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An Analysis of Water Environment Management Priorities in Hong Kong*

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Abstract: *With a high population density, immense commercial and industrial activities, Hong Kong produces over two million tonnes of municipal wastewater each day. Until recently, about 50% of the municipal wastewater enters water courses, rivers, and coastal waters without treatment. Untreated organics, heavy metals and refractory synthetic materials accumulate in certain areas, and have led to breakdown of aquatic and marine ecological systems, closure of beaches, red tides and bioaccumulation in seafood. In 1974, a team of consultants was commissioned to study the water pollution problems encountered in Hong Kong. After two decades in the effort to improve the water environment, a flexible framework for environmental planning and management over the following ten years has been designed. This programme comprises (1) establishment of water control zones and pollution control legislation, (2) upgrading of services and facilities for management of municipal sewage and chemical wastes, and (3) construction of the "Strategic Sewage Disposal Scheme". In line with this programme, a priority has been set on implementing a "polluter pays policy" which requires the industries to share the costs of sewage treatment and encourages them to install on-site wastewater pretreatment facilities to reduce wastewater generation and to ensure sustainable development.*
Keywords: *Hong Kong, polluter pays policy, sewage disposal, water pollution.*

1. Introduction

Hong Kong has a land area of 1 070 km^2 and a population of over six million (Hong Kong Census and Statistics Department, 1991). A large fraction of the population resides in the urban area around the Victoria Harbour (Fig.1), resulting in a high population density of 1 000 residents per hectare. Population growth, concentrated commercial and industrial activities, and a lack of pollution control in the past decades have resulted in severe environmental problems (Chua *et al.*, 1995; Chung *et al.*, 1993).

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Currently, Hong Kong produces over two million tonnes of municipal wastewater each day (Hong Kong Environmental Protection Department, 1996). While 10% of this wastewater receives secondary treatment and 40% are screened and macerated before discharge, the remaining 50% enters the coastal waters either directly or indirectly via streams without any treatment. The dynamism of the light industries in changing production patterns leads to generation of wastewater with varying quantities and compositions, which is beyond the handling capacity of communal treatment works (Hodgkiss, 1992). Untreated organic loads, oil and grease, heavy-metal pollutants, persistent and recalcitrant synthetic materials such as polychlorinated biphenyls tend to accumulate in certain inland waters and coastal areas (Chua, 1997; Hong Kong Planning Department, 1993; Dow Chemical, 1992; Keen *et al.*, 1989). These have led to breakdown of aquatic and marine ecological systems, closure of beaches, occurences of red tides, bioaccumulation and contamination of seafood (Chua *et al.*, 1994; Hong Kong Environmental Protection Department, 1991a; 1991b; 1991c; 1992a; 1992c).

Fig. 1 An Aerial View of the Victoria Harbour, Hong Kong

In 1974, legal requirements for environmental protection were initiated (Yang *et al.*, 1989), and in 1977, an Environmental Protection Unit was established. The Unit was then developed into the present Environmental Protection Department (EPD) in 1986 and was made responsible for all environmental protection and control measures, including sewage and waste management programmes. A flexible framework for environmental planning and management over the following ten years have been designed. This paper critically reviews the legislation and management priorities relevant to the water environment.

2. Water Environment Management Programmes

A systematic and wide-ranging monitoring and management programme has been established for the water environment in Hong Kong. The management programme includes (1) establishment of water control zones and pollution control legislation, (2) upgrading of services and facilities for management of municipal sewage and chemical wastes, and (3) construction of a Strategic Sewage Disposal Scheme (SSDS).

