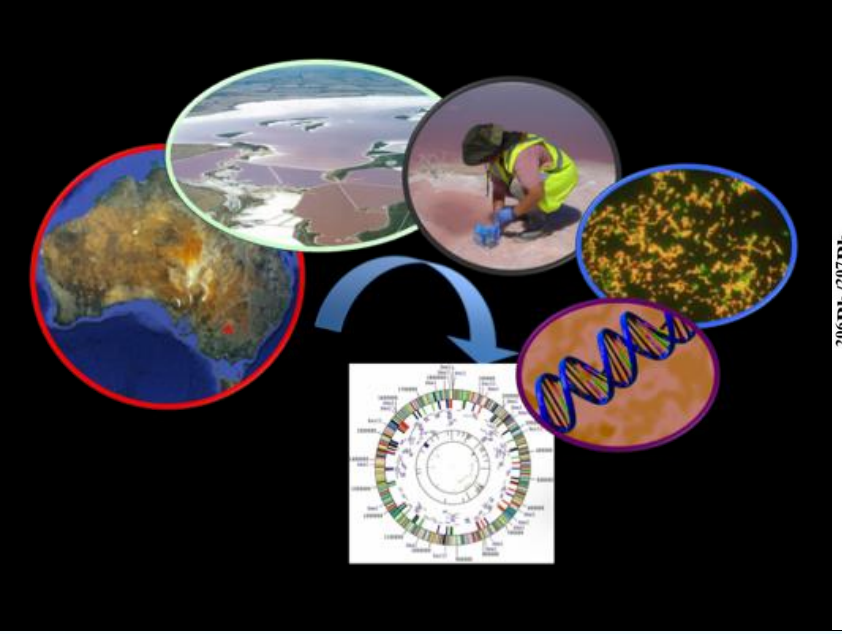
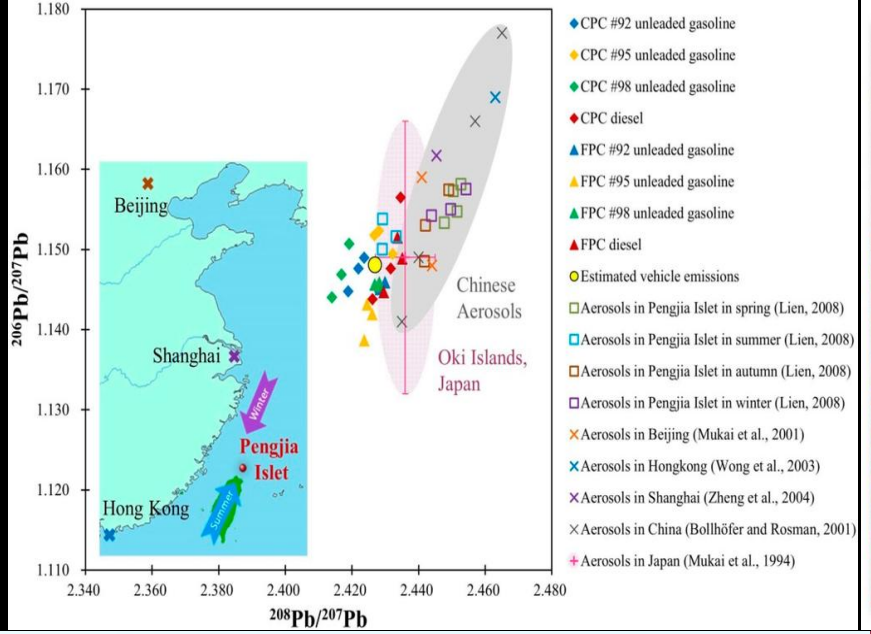
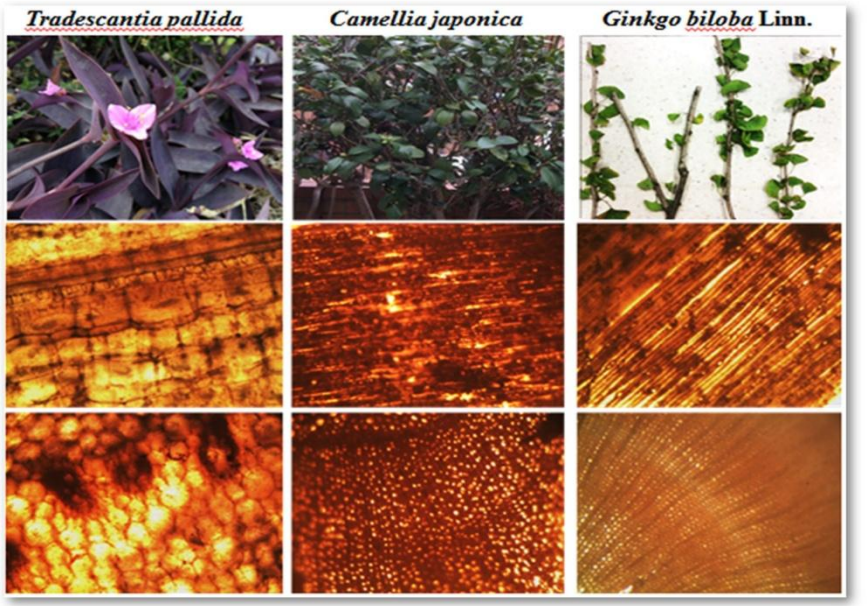






