ROLE OF WASTEWATER TREATMENT IN THE SUSTAINABLE DEVELOPMENT IN HONG KONG

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ABSTRACT

The reason for choosing this topic is that I hope my review work will begin to fill up a research gap on the wastewater treatment for sustainable development in Hong Kong. This report presents a review of the wastewater treatment situation in Hong Kong and a discussion on how it is related to the sustainable development. Three indicators of sustainability in wastewater treatment are dealt with: economic, environmental, and societal indicators. The overall results of each treatment technology, which are mechanical (activated sludge), lagoon system, and land treatment system), show that they have various degrees of efficiency. In addition, it will summarize the government's measures in controlling water pollution in Hong Kong. The paper will then present sustainable development in wastewater treatment engineering. A good example, Ngong Ping Sewage Treatment Works, will be presented later. This treatment plant incorporates the tertiary treatment stage and reuse of effluent as flushing water for local public toilets there. Finally, the author will make some recommendations for policy makers in maintaining sustainable development and good water quality in Hong Kong.

KEYWORDS

Activated sludge, Indicators of sustainability, Sustainable Development (SD), Wastewater treatment in Hong Kong.

INTRODUCTION

The land area of the Hong Kong Special Administrative Region (HKSAR) is 1,104 km^2 and its marine water cover an area of 1,651km^2(Hong Kong Environmental Protection Department, 2009). The provisional estimate of the Hong Kong population was 7,061,200 in mid-2010 (Hong Kong Census and Statistics Department, 2010). Almost two thirds of the total population resides around Victoria Harbour, and this results in a high population density of 1000 residents per hectare. Besides, a geological term, a hard granite base yields no appreciable underground water, so Hong Kong itself is seriously lacking in natural water resources. As a densely populated international world-trading center, Hong Kong has suffered a water shortage for most of its 160-year history (Lu, 2003). Nowadays, finding adequate water supplies is still a significant task for the local population especially in the current situation of sustainable development in Hong Kong.

Sustainable Development in Hong Kong

Before considering the sustainability of Wastewater Treatment in Hong Kong, it is helpful to review the definition of sustainability and its implementation in Hong Kong. The modern definition of the concept is most often credited to the Brundtland Commission Report of 1987, which describes it as 'development that meets the needs of today whilst not affecting the ability of future generations to meet their own needs' (Mottershead, 1998). This concept has been accepted and commenced by most world governments, including Hong Kong, since the end of last century. However, it is also obvious that the implementation of this concept is becoming increasing difficult.

Mottershead states that the Hong Kong Government first began its formal recognition of sustainable development in the early 1990s, but its commitment to it as a matter of policy has been spearheaded by the infusion of environmental issues into the most recent review of the Territorial Development Strategy (Mottershead, 1998). The impact of this term, sustainable development (SD), will have a tremendous impact on

all aspects of Hong Kong life, including social and economic perspectives, the living environment, industry and education. However, Hong Kong is approaching the SD strategy more slowly than other countries such as the United States, Australia, India, and Taiwan. As regards their worsening pollution problems (particularly air and water pollution) and health issues, there is a saying that 'Hong Kong is situated with first world economy but third world hygiene standards'.

Water Pollution Control in Hong Kong

The Water Pollution Control Ordinance (WPCO), Hong Kong's main water management law, was enacted in 1980. However, during the 1970s and 1980s, there was almost no development of sewage management in Hong Kong, so that there was a rapid decline in water quality in the Vactoria Harbour. However, in the last 20 years, Hong Kong has worked diligently to improve its water quality. The water quality for the marine ecological system has been effectively controlled.

In 1989, the Hong Kong government issued the White Paper, which partially dealt with overall policy objectives for water pollution. In order to control effluent, discharges were regulated, ten Water Control Zones (WCZs) were declared from 1987 to 1996. In addition, three major water zones, Tolo Harbour, Deep Bay and the Victoria Harbour, received special attention, which was designed to protect the sensitive water body, upgrade sewage treatment plants, and control livestock waste. They were the first positive result of the enactment of WPCO. The number of red tide incidents also decreased from a peak level of 39 in 1988 to 8 in 1995 and a major reduction of pollutant input to Tolo Harbour was achieved in 1996 (Chau 2007; Hong Kong Environmental Protection Department, 1996). Figure 1.2.1 and Figure 1.2.2 is shown the Overall compliance with the marine Water Quality Objectives, the overall compliance rate with the WQOs and the compliance rates for the four objectives in Hong Kong, 1986-2009, respectively.

