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WATER, SANITATION AND HYGIENE: CHALLENGES OF THE MILLENNIUM

Dual water supply in Hong Kong

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NOT MANY COASTAL cities in the world use dual water supply systems (fresh/sea water systems in two separate distribution networks) for potable and non-potable (e.g. toilet flushing, fire fighting, etc.) uses, although these are currently being operated satisfactorily in several locations world-wide (DFID, 1997). A study on the effectiveness of using seawater for non-potable purpose and how the consumption of potable water can be reduced was carried out four years ago (Smith, Stear and Parr, 1996). Its conclusion was that dual water supply systems could become an increasingly viable option for large urban areas in coastal zones. Hong Kong is one of those few cities using the dual systems, and the systems have been available since the 1950's. The objectives of this paper are to describe the implementation of the dual water supply systems in Hong Kong and evaluate the effectiveness of the systems. Since the used water will enter the wastewater sewerage system, therefore the effect of the mixed wastewater (fresh/salt) treatment in biological sewage treatment works will also be addressed.

Fresh water supply system

Hong Kong is a coastal city in China with an area of about 1,000 m^2 and a population of 7 million. With reference to geology, Hong Kong has a hard granite base which yields no appreciable underground water. Moreover, the mountainous nature of much of the territory has made the collection and storage of rainwater extremely difficult. The average annual fresh water demand in Hong Kong is about one billion cubic meters. As a result of high demand and low supply, over 70% of the fresh water used in Hong Kong is purchased from Guangdong Province of China (WSD, 1996). The water is extracted from Dongjiang (ie. East River) at a point about 83 km away from the northern boundary of Hong Kong and is received at the Muk Wu Pumping Station at the very north of the Hong Kong territory. From Muk Wu, the water is delivered to the 17 storage reservoirs at various locations (ie. 17 impounding reservoirs in which a total of less than 30% of water demanded annually in Hong Kong is catched). Then, a series of treatment processes is carried out and after that,

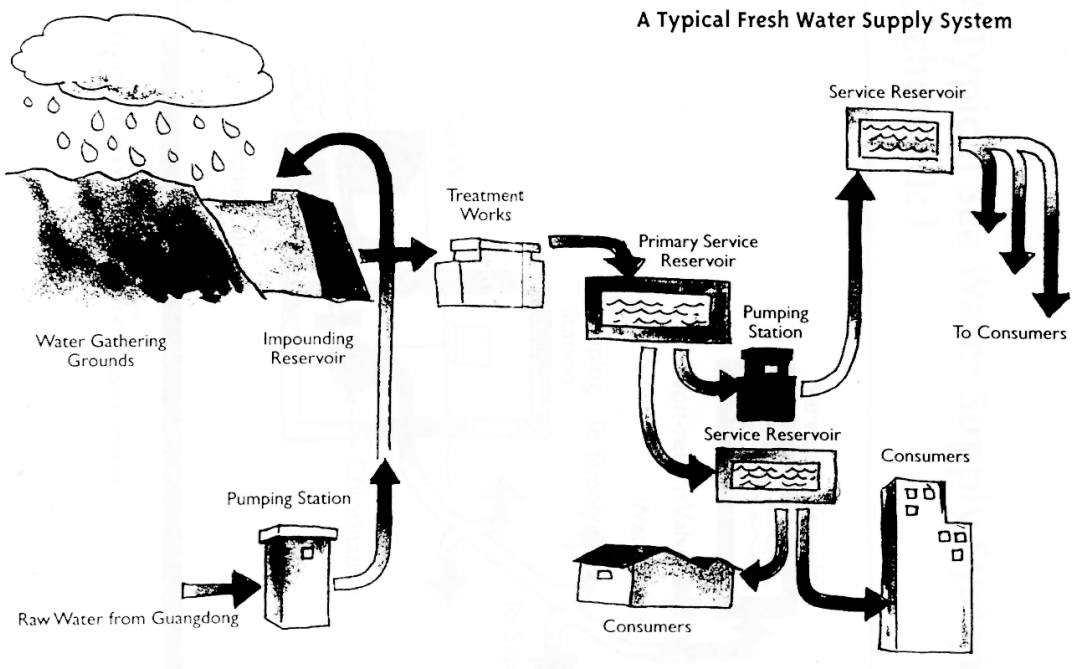

Figure 1. A typical fresh water supply system

water is delivered to the consumers though a distribution system (see Fig. 1).

The distribution system consists of 166 service reservoirs situated throughout Hong Kong with a total capacity of 3.42 Mm^3, 141 pumping stations with a total pumping capacity of 28.57 Mm^3/day, and a huge piping network consisting of a total of 4800 km water mains. Water from the service reservoirs is distributed to consumers by gravity via extensive networks of water mains. The pressure in the system is sufficient to provide a direct supply to buildings of seven storeys above street level. With the assistance of individual pumping systems installed inside tall buildings, consumers at higher floor can be served. For remote village areas, the pressure is normally sufficient to provide a direct supply to three storeys above ground level.

The usual water treatment processes adopted are firstly mixing and coagulation (with alum) in mixing chambers, then flocculation and sedimentation in clarifiers, then rapid gravity filtration, and lastly disinfection. There are 19 treatment plants at various locations in Hong Kong with a total capacity of treating 4 Mm^3 of fresh water per day. The treated fresh water will then enter into the distribution system. Water samples are collected at various locations of the entire system for water quality testings. The locations include catchment intakes, pumping stations, treatment works, service reservoirs, other strategic points in the distribution system, and consumers' taps.