Advanced Environmental Laboratories

ZS1104, ZS1113 and ZS1114, Block Z,
Department of Civil and Environmental Engineering,
The Hong Kong Polytechnic University

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
土木及環境工程學系

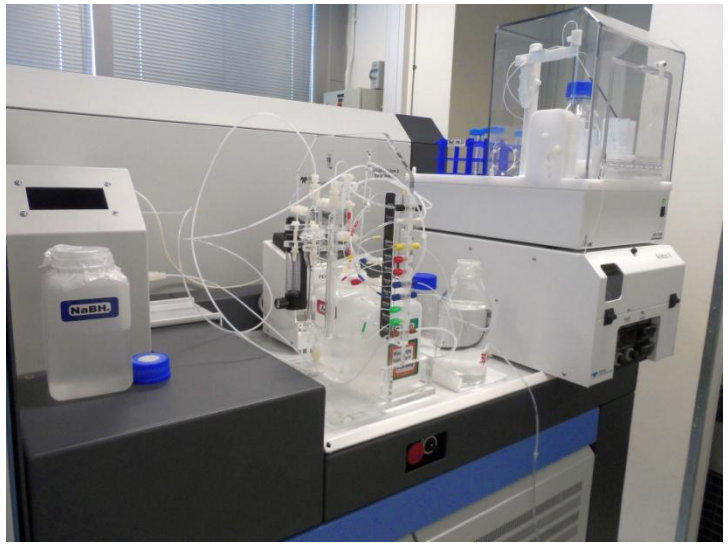
Opening Minds • Shaping the Future
啟迪思維 • 成就未來

Introduction

The Advanced Environmental Laboratories are the latest addition to the Water and Waste Laboratories group which composed of three laboratories. Laboratory for Advanced Environmental Studies hosts two research instruments for University Research Facility in Chemical and Environmental Analysis in the area of Metagenomics and Isotope Analysis. Advanced Environmental Microbiology Laboratory provide the necessary facilities for genomic sample preparations and also support biosafety level II microbiology test environment. Bioenergy Research Laboratory is dedicated to the development of biofuel and nano-catalytic research.

Major Equipment List

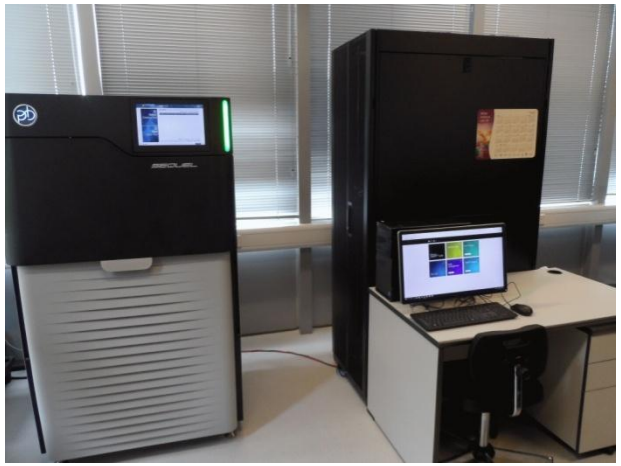
- 3rd Generation Deoxyribonucleic Acid Sequencer
- High Resolution Multicollector Inductively Coupled Plasma Mass Spectrometer
- Pilot Scale Bio-fuel Manufacturing Plant
- VITROCELL Exposure System
- Thermal-Press Processor
- PCR Thermal Cyclers
- Surface Tension Analyzer
- Gel Documentation System
- Anaerobic Chamber
- Automated DNA Size Fragment Selector
- Real-Time PCR
- Bioanalyzer
- NanoDrop Spectrophotometer
- Lab-scale Anannox Reactors
- Grinder
- Hybridiser
- Water Baths



