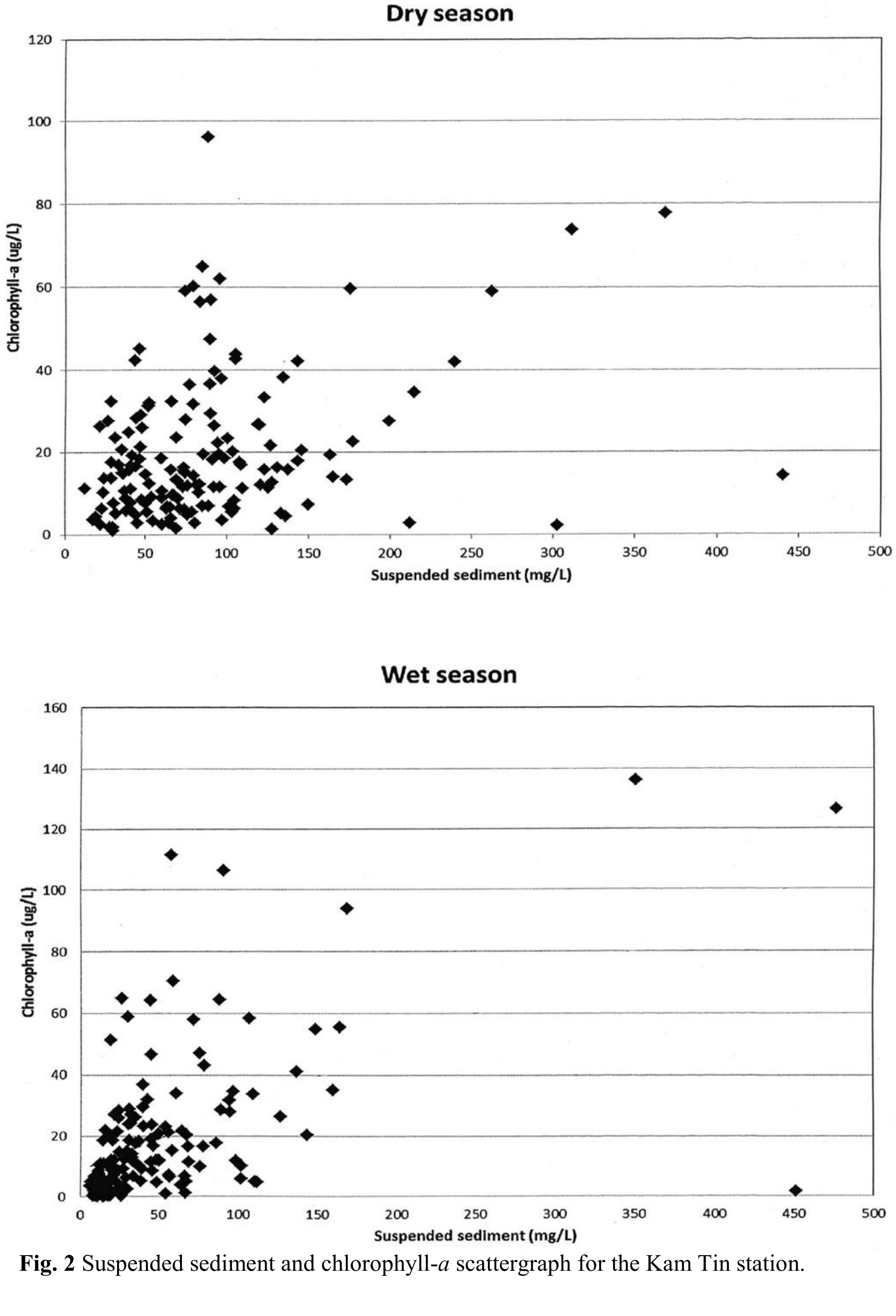

Fig. 2 Suspended sediment and chlorophyll-*a* scattergraph for the Kam Tin station.

DISCUSSION

The influence of climate is detectable in the data for suspended sediment concentrations presented in Table 1, which is divided into dry (January, February, March, October, November and December) and wet (April, May, June, July, August and September) seasons. The summer wet season at the Kam Tin site is characterized by much lower median and mean values compared to the winter. This phenomenon is also exhibited by the SHELL sampling site and it may relate to the seasonality of runoff (Jayawardena & Peart, 1989) and the higher water levels observed in the summer which act to dilute the suspended sediment concentrations. Interestingly, for the two upland streams, with their very low suspended sediment concentrations, this seasonal contrast is not obvious.