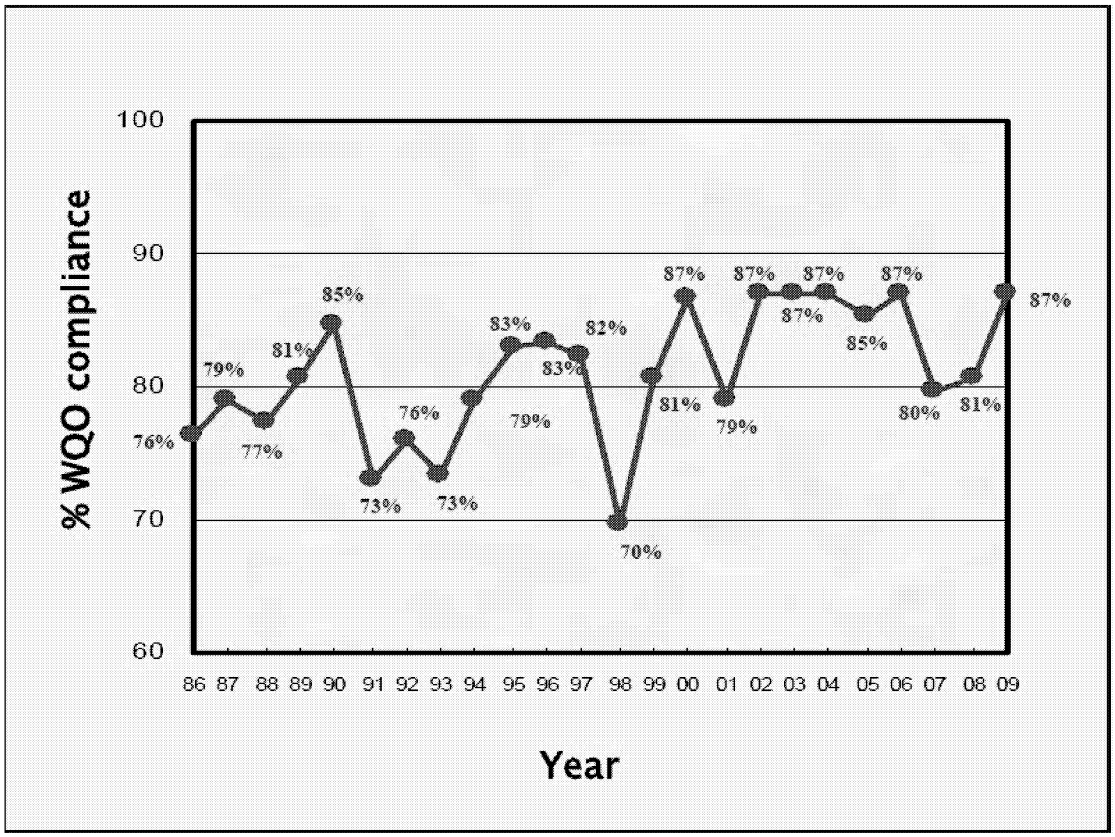

Figure 1 Overall compliance with the marine Water Quality Objectives in Hong Kong, 1986-2009