Major Equipment List

- High Performance Bioinformatics Supercomputer Cluster
- Elemental Analyzer
- Raman Spectrometer
- Electronic Desiccators
- Centrifuges
- Vibration Mixers
- CO2 Incubator
- Microbiological Incubators
- Drying Ovens
- Digital Microscopes
- Freezers
- Rotary Evaporators
- Ultrasonic Baths
- Vacuum Ovens

Main Equipment



3rd Generation Deoxyribonucleic Acid Sequencer

The new Sequel System is based on the Single Molecule, Real-Time (SMRT) technology and delivers about 7X more reads with 1 million zero-mode waveguides (ZMWs) per SMRT Cell. The Sequel System is ideal for projects that require high-quality whole genome de novo assemblies. This innovative sequencing system features automated reagent and SMRT Cell handling and an integrated software suite.

High Resolution MC-ICP-MS

The Neptune Plus system combines field-proven technology with the latest innovations in amplifier technology. This powerful double-focusing mass spectrometer, with high mass resolution, variable multicollectors, and multi ion counting capability, offers ground-breaking sensitivity, high dynamic ranges, unsurpassed linearity, and robust stability for high-precision isotope ratio measurements.

Surface Zeta Potential Cell

Along with ZS90 Zetasizer Nano, the Surface Zeta Potential Cell kit has the ability to measure zeta potential and electrophoretic mobility of material surface using Laser Doppler Microelectrophoresis. The apparent tracer mobility is measured at a number of different distances from the sample surface.

Main Equipment

AUTOMATED EXPOSURE STATION

VITROCELL Exposure Systems have been specifically designed with scientists so that the direct exposure of cell cultures to airborne substances such as gases, complex mixtures, nanoparticles and fibers can be optimally researched at the air/liquid interface.

The Automated Exposure Station facilitates the research of mammalian cell cultures in direct exposure to airborne substances. The system authentically simulates the conditions of human physiological exposure.

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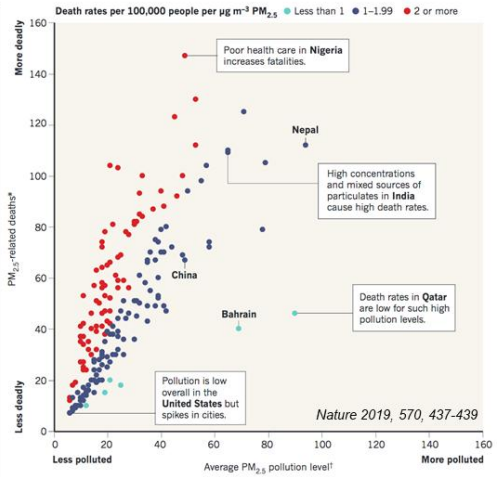
Research Spotlight

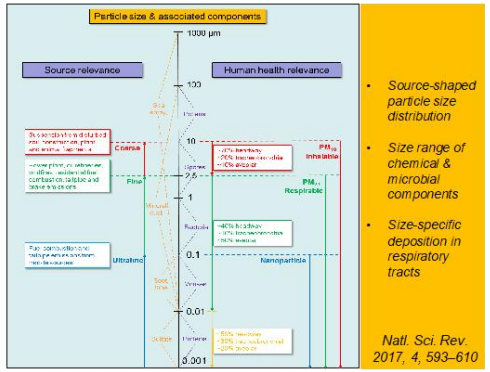
Air Pollution and Human Health

Introduction

Each year, more than 4 million people die early because of outdoor air pollution. The main culprits are airborne fine particulate matter ($PM_{2.5}$).



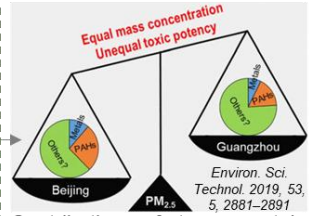
$PM_{2.5}$ is a complex chemical-microbial mixture. Mass concentrations give only a rough guide to its toxicity in a particular place. Reducing the toxicity-driving components is more important than reducing its bulk concentration.