Legislation and Enforcement

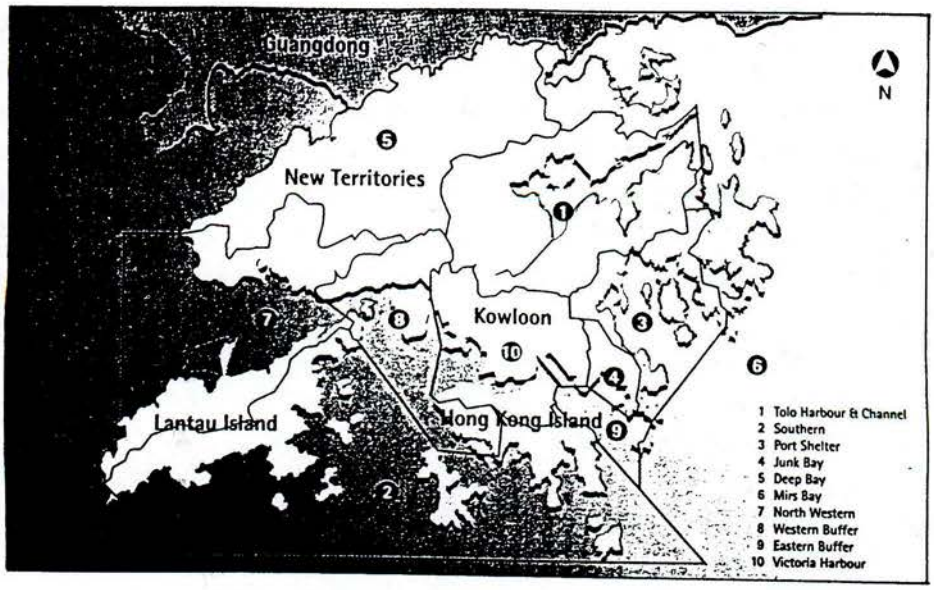

Fig. 2 Chemical Waste Treatment Centre

The Water Pollution Control Ordinance (WPCO), enacted in 1980 (Pearce, 1980), establishes ten water control zones (WCZs) (Planning, Environment and Lands Branch, 1993b) (Fig.2). The Tolo Zone (WCZ1), declared in 1987, was the first among the nine zones that are currently in force. The Victoria Harbour Zone (WCZ10) will be declared in phases, from 1994 to 1997, by which time all the waters in Hong Kong will be within the jurisdiction of the WPCO. The water

quality objective in each WCZ is a separate set of scientific expressions in precise numerical terms of the minimum water quality that is required for environmental conservation. Water quality objectives including parameters for dissolved oxygen, pH, ammonia, inorganic nitrogen, and *E. coli* are set according to the beneficial uses of the waters within each WCZ. A technical memorandum is published by the Environmental Protection Department to assist wastewater producers understand the water quality standards established for wastewater discharges into drainage and sewerage systems, inland and coastal waters under the WPCO (Hong Kong Environmental Protection Department, 1991d). A Licence has to be applied for discharge of wastewater and the control authority is responsible for ensuring that water quality objectives for these control zones are met. The WPCO was subsequently amended in 1993 to allow the control authority to ensure the sewage from private plots is connected to the public foul sewers. It also means that every effluent discharge in a WCZ should have a licence which controls its quality and limits its volume in order to meet the water quality objectives for that WCZ. In order to assess the effectiveness of the WPCO in environmental conservation, the Environmental Protection Department conducts an extensive programme to monitor the state of coastal environment by sampling water at 81 locations and marine sediments at 66 locations.

The principle waste management law in Hong Kong is the Waste Disposal Ordinance. The Waste Disposal (Chemical Waste) Regulation made under this Ordinance to control chemical waste was enacted in January 1992 (Hong Kong Environmental Protection Department, 1992b). This Regulation requires chemical waste producers to register with the Environmental Protection Department and to provide suitable packaging, labelling and storage for chemical wastes. An integrated Chemical Waste Treatment Centre commissioned in April 1993 provides central treatment facilities for the 100 000 tonnes of chemical wastes produced annually in Hong Kong. As livestock waste remains a major source of pollution, the Waste Disposal (Livestock Waste) Regulation under the Waste Disposal Ordinance has imposed a ban on keeping livestock in designated urban areas. A scheme for licensing of livestock farms has been introduced to regulate livestock keeping and ensure effective on-site controls over livestock waste (Hong Kong Government Industry Department, 1993). With these regulations in place, disposal of wastes directly into receiving waters is being eliminated.