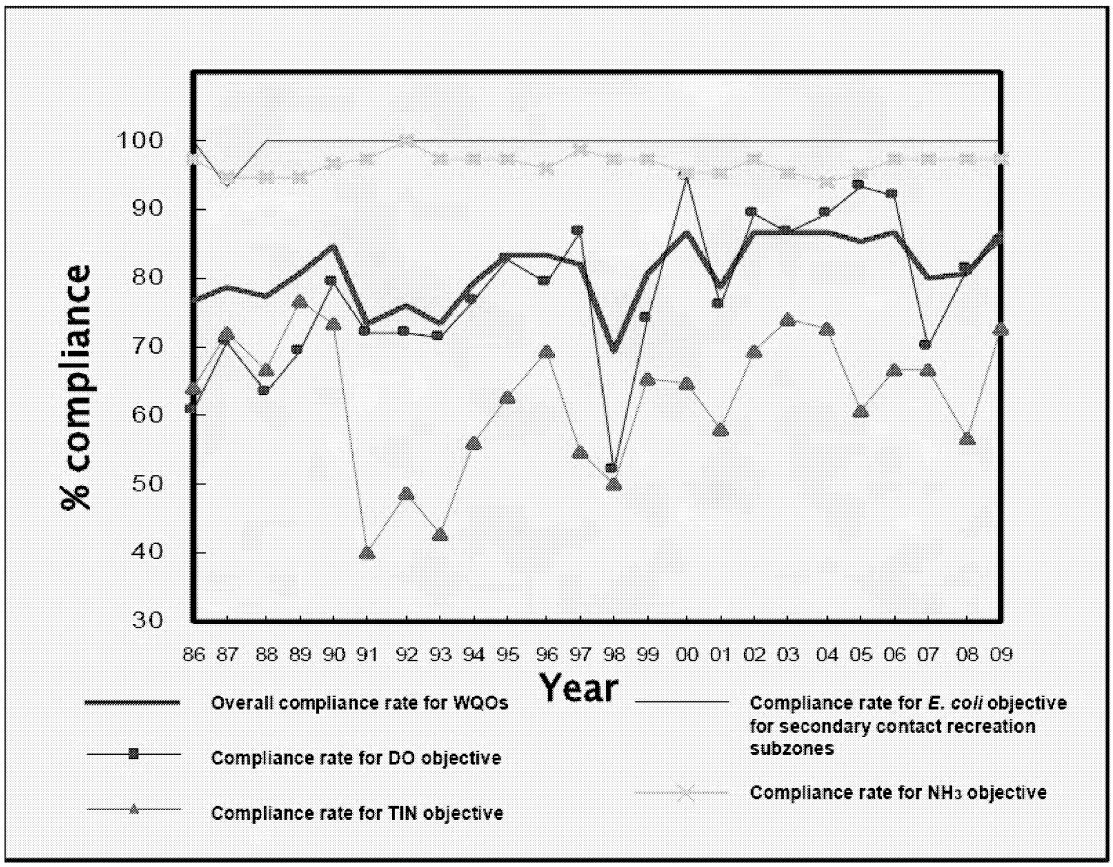

Figure 2 The overall compliance rate with the WQOs and the compliance rates for the four objectives in Hong Kong, 1986-2009

Sustainable Wastewater Management in Hong Kong

Toward sustainability of wastewater management in Hong Kong, the concept of "the polluter pays" was adopted especially for changing the sewage and chemical waste in order to put water quality under control. This measure has been successful in dealing with wastewater treatment. Apart from the treatment and disposal options discussed, measures to tackle the problem at source need to be considered. Clean technologies have been introduced to the industry to reduce wastewater discharge (Cook and Ng, 2004). However, there is a vast concern resting with disposal of the excess activated sludge, which the sewage treatment plant produces every day. The Tseung Kwan O Bad Smell problem is caused largely by most of the sludge disposed into Tseung Kwan O landfilling area. This is also the reason why the inhabitants reject the goverments' plan on extending the Tseung Kwan O Landfilling area. The Environmental Protection Department said continuing to bury at landfills could also lead to slope failures and dangerous sludge-slides. It is estimated that the total quantity of sludge arising in Hong Kong, primarily from 86,000 tonnes of dry solids (tds) in 1997, will amount to over 300,000 tds in 2021 (Cook and Ng, 2004).

To treat the excess activated sludge produced by the local sewage treatment plants, the HKSAR government has already implemented a Tuen Mun Incinerator Plan since October, 2010. The Legislation Council has already made an appropriation of HK$ 5.15 billion and HK$145 million a year in maintenance to the Environment Bureau for building an incinerator in Tsang Tsui, Tuen Mun, which will reduce sludge by 90 percent. The incinerator will be commissioned by 2012 and handle 2,000 tonnes of sludge a day by 2016. It is anticipated that this plan will bring benefits to the sustainable development of Hong Kong.

REVIEW METHODOLOGY

The three main areas in studying the wastewater treatment in Hong Kong are:

- ✧ Wastewater Treatment in Hong Kong;
- ✧ Indicators of Sustainability in Wastewater Treatment;
- ✧ Sustainable Wastewater Management in Hong Kong.

After reviewing the literature on the three aspects mentioned above, in particular that of sustainable development in wastewater management, this report states the research questions of the study and answers. It continues to explain wastewater treatment in the sustainable development and discuss of environmental preservation on treating wastewater in Hong Kong.