- *Source-shaped particle size distribution*
- *Size range of chemical & microbial components*
- *Size-specific deposition in respiratory tracts*

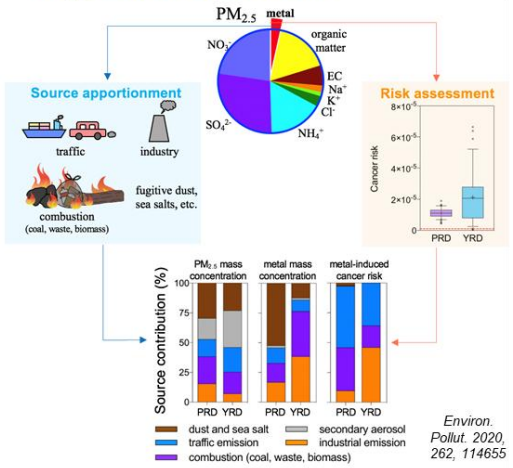
Featured progress

- **Differential toxic potencies of city-specific $PM_{2.5}$ at equal mass concentrations**



Contribution of trace metals and PAHs to intracellular reactive oxidation stress induced by $PM_{2.5}$

- **Health risk-oriented source apportionment of $PM_{2.5}$-associated trace metals**

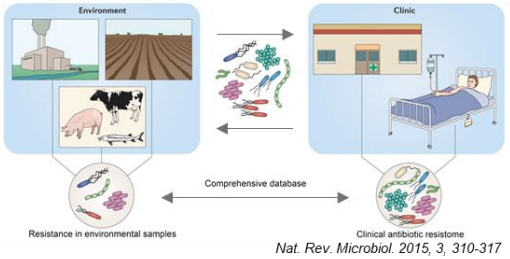


Mass concentration-based source apportionment does not inform adequate mitigation of health risks. A paradigm shift to health-oriented source apportionment is required for cost-effective management of air quality and public health.

Airborne Transmission of Antibiotic Resistance

Introduction

Antibiotic resistance poses an emerging challenge to public health. Airborne transmission is one of the environmental dissemination pathways of antibiotic resistance genes (ARGs), and airborne fine particulate matter ($PM_{2.5}$) as an important ARG carrier has critical implications for human exposure.



Nat. Rev. Microbiol. 2015, 3, 310-317

Sequencing and data processing

Sequencing platform

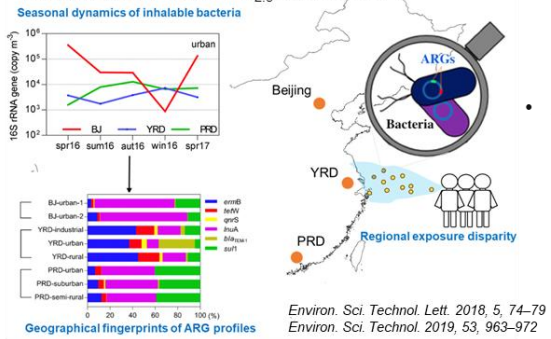
UBDA University Research Facility in Big Data Analytics 大數據分析中心實驗室

DEEPARG Antibiotic Resistance | Nano | ARG

Identification of resistome and hosts

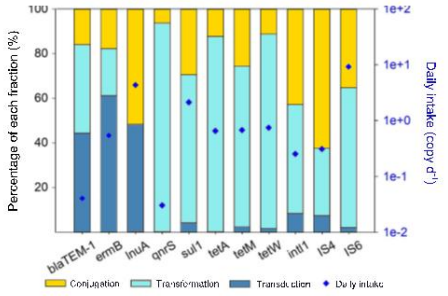
Featured Findings

- Spatiotemporal variations of bacteria and associated-ARGs in $PM_{2.5}$ from China

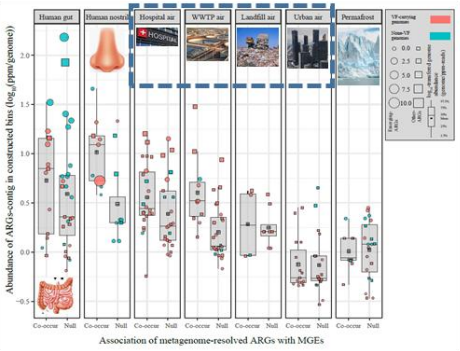


Environ. Sci. Technol. Lett. 2018, 5, 74–79
Environ. Sci. Technol. 2019, 53, 963–972