Upgraded Sewage Treatment Facilities

About 1 100 kilometers of public sewers and 110 sewage treatment (mostly screening) facilities have been constructed in the past decade (Hong Kong Drainage Services Department, 1993; Tam, 1994). In 1991, about 500 million cubic meters of domestic sewage and industrial wastewater enter the sewage system from the drains of residential, commercial and industrial buildings. This flow is delivered to sewage screening plants either by sewage pumps or by gravitational flow. The treated effluent with no solid particles larger than 6 mm is then discharged into the sea. The solids removed from the sewage are disposed of at landfills. In addition, five major secondary sewage treatment plants are built at locations where the movement of

the receiving water is slow or infrequent, and thus has little assimilative capacity (Fig.1). Biological extended aeration is employed and over 90 % of the organic pollutants are removed from the sewage that passes through these plants. Two of these secondary treatment plants which discharge into the Tolo Harbour have been modified to increase the nutrient removal capacity in response to the red tide problems occurring in the area (Wu *et al.*, 1993). These five secondary treatment plants, after modifications and upgrading, treat up to about 25 % of the total sewage flow.

Chemical Waste Treatment Centre

The manufacturing industries in Hong Kong generate around 100 000 tonnes of chemical waste per year. The usual practice for disposal of such waste has been indiscriminately into storm water drains and sewers. This has led to problems like poor water quality, contaminated marine organisms and build up of toxic substances in the marine sediments. This has also led to damages of the sewage systems which were not designed to treat chemical wastes.

The Chemical Waste Treatment Centre, completed in 1993, is an integrated part of the pollution management programme designed to solve chemical waste disposal problems (Newby *et al.*, 1993; Enviropace Limited, 1993). The treatment centre comprises of a number of treatment processes, designed to treat specific types of chemical wastes (Fig.3). Wastes with high contents of oil and grease are collected for bulk separation. The recovered oil is used as fuel in incinerators and the water phase is sent through a sequencing batch reactor where organic components are degraded by activated sludge. A dual-media filter is used to remove the solids and a carbon-absorption system is used to further polish the cleaned water. On the other hand, inorganic aqueous wastes are treated by physico-chemical processes that include reduction, acid-alkalis neutralization, heavy-metal precipitation, evaporation and catalytic oxidation. Solids and semi-solid residues from these treatment processes are chemically stabilized to meet strict leaching criteria and standards prior to disposal in an off-site landfill. An incineration system is used to destruct other organic materials and cyanide wastes.

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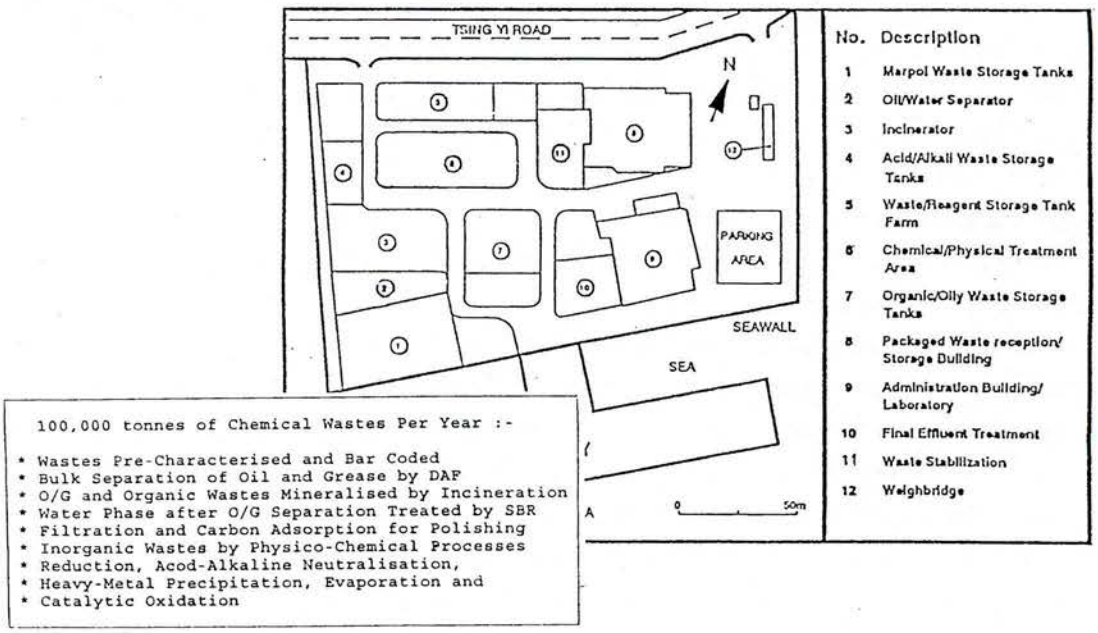