The intra-year variation in median suspended sediment concentrations may also relate in part to climate. Data from the Hong Kong Observatory for the Kadoorie Farm and Botanic Garden located close to the SHELL and KARC sites show that annual rainfall for 2006 to 2010 ranges from 1996.0 to 3473.7 mm and summer wet season rainfall totals are 2404.0, 2045.2, 3162.2, 2301.3 and 1698.6 mm, respectively, from 2006 to 2010. It is tempting to attribute the low, 19.1 mg/L, median sediment concentration at the Kam Tin in 2008 to the very high rainfall, however, the median concentrations for the two succeeding years (2009 and 2010) remain low and summer rainfall totals were much reduced compared to 2008 such that if rainfall were the only control of the median suspended sediment concentrations, those of 2009 and 2010 should have been higher than observed.

The Hong Kong Government has sought to improve water quality in surface waters and in order to do so Water Quality Objectives, amongst other measures, have been introduced. For the Kam Tin drainage basin the suspended sediment of Water Quality Objective is an annual median value of <20 mg/L based upon monthly sampling. Table 1 reveals that the two natural upland basins with no settlement easily meet this standard. The marked contrast is the downstream Kam Tin station where in the winter dry season the median value for all the years greatly exceeds <20 mg/L. In the summer wet season for the Kam Tin the situation improves with the median meeting the <20 mg/L target in 2008 and close to the target in 2009 and 2010. Regarding the intermediate SHELL station, in the summer wet season it in general meets the <20 mg/L criteria. In the winter dry season, from 2008 onwards, the SHELL site has also met the criteria, and shows a temporal trend of decline in the median suspended sediment concentration values.

Peart (1999) presents the suspended sediment in the two sites KARC and Kam Tin for the periods 1993/94 and 1998/99. At Kam Tin the mean suspended sediment concentrations collected under non-storm flow conditions in the two periods of observation were 80.6 and 88.9 mg/L, respectively, for sample sizes of 77 and 77. At the upland KARC basin for the two periods of observation the mean suspended sediment concentrations were 4.3 and 11.0 mg/L, respectively, for sample sizes of 67 and 57. The data for 1993/94 and 1998/99 reveal that the contrast between the undisturbed uplands and the developed lowland alluvial plain existed in the 1990s. Moreover, the mean data for 2006–2011 in Table 2 are similar to those for the 1990s reported by Peart (1999), although the average of 60.8 mg/L in the wet seasons from 2006–2011 is lower.

The data published by the Environmental Protection Department (EPD) affords a comparison to the data in Tables 1 and 2. The annual reports on River Water Quality in the Kam Tin North River give annual median concentrations of 40, 45, 26, 39 and 29 mg/L, respectively, for 2006, 2007, 2008, 2009 and 2010. The EPD identifies 2008 with the lowest median value and this may reflect the very wet summer of that year. In a longer term context, the EPD (2011a) reports that based upon observations from 1986 to 2010, suspended solids concentrations exhibit a downward trend. An important contributor to this is the great reduction in livestock and poultry farming in the basin, due to the Livestock Waste Reduction Scheme which was introduced in 1987 and amended in 1994. This led to a dramatic decline in the pollution load from agriculture (Dudgeon, 1996) during the period 1988 to 1998 and small reductions in the pollutant load to streams and rivers still occur under the influence of this scheme. However, the EPD (2011a) recognizes the continued existence of discharge of waste by livestock farms.

Syvitski *et al.* (2005) have noted that there are many anthropogenic influences on sediment yield and that these include urbanization, deforestation, agricultural practices, mining and the retention of sediment by reservoirs. In the Kam Tin drainage basin housing expansion in the lowland area and changing agricultural practices may exert an influence on sediment. Other possible influences include the river training carried out on the lowland sections of the river to combat the flood hazard (Peart & Wong, 2002), the increase in open-storage, and hill fire in the uplands as recorded by Peart *et al.* (2009).

Much of the Kam Tin North river channel on the lowland alluvial plain is not natural with both plan-form and channel cross-section, reflecting river training works undertaken to mitigate the flood hazard (Peart & Wong, 2002). At the Kam Tin sampling site the channel has a trapezoidal cross-section in which there is a dry-weather low flow channel. The bed of the channel is 15 m wide and the low flow channel has a width of 3 m. The channelization has fixed the plan-form (Peart & Wong, 2002) and may have impacted phytoplankton production and hence chlorophyll-*a* concentrations due to its effects upon light (the new channel does not have much shade). The new channel may also affect water velocity due to its artificial design and the lack of natural flow resistance. As Hilton *et al.* (2006) note, flowing water may impose strong forces which may dislodge or uproot algae and plants. Yang *et al.* (2009) also recognize the possibility of scour, abrasion and sloughing for removal of benthic algae from substrate in Hong Kong streams. The velocity of water flow in the man-made channel of the lower reaches of the Kam Tin River may be an important factor in the entrainment and subsequent transport of chlorophyll-*a* bearing organic matter from the margins of the channel where well developed algal mats exist on the walls of the low flow channel. Moreover, the lack of shading, and hence abundant light, may be a further contributor to the contrast in chlorophyll-*a* at the Kam Tin and the other three sampling sites, the KARC, the RDH and the SHELL sites which all experience shading from trees and other channel-margin vegetation. Yang *et al.* (2009) observe that algal biomass tends to increase in response to reduction in shading and this is a characteristic of the Kam Tin channel above the sampling site on the trained river.