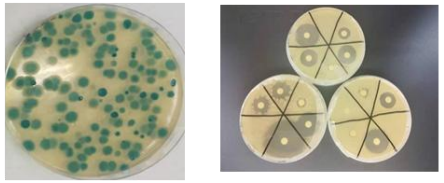
- Contributions of extracellular (transformation, transduction) and intracellular (conjugation) fractions to inhalation exposure to airborne ARGs



- Enrichment of airborne ARGs in emission hotspots compared to urban and pristine environment

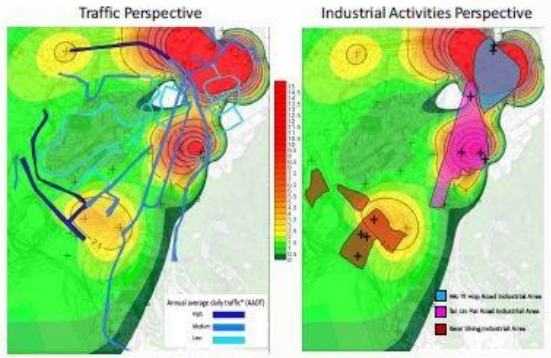


- Antibiotic susceptibility/resistance test of bacterial isolates from $PM_{2.5}$



Research Spotlight

Trace metal contamination of urban soils from a New Town in Hong Kong



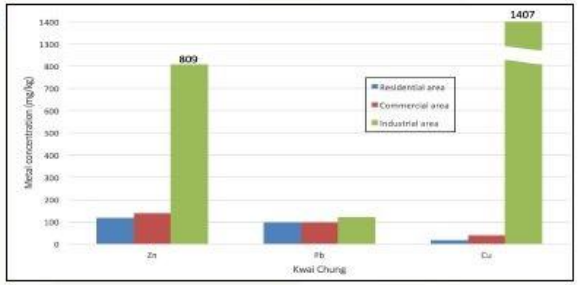
- Roadside and Industrial area (SPI > 2)
  -> Proximity to the major roads
  -> Medium or high traffic volumes
- Automotive emission
- Wear and tear of vehicular component and tyres

- Industrial areas (1 < SPI < 133)
- Historical industrial emission
  ->Industrial manufacturing
  ->Poor wind movement
- Some active industrial activities
  ->Recycling and metal manufacturing

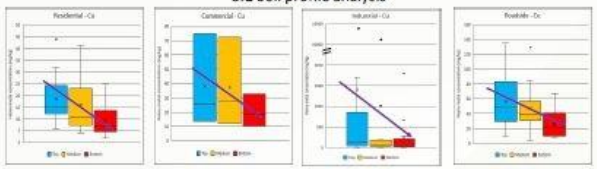
Objectives

This study aims to (1) Provide a background information about heavy metal contamination in urban soils and street dust in Kwai Chung; (2) Develop a soil contamination distribution map to seek for the pollution hotspots; (3) Assess the pollution pattern of urban soils through the comparison between different land uses and analysis of soil profile; and (4) Propose suitable remediation measures.

(1)



3.2 Soil profile analysis



pH: ->Neutral or alkaline soil (6.59 – 7.56)
->Metal leachability is pH dependence
->Mobility of metal decreases

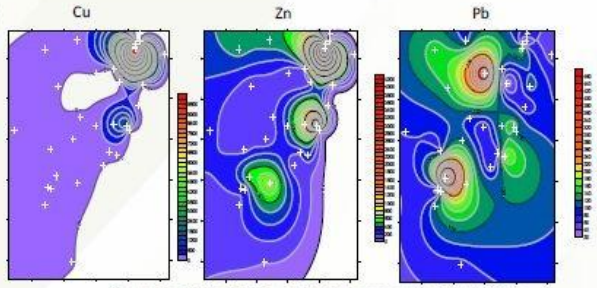
TOC: ->High organic matter in topsoil
->Strong binding affinity of heavy metals
->Formation of insoluble complexes

Road dust

Traffic loadd (AADT)	Cu (mg/kg)	Pb (mg/kg)	Zn (mg/kg)
High	371	155	2420
Medium	549	189	2970
Low	267	111	2430