Fig. 3 Chemical Waste Treatment Centre

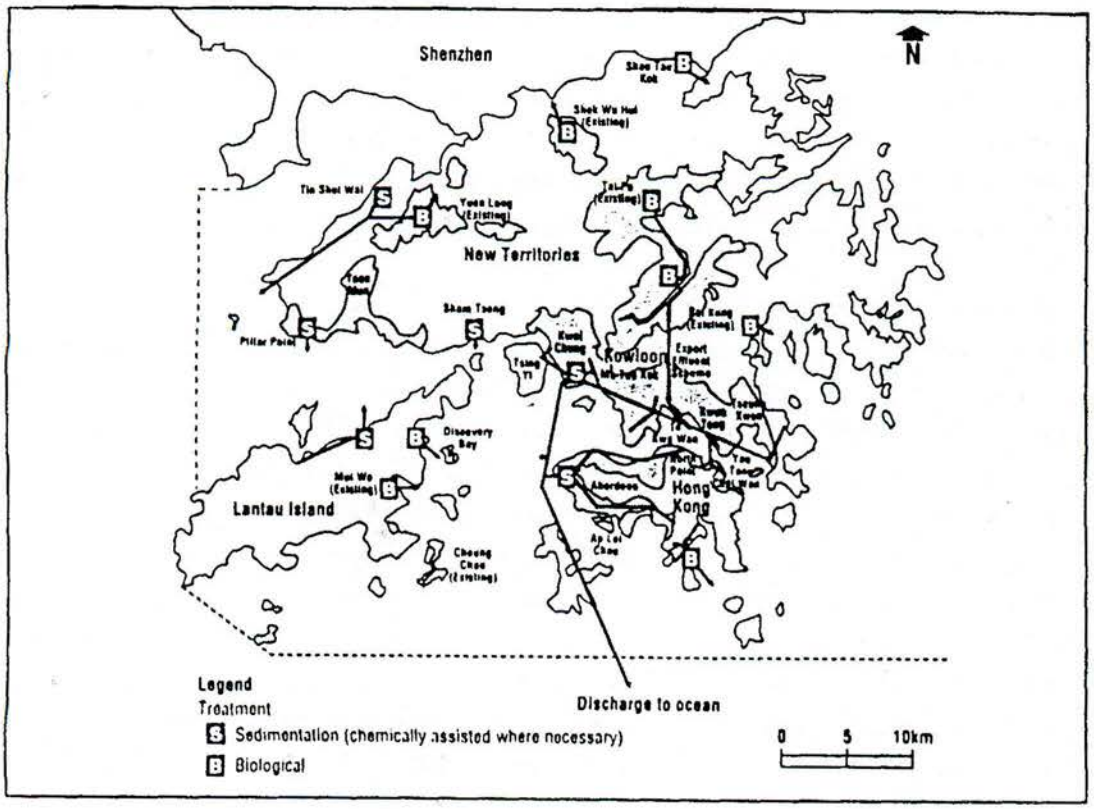

Fig. 4 Strategic Sewage Disposal Scheme

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Strategic Sewage Disposal Scheme

In the urban areas around the Victoria Harbour, fifty percent of the sewage, including most of the industrial wastewater, is discharged into stormwater drains leading directly to the Victoria Harbour. The Strategic Sewage Disposal Scheme is a mojor part of the wastewater management programme designed to handle the sewage from the urban areas around the Victoria Harbour and a number of industrial estates. Scheduled to be completed in phases during the next decade, the Strategic Sewage Disposal Scheme will direct all sewage and wastewater via foul sewers into a 32-km long deep-tunnel intercepting sewer system which is one hundred and fifty meters underground (Fig.4) (Siu, 1992). The flow will then enter a sewage treatment work located on an offshore island (Stonecutters Island) for chemically-assisted primary treatment. The treated effluent will be discharged through an interim outfall. This phase of the Strategic Sewage Disposal Scheme will improve the water quality in the Victoria Harbour.

The Strategic Sewage Disposal Scheme will be expanded in later phases to comprise a 15-km deep-tunnelled oceanic outfall to transfer the treated effluent through a number of pumping sta-

tions and a system of submarine diffusers into the South China Sea (Chung *et al.*, 1993). Toxic metals, nutrients and bacteria in the sewage will be reduced during the primary treatment process to safe levels, leaving only biodegradable and inert residues to be handled by the natural self-purification capabilities of the ocean. The entire capital investment in the Strategic Sewage Disposal Scheme amount to about HK$ 12 billion over the next 10 years.

