TBR Project Title: **Enhanced Separation and Sludge Refinery for Wastewater Treatment – Solving the Nexus of Pollution Control and Resource Recovery in Mega Cities**

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Theme 2: **Developing a Sustainable Environment**

Abstract

Many forms of development erode the environment, causing serious water pollution in Hong Kong, China and many other regions of the world. Most core wastewater treatment technologies were developed about half a century ago that are no longer capable of accommodating the fast population growth, industrialization and urbanization. A city like Hong Kong discharges more than 2 million tons of municipal wastewater every day. Removal of the pollutants in wastewater treatment is not only difficult and costly (~HK$3/ton) but also produces a large amount of sludge (~1 ton dewatered sludge per 1000 ton wastewater). Disposal of the sludge, and the food waste as well, is one of the most challenging and expensive environmental problems for large cities.

On the other hand, major pollutants (organics and nutrients) in wastewater are valuable resources that should be recovered instead of being degraded or wasted with the sludge. As a mega city with over 7 million people, Hong Kong is a typical urban environment needing such technological breakthroughs for its planned wastewater treatment upgrading from the current primary level to the secondary level. In this project, novel technologies, namely Enhanced Separation and Sludge Refinery (ESSR), will be developed for advanced wastewater treatment and food waste processing. The theme-based research includes the following programs.

(a) Chemically-enhanced Membrane Filtration (CeMF) replacing the conventional primary sedimentation, together with the side-stream Acidogenic sludge and food waste Co-Fermentation (sACF), for phosphate recovery and organic hydrolysis for use in production of organic acids and bio-plastics and in nitrogen removal by denitrification;

(b) Treatment of the waste sludge by thermal Sludge Hydrolysis followed by fungal Fermentation and Refinery (SHFR) for waste minimization and production of ethanol and bio-fibres, with the subsequent recovery of ethanol and ammonia from the solution;

(c) Integration and pilot demonstration of the novel CeMF-sACF and SHFR modules for advanced wastewater treatment with improved nutrient removal, energy saving, resource recovery and sludge reduction, together with the assessment of the effluent quality and its impact on the receiving aquatic ecosystem.

The proposed technological development will fundamentally transform wastewater treatment from an end-of-the-pipe purification to a resource-mining practice. Besides the design of new treatment plants, the novel processes can also be used as add-on modules to retrofit existing treatment facilities, achieving more sustainable water pollution control, resource recovery and sludge minimization for Hong Kong, China and elsewhere.

Main Points

- **Objectives**

(a) To develop a new wastewater treatment process aiming for effective and energy-saving treatment, sufficient nutrient removal and high-quality effluent;

(b) To create the capabilities of recovering resources and energy from municipal wastewater, achieving sludge minimization together with the production of value-added products; and

(c) To present an advanced urban water pollution control system with a sound integration of wastewater treatment, resource recovery and minimization of sludge and food wastes.

- **Deliverables:**

(a) Development of an innovative chemical-biological process, namely Chemically-enhanced Membrane Filtration (CeMF) by ceramic membranes with side-stream Acidogenic sludge & food waste Co-Fermentation (sACF), that can greatly advance wastewater treatment to fulfil the demands of high nutrient removal, small footprint, energy-saving, and phosphate and organic recovery;

(b) Development of a novel sludge treatment system, namely thermally-enhanced Sludge Hydrolysis followed by fungal Fermentation and Refinery (SHFR), that can greatly reduce the waste sludge and recover energy and resources for valuable products, including ethanol, organic acids, bio-plastics, phosphorus, ammonia and bio-fibrous materials; and

(c) Pilot trials and demonstration of the novel CeMF-sACF and SHFR scheme for both new and existing wastewater treatment systems, together with the assessment of the effluent quality and system performance, in particular the ecological impact of the effluent from the proposed treatment system.

主題 2：　　建設可持續發展的環境

項目名稱：　　高效濃縮分離和污泥精煉協同新技術實現城市水污染控制和資源回收

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摘要

隨著經濟社會的發展，水污染問題日益嚴重，香港、中國大陸以及世界很多地區的自然環境都承受著越來越大的污染壓力。傳統的污水處理技術沿用至今已超過半個世紀，難以應對當今工業化和城鎮化所帶來的不斷增加的污染負荷。作爲一個典型的超大城市，擁有七百萬人口的香港每日產生兩百多萬噸的污水。去除污水中的污染物不僅困難且成本很高（處理每噸污水約需港幣三元），同時還會產生大量的污泥（每處理一千噸污水約產生一噸的剩餘污泥）。污水處理所產生的剩餘污泥，以及城市廚餘垃圾等有機廢物，由於其產量大、處置困難，已成爲大型城市最棘手的環境問題之一，威脅城市的生態環境和人體健康。

另一方面，作爲污水中主要的污染物，有機物和營養物質（氮和磷）也是寶貴的資源，應該加以回收利用而不是隨剩餘污泥棄置浪費。香港目前大部分污水僅得到一級處理，有必要提升至二級生物處理的水準，以加強水環境的保護。本項目提出了一項全新的技術，即高效濃縮分離和污泥精煉（ESSR）協同新技術，以物質分離和資源回收爲手段，實現高效的污水處理和廚餘垃圾處置。項目主要包含以下三個內容：

(一) 化學強化膜過濾（CeMF）技術取代傳統的初級沉澱，高效去除污染物，結合側流污泥和廚餘垃圾的聯合酸化發酵（sACF）實現磷資源的回收和有機碳的利用，用於生物脫氮和生產有機酸和生物塑膠；

(二) 剩餘污泥的熱水解處理及後續真菌發酵（SHFR）實現污泥減量化和資源回收，生產高增值產品，包括氨水、酒精、生物纖維等;

(三) 高效濃縮分離和污泥精煉協同新技術一體化和試點示範，強化營養物的去除，降低能耗和污泥產量，實現資源回收，並爲出水水質作環境評估。

該技術的研發將幫助解決大型城市污泥和廚餘垃圾的處理問題，同時實現資源的有效回收，將污水處理由尾端淨化轉變爲資源回收和開發。此外，本項新技術可順利配合現有污水處理的基本系統，以單元模塊的形式直接添加到所需處理階段，方便實現處理設施的升級換代，在污水處理的同時進行資源回收和污泥減量，在香港、中國大陸和世界其他地區實現可持續的水污染控制。

要點

- **科研目標**

(一) 開發一個全新的城市污水處理系統，提高污染物去除效率，降低能源消耗，改善出水水質；

(二) 實現污水處理過程中污染物從廢物到資源的轉化，在污泥減量的同時獲得高增值的產品；

(三) 集成開發先進的城市污水處理示範系統，實現污染物的高效去除、污泥及廚餘垃圾的減量和資源的有效回收。

預期成果

(一) 開發創新性的化學-生物污水處理技術，以化學強化膜過濾（CeMF）結合側流污泥和廚餘垃圾的聯合酸化發酵（sACF），有效提高營養物去除效率，降低能耗，減少佔地面積，回收磷和有機碳資源；

(二) 開發新的剩餘污泥處理技術，利用污泥熱水解及其真菌發酵（SHFR）技術，大幅降低污泥產量，同步實現資源和能源的回收，生產高增值產品，包括有机酸、生物塑膠、酒精、氨水、生物纖維等；

(三) 污水和污泥處理技術（CeMF-sACF 和 SHFR）的模組集成和試點示範，相應的系統優化和出水水質的環境影響評估。