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Water recycling with PV-powered UV-LED disinfection

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Abstract

Water is in short supply with countries vying for access to river heads. Hong Kong (HK) is no different. It relies on supply from Mainland China with other cities rivalling access. Yet there is still no great impetus for water conservation. This paper reports on progress in setting up a pilot biological wastewater treatment plant and a PV-powered UV-LED disinfection system plus a feasibility study carried out in conjunction with a local developer investigating the application of the treated water for irrigation. The objective is to incorporate the systems within a small-scale community for its contribution to water and energy conservation as well as establish the parameters for replication in other countries with potential up-scaling for urban application.

Keywords: Water conservation; Biological wastewater treatment; PV system; UV-LED disinfection

1. Introduction

United Nations has designated 2005–2015 as the International Decade for Action highlighting Water for Life. Szollosi-Nagy, in a 2004 UN-sponsored seminar [1], identified that water can be the catalyst for peace, at the same time calling on the Active Management of Shared Water Resources to avoid conflict over the vital commodity. Disputes are common in central Kenya, where media report that rows over water have recently led to 16 deaths [2]. In SE Asia, the countries sharing the waters of the Mekong are in dispute over dams proposed upstream that threaten the water source of Laos, Cambodia

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and Vietnam downstream. Even when advantageous trade deals are agreed, growing demands create new pressures. The Hong Kong (HK) Special Administrative Region has for many decades sourced its water from the riverhead of the Dongjiang River in Mainland China, but now, newly developed cities in the region rival for closest access to the riverhead. While HK draws its water from across the border and its citizens complain of high cost and low quality, very little is being done to encourage water conservation in the home territory. Moreover, the responsibility is disparate with water supply quality being covered by one department and sewage systems by another. As with other services, there is a tendency to consider only centralised systems though these have long lead-in time, tending to be inflexible to change and extremely expensive large-scale infrastructure projects. Presently in HK, with a population of 6.28 million, 1.4 million cubic metres of sewage is produced every day. According to HK Environmental Protection Department (EPD) officers, 99% of that sewage is water. [3]

The impetus to promote biological wastewater treatment arose not only from concern for water conservation, but also the treatment process's potential for generating methane gas as a secondary energy source, plus considering the advantages of de-centralised sewage treatment and its possible integration within new (residential) developments in a holistic approach to providing sustainable services. In remote areas of cultural and nature tourism, reclaimed water can be used for man-made wetlands and landscape irrigation.

2. Pilot project development

The University of Hong Kong's (HKU) Marine Campus is sited at Cape D'Aguilar, on the south side of HK Island. It operates a non-mains sewage system. Chu, in her thesis research, organised the addition of planted filtration beds extra to the sedimentation tank to form a small biological wasterwater treatment process. As a botany project, Chu's results highlighted the improved performance of plants fed with fertiliser, the organic residue of the biological wastewater system. [4] In 2002, the waters surrounding Cape D'Aguilar were designated a marine reserve and required the discharge from the system to be upgraded. Despite its known toxicity for organic life, a chlorination process was adopted to meet the raised standards required by HK's EPD.

However, researchers at the Kadoorie Farm and Botanical Gardens (KFBG), a research facility affiliated to HKU, had co-operated with Chu, and later adopted biological treatment for its pig-farm waste, further extending the plant research to establish the performance of more varieties in the HK sub-tropical climate. (Fig. 1)

This second HKU research project revives the original Marine Campus biological treatment process adding large plastic tanks which culture algae and aquatic plants *Cyperus alternifolius* L., *Vetiveria zizanioides*, and *Canna generalis*, as suggested from the KFBG experience, to feed on the suspended solids and nutrients in the sewage. There is a degree of trial and error expected to establish optimum culture in this seashore location due to its varying salinity through the seasons. The quality of the sewage and effluent will be monitored regularly according to standards and criteria set by HK's EPD (1991) [5] in order to identify this best configuration. The project seeks to meet WHO standards for irrigation-quality water. Until the standards have been documented and authorised by HK's EPD, the discharge is required to be returned to the chlorination process before final discharge into the marine reserve (Fig. 2).