INDICATORS OF SUSTAINABILITY IN WASTEWATER TREATMENT

This part will focus on the indicators of sustainability in wastewater treatment. A set of indicators that incorporate the economy, environment, and societal sustainability were analyzed. These indicators also determine the reuse potential of the treated wastewater. The set of indicators selected were based on: (1) the relevance of the indicators to different wastewater treatment technologies, and (2) their ability to indicate progress towards balanced sustainability or away from it, that is equal inclusion of economic, environmental and social aspects (Muga, 2007). The wastewater treatment technology is divided into 3 categories, which are mechanical (Secondary Treatment Plant), lagoon, and terrestrial.

There is a greater need to develop more environmentally responsible, appropriate wastewater treatment technologies nowadays. Sustainable technology is technology that does not threaten the quantity and quality (including diversity) of the resources (Balkema, 2002). One important concern is that the sustainable technology will change as the quantity and quality of the resources and the resilience of the environment to emissions change. A more accurate description of the sustainability indicators is provided below.

Economic Indicators of Sustainability in Wastewater Treatment

The economic indicators selected are capital, operation and management, and user costs because they determine the economic affordability of a particular technology to a community (Muga, 2007). The capital costs are different for the different wastewater treatment technologies, based on the cubic meters of wastewater treated per day. More capital construction costs will be spent on the mechanical system, but less on the lagoon system because of high degree efficiency in treating wastewater. The operating and management costs include labor, energy, purchase of chemicals and replacement equipment and maintenance fee. Muga (2007) shows that the cost for mechanical treatment is approximately 4-5.5 times higher than a lagoon system and 4-6.5 times greater than a land treatment system. A secondary treatment plant requires more highly mechanized equipment and complicated processes that need more cost. The cost of wastewater treatment for a resident of a smaller population, serviced by a treatment plant capacity of $< 37x10^3$ m^3, is much higher ($0.10–$1.24) than that of a resident of a larger population serviced by a larger plant capacity $>708x10^3$ m^3 using similar treatment systems (Raftelis Financial Consulting, 2004). Cost-effective treatment technologies such as lagoon and land treatment systems have the potential to reduce these costs by at least one-half (reduced costs to the order of US$100 per household) (Helmer and Hespanbol, 1997).

Environmental Indicators of Sustainability in Wastewater Treatment

Environmental indicators include energy use, because it indirectly measures resource utilization, and performance of the technology in removing conventional wastewater constituents such as biochemical oxygen demand (BOD), ammonia nitrogen, phosphorus(TP), and pathogens (Muga, 2007). The reason for the energy use is very significant is it is associated with global environmental problems, like global warming, such as carbon dioxide emissions. Due to the energy consumption during aeration and pumping influent and effluent, the activated sludge treatment plant requires more energy than used in the lagoon system and the land treatment systems. Some activated sludge plants in the United States may have lower energy consumption due to the use of internal energy produced, methane gas from the treatment of excess activated sludge.

In order to reduce energy use and harmful impacts, the treatment plant design should consider about the technology selected, use of recycled construction materials, and proper time management for operating equipment, even the internal use of methane as electrical power. For the removal efficiency of different treatment technologies, mechanical treatment has higher removal efficiency of BOD, TSS, but lower in total phosphorus (TP) and total nitrogen (TN). Lagoon system has higher removal efficiency in TSS but medium to high in BOD, and low to medium in TP and TN. The land treatment system only has high removal efficiency of fecal coliforms but varying in other factors. However, all three kinds of systems evaluated have the capability of producing effluent quality within the suggested WHO guidelines for reuse.

Societal Indicators of Sustainability in Wastewater Treatment

Societal indicators capture cultural acceptance of the technology through public participation and also measure whether there is improvement in the community from the specific technology through increased job opportunities, better education, or an improved local environment (Muga, 2007). It is investigated that a best technology is going through a public's perception and preferences for selection with their local and broader sustainability concerns. For consideration of community size, mechanical and lagoon systems are more capable of serving a larger population than land treatment systems. The key factors in community size are the land requirement and open space availability especially in urban areas.