3. Pollution Management Priorities—"Polluter Pays Policy"

The capital cost of the new sewarage works will be financed by the Government in full, while the operating costs are proposed to be recovered from users of sewage services. As part of the wastewater management strategy, it was proposed in the 1989 White Paper on pollution management in Hong Kong that polluters should pay for the disposal of the wastewater they produce (Planning, Environment and Lands Branch, 1993b). Under this charging scheme, a general sewage charge which represents the cost of treating sewage of domestic strength took effect since early 1996. Charges include a fixed charge which is based on the capacity of water meter in each household. In addition, a variable charge is based on the volume of sewage produced by each water consumer and calculated according to the volume of water consumed by the rate of HK$ 0.66 per cubic metre (Federation of Hong Kong Industries, 1993). On the other hand, heavier industrial and commercial polluters have to bear an additional trade effluent surcharge (TES) based on the additional operating costs of providing treatment to the excess pollutant loads in these effluents above the average strength of domestic sewage (Planning, Environment and Lands Branch, 1993a; Choy *et al.*, 1993; Wan, 1994). The TES, as expressed by Equation 1, is based on pollutant load determined by both volumetric flow and strength of wastewater, for which chemical oxygen demand (COD) is used as the determinant (Federation of Hong Kong Industries, 1994). Insoluble COD and soluble COD are used to measure the pollutant loads to be removed by primary and secondary treatments, respectively.

$$TES/Q = \frac{P_i - P_d}{P_d} \times C_p + \frac{S_i - S_d}{S_d} \times C_s \quad (1)$$

where

TES = trade effluent surcharge, HK$

Q = volume to be charged as measured by the discharger's water meter, m^3

P_i= concentration of industrial and commercial load to be removed by primary treatment, $g \cdot m^{-3}$

= (total COD - soluble COD) in the effluent

P_d = average concentration of domestic load to be removed by primary treatment, which is assessed to be 150 $g \cdot m^{-3}$

C_p = cost of providing primary treatment to each cubic metre of domestic sewage, which is assessed to be HK$ 0.72 m^{-3}

S_i = concentration of industrial and commercial load to be removed by secondary treat-

ment

= soluble COD in the effluent

S_d = average concentration of domestic load to be removed by secondary treatment, which is assessed to be 350 $g \cdot m^{-3}$

C_s = cost of providing secondary treatment to each cubic metre of domestic sewage, which is assessed to be HK$ 0.80 m^{-3}

Specific trades, including textile bleaching and dyeing, beverage manufacturing, ice-making and restaurants, which discharge substantially less wastewater than they consume as a result of production losses may apply a discharge factor of 0.8 to the water consumption. As it is not possible to sample all industrial and commercial premises for COD levels during the initial stage of implementation of the TES scheme, average values for each industrial sector are used. A TES payer who has installed on-site pretreatment facilities may apply for review of the effluent COD.

4. Conclusion

The "Polluter Pays Principle" is widely accepted as an effective policy that requires domestic households to share the operational costs of sewage treatment. The policy also encourages the industries to install on-site wastewater pretreatment facilities which will be cost-effective in the long run compared with the TES levied for communal treatment. The government will provide additional financial assistance for livestock farmers to install on-site waste treatment facilities in farmlands. Generally, the policy provides an incentive to minimize wastewater generation and adopt cleaner production techniques.

Heavy charges imposed on the industries would eventually be transferred back to the consumers who have to pay for the additional production costs. Taxpayers have already contributed their share by funding the capital investment for the drainage system and the current daily sewage disposal. The poluter pays policy, in essence, implies a double taxation for members of the public. The end effect is that the burden inevitably falls hard on the lower income families who are users of these services. A preliminary calculation, based on the proposed charging rate, showed that a family of four with a monthly income of HK$ 11 000 pays a sewage tax of abour HK$ 260 a year, representing a 70 % increase in total tax. Therefore, it has been propose that a basic water consumption that is essential to daily living is determined. Households consuming less than this pre-determined amount should not be charged. Only the lavish users, industrialists and commercial sectors should pay for the sewage treatment.

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