Sea water supply system

About three quarters of the population in Hong Kong are supplied with seawater for toilet flushing. The seawater supply system consists of pumping, treatment, storage and distribution. Seawater pumping stations are constructed near the shore and the seawater is extracted from the sea directly. Treatment processes which are much simpler than that of fresh water are then carried out. The treatment processes usually comprise only screening and disinfection and because they are simple they are usually carried out inside the pumping stations. After that, the treated seawater is pumped to service reservoirs and then to consumers by means of extensive pipe network systems (see Fig. 2). There are totally 38 seawater pumping stations located at various locations (usually at seaside) in Hong Kong and their total pumping capacity is 1.43 Mm^3/day. There are also 49 service reservoirs built for seawater and their total capacity is 0.2 Mm^3, with a network of seawater mains whose total length sums up to 1100 km. In order to avoid corrosion, seawater mains are normally made of materials such as polyethylene or polyvinyl chloride pipes.

Annual expenses

The operating and administration expenses for the dual supply systems amount to HK$1,165 million a year (HK$7.80=US$1.00). This figure excludes the purchase

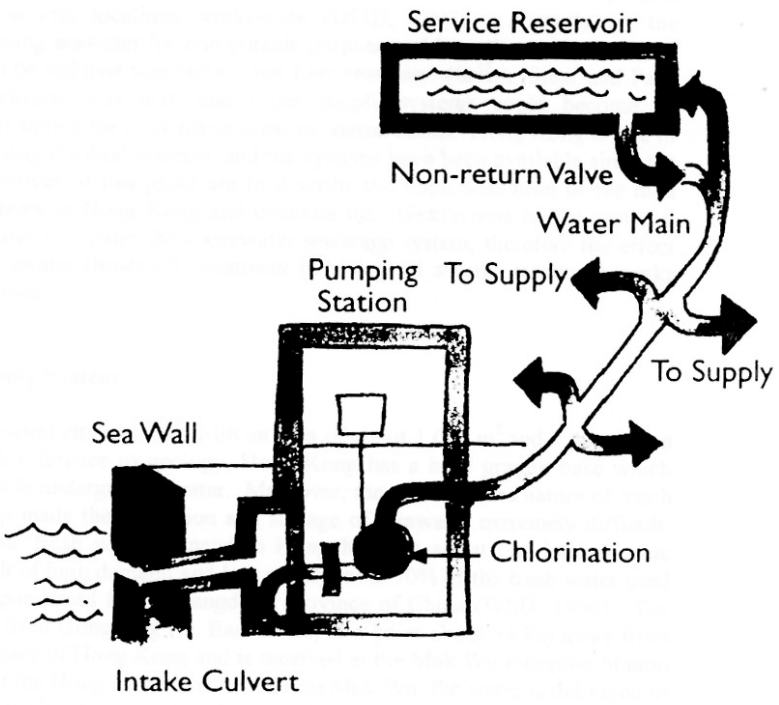

Figure 2. A typical sea water supply system

cost of water from China (HK$2,300 million a year) and the staff cost (HK$1,280 million a year). Nearly half of the total operating and administration expenses goes to paying light and power (HK$542 million) and the other 26% is for the payment of contract maintenance (HK$306 million) which includes the provision for maintaining waterwork buildings, reservoirs, water mains, filtration and pumping plants, and for emergency repairs resulting from typhoon and rainstorm damages. Other items in the operating and administration expenses belong to the hire of services and professional fees, specialist supplies and equipment, maintenance materials and general departmental expenses, etc. (Leung, et. al., 1999).

The above expenses have not included expenditure on capital investment. It is envisaged that new water treatment and distribution facilities must be constructed to meet the increasing demand of fresh water and seawater. Pipeline rehabilitation programme is also necessary because some old pipes in certain areas are leaking due to old age. These new facilities and renewal programmes need money and an accurate figure of the money was not available at the time when this paper was written. Only a very rough estimated figure is known: HK$2 billion per year for the next five years (i.e. 2000-2005).

Treatment of mixed (fresh and salt) Wastewater at sewage treatment works

Since fresh water and seawater both go to the same sewerage system after they are used by the consumers, they will be led to the same sewage treatment works. The ratio of fresh wastewater and saline wastewater entering into the works is about 3:1, that is, 25% of the total wastewater is seawater. According to an investigation work done by Kessick and Machen (1976), physical-chemical treatment procedures (coagulation, flocculation and sedimentation) are equally effective in both fresh and salt water waste samples. Another work done by Li and Gu (1993) suggested that when the concentration of NaCl is below 35000 ppm (NaCl concentration is 32000 ppm for seawater), a two stage oxidation process is effective in treating the saline water. Although there were a few more works reported, not many existing literatures could be found available on the issue of saline wastewater treatment.

The experience in treating mixed wastewater in Hong Kong has revealed that no big problem has occurred so far. This may be due to the low saline content (25% seawater only) of the wastewater. The Drainage Services Department of the Hong Kong Government is now undertaking a research work named "Comprehensive Study on the Effect of Seawater Flushing on Biological Treatment Processes". The results of the work were not yet known at the time when this paper was written.

Conclusion

The dual water supply system in Hong Kong have been successfully run for over 40 years. Undoubtedly, the use of seawater for toilet flushing (and fire fighting etc.) can help reduce a considerable amount of fresh water demand. Provided that fundamental precautions regarding the choice of materials are taken, a seawater supply system is technically no more difficult to construct, operate and maintain than any other reticulation systems. The consequence of dual water supply is mixed (fresh/salt) sewage. Mixed sewage, however, at least in the Hong Kong situation, is treatable and causes no adverse effect and extra treatment expenses. Experience shows that the treatment method (e.g. conventional activated sludge process without any modification) used in Hong Kong is adequate for mixed sewage. A profound study on biological treatment of mixed sewage, as mentioned earlier, is currently being undertaken by the Drainage Services Department of the Hong Kong Government. It is hoped that the results of the study will reveal further knowledge on the issue of saline wastewater treatment.

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