Another easy regard-lessness is ordor assessment for considering the societal indicators. For the treatment system, all kinds of them have the potential to produce odorous emissions. It occurs principally from the influent station, aeration tank, and excess activated sludge tank. The excess sludge produced from the plant can generate significant odorous emissions. The overgrowth of filamentous bacteria, scum and foam buildup, and bad sludge settling property also contribute to the odorous problem. Overall, the mechanical systems appear to have the greatest odor potential, followed by lagoon systems, and land treatment systems (Muga, 2007). Furthermore, the level of education is also considered as a key indicator for sustainability. The activated sludge treatment plants often require some skillful operators, even with qualifications. Generally speaking, land treatment was found to obtain good performance of all three systems, including lowing capital cost, user cost and low potential to produce odor.

WASTEWATER TREATMENT IN HONG KONG
Governments' Action

As mentioned previously, Hong Kong has achieved a great improvement since a systematic and wide-range monitoring management master plan was established. Due to the effective implementation, the quality of sea water obtained visible benefits. The master plan includes (Hua, 2008):
(1) Establishment of Water Pollution Control Ordinance (WPCO) and Water Control Zones (WCZs);
(2) Constitution of Harbour Area Treatment Scheme (HATS);
(3) Upgrade of services and facilities for management of municipal wastewater and chemical wastes;
(4) Implementation of a "Polluter Pays Policy".

Currently, about 2.6 million m^3 of wastewater is treated each day and 28.7% receives primary treatment, 54.5 % receives chemical-enhanced primary treatment and 16.4% receives secondary treatment (Table 4.1) (Hong Kong Drainage Services Department, 2005).

Table 1 Proportions of sewage treatment methods in Hong Kong (Hua, 2008)

Treatment Level	(Number of Plants)				
	HK Island	Kowloon	Outlying Island	New Territories	Percentage (100%)
Preliminary Treatment Plant	11	9	1	3	28.7
Primary Treatment Plant	0	0	2	0	0.4
Chemical Enhanced Primary Treatment Plant	1	1	0	0	54.5
Secondary Treatment Plant	2	1	11	23	16.4
Total	14	11	14	26	100

Sustainable development of wastewater

In keeping pace with other countries in sustainable development of wastewater treatment engineering, Hong Kong not only addressed the issue of sewage treatment but also reduced the quantities of wastewater discharged into local waters, which is the water recycling. Water recycling is a key choice to reduce the water pollution. It is also a good way to relieve the pressure of local shortage in potable water supply.

The existing secondary treatment plant in Ngong Ping is a good example in reuse of the treated effluent. Ngong Ping is located within the water gathering ground of Shek Pik Reservoir and surrounded by country parks. After the upgrade of sewage treatment services and facilities, Ngong Ping Sewage Treatment Works became the first tertiary sewage treatment plant in Hong Kong, in which the sewage collected in Ngong Ping will be treated with tertiary level before discharge. What's more, the treated effluent is reused for flushing water in the public toilets since the Cable Car system and associated tourism developments in late 2005.

DISCUSSION AND CONCLUSION

In order to maintain a sustainable development and a good water quality in Hong Kong, the government has implement a series of measures such as legislation, clean actions, upgrade of treatment facilities, and economic policy. It still needs to apply with various programs to promote the good water quality in Hong Kong, which includes,

(1) Implementation of next stage of HATS;
(2) Application of advanced wastewater treatment technologies (biological aerated filter, nutrient removal);
(3) Reducing discharge loading from the local and the Pearl River Delta through better sewage infrastructure treatment facilities and transportation;
(4) Controlling industrial effluents and agricultural runoff;
(5) Developing the higher efficiency in dealing with tertiary treatment of sewage;
(6) Constructing more incinerator plant in treating with excess activated sludge produced from wastewater treatment plant;
(7) Developing the technology in reuse of treated effluent and sludge;
(8) Conducting on public education in promoting awareness of water conservation.

The government should enhance the "Polluter Pays Principle", which is widely accepted as an effective policy that requires domestic households to share the operational costs of sewage treatment. This policy not only provides additional financial assistance for livestock farmers to install on-site waste treatment facilities in farmlands, but also provides an incentive to minimize wastewater generation and adopt cleaner production techniques.

It still plays a significant role for the wastewater treatment in the sustainable development in Hong Kong, since Hong Kong still has less experience with sewage treatment and disposal as compared to other countries like Japan, Unites Stated and Europe. It is unlikely to find a satisfactory solution in the short term.

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