The data in Table 2 reveal that chlorophyll-*a* concentrations exhibit seasonality and are highest at the four sampling sites in the winter season. This observation accords with observations made by Yang *et al.* (2009) in Hong Kong streams that algal biomass was higher in the dry season with average standing stocks of above 18%. They also demonstrate that rainfall, or spate-induced disturbance, would reduce algal standing stocks, thereby influencing seasonal variation in algal biomass production. This was supported in one of their studied streams, but not in the other three. However, the decline in chlorophyll-*a* during the wet season shown in Table 2 provides evidence for spate-induced disturbance in Hong Kong.

In terms of chlorophyll-*a* there is evidence that nutrient content of the surface waters may exert an influence. For the Kam Tin site in the wet season chlorophyll-*a* is positively correlated with NH_3^--N (r = 0.43) and PO_4^{3-} (r = 0.37), whilst for the SHELL station both dry (NH_3^--N; r = 0.34: PO_4^{3-}; r = 0.6) and wet (NH_3^--N; r = 0.28: PO_4^{3-}; r = 0.22) seasons evidence a positive association between nutrients and chlorophyll-*a*. The possibility of polluting discharges from unsewered villages and expedient discharges from industrial enterprises and livestock farms to the Kam Tin River is indicated by the EPD (2011a). Other researchers have reported the role of nutrients for chlorophyll-*a* (Neal *et al.*, 2006; Hilton *et al.*, 2006). Neal *et al.* (2006) report that chlorophyll-*a* in rivers in eastern England was directly related to basin area. Table 2 also supports the association between drainage basin area and chlorophyll-*a* concentrations. The chlorophyll-*a* data for the four sampling sites suggest that algal-derived organic matter plays a role in the increase in the median suspended sediment concentrations with increase in basin size (Table 2).

Comparison of the metal concentrations for the Kam Tin site, given in the results section, to data reported by Li (1994) for the upper continental crust in China reveals that the suspended sediment is 5.6, 5.9, 4.7, 9.4 and 1.5 times higher for As, Cu, Pb, Zn and Ni, respectively. Compared to the global average concentration of river suspended matter provided by Thomas & Meybeck (1996), the median values of As, Cu, Pb and Zn in the Kam Tin River are greater by 1.8, 3.8, 2.2 and 4.3 times. In contrast, the median concentration of Zn in the Kam Tin River is less than the global average (80 ppm) (Thomas & Meybeck, 1996). It is noteworthy that, with the exception of Ni, all other metals have median concentrations that exceed the Lower Chemical Exceedence Level (LCEL) used by the Hong Kong Government in the management of dredged/excavated sediments, thereby indicating contamination. In fact, Cu, Pb and Zn exceed the values for Upper Chemical Exceedence Level of 110, 110 and 270 mg/kg dry weight, respectively. Possible contributors to the contamination exhibited by these metals in the Kam Tin River are a number of anthropogenic sources, including industry, agriculture, transport and waste water (Sewell, 1999; Cheung *et al.* 2003; EPD, 2011a,b). With respect to sediment quality in Deep Bay into which the Kam Tin River discharges, the human impact recognized includes the influence of wastewater, surface runoff, vehicle emissions and industrial activities (Cheung *et al.* 2003; Zhou *et al.* 2007). The delivery of metals in sediment has implications for water quality and the ecological health of Deep Bay (Cheung *et al.* 2003; Zhou *et al.* 2007). However, the role played by natural factors, such as mineralization associated with the igneous rocks in the basin, cannot be excluded (Sewell, 1999).

CONCLUSION

Observations on suspended sediment concentrations made at four sampling sites in the Kam Tin basin in Hong Kong have been presented. They reveal spatial variation in sediment concentrations and also seasonal contrasts with median values being higher, especially at the Kam Tin site and in the dry season. Suspended sediment annual median concentrations for both wet and dry seasons are very low in the two undisturbed upland drainage basins (KARC and SHELL) compared to the Kam Tin and the SHELL sites. At the Kam Tin site on the developed lowlands, annual median dry and wet season values exceed the Water Quality Objective for the drainage basin. Chlorophyll-*a* has also been determined at the four sampling sites and also exhibits spatial and temporal variation. The chlorophyll-*a* concentrations are highest at the downstream Kam Tin sampling site, and at this site chlorophyll-*a* correlates positively with suspended sediment concentration in both dry and wet seasons. This correlation suggests that algae and/or macrophytes influence suspended sediment concentrations in the basin and the impact of river training and nutrient content upon algal production are discussed. Storm period suspended sediment obtained at the downstream Kam Tin site reveals that the suspended matter contains Zn, Pb, Cu and As, thereby illustrating the quality dimension of sediment transport in rivers in Hong Kong.

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