Traffic volume ∝ Heavy metal content

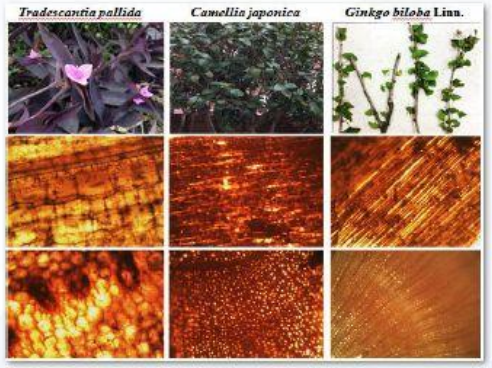
(2)



Cu: Industrial district; **Pb**: Widespread contamination;
Zn: Major roads and industrial areas

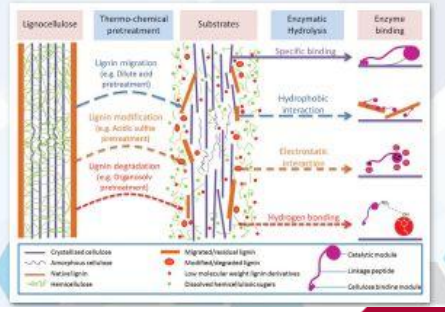
Whole Plant Cell Wall Analysis

Smart Greening – global warming arising from the increase of greenhouse gases emission has been a significant scientific and political issue in affecting the sustainable development of modern cities. Urban greening (e.g., rain garden or green wall) plays an critical role alleviating this problem, as plant has the potential to sequent carbon from atmosphere and can serve as a feedstock of urban biorefinery. Plant cell wall analysis is a useful tool to make better use of those benefits.



Plant Cell Wall Analysis – plant biomass is a sustainable source of many chemicals. To take out those chemicals for downstream process it is essential to understand in details the physiochemical properties of the plant cell wall. Figures at the left shows a most basic example for the microscopic morphology of the transverse section and outer surface of the stem samples from grass, shrub, and tree, respectively. It can be seen that the parenchyma cells predominate the inner region of the plant cell in herbs (left), with some vascular bundles; while the plant cells arrangement in shrub are more close to tree cells.

Chemistry of the Lignocellulosic Biomass – plant cell wall is a complex structure of three types of building-block chemicals, *i.e.*, lignin, hemicellulose, and cellulose. In order to understand the chemical composition of the plant cell, our laboratory is equipped with a High Performance Liquid Chromatography (HPLC) with a refractive Index (RI) detector, which can determine the carbohydrates contents in the plant cell wall. The gel permeation chromatography can measure the molecular weight of the fragments and chemicals withdrawn from the plant cell wall or other compounds from biorefinery or oil refinery.



Enzyme-Substrate Interaction – with the instruments, analytical tools and reagents we can obtain information of changing properties of the substrates during bio-decomposition (in nature) and/or bioconversion processes (in a biorefinery). A fundamental question we would like to resolve is of the complex interactions among the substrates, enzyme complex (to break down the plant cell wall into sugars), and different reaction by-products generated from the plant cell wall. New engineering processes can be developed to improve the efficiency of bioconversion with those knowledge.

Research Spotlight

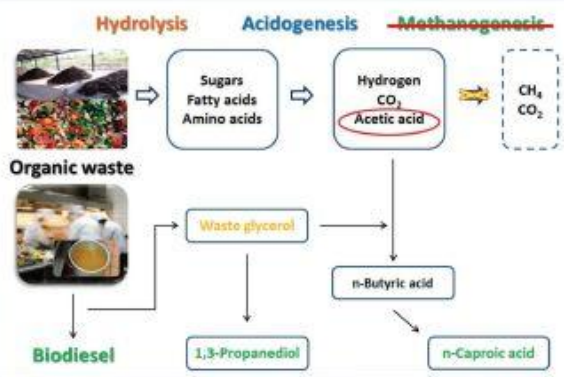
Green Fermentation Process from Waste Feedstock to High Value Chemicals

Glycerol is a low value by-product in bio-diesel production. The production ratio of glycerol to bio-diesel is 1:10. PolyU developed a novel anaerobic undefined mixed culture fermentation process to produce high value chemicals from glycerol and volatile fatty acids in waste water. In the fermentation process, glycerol provide electron to convert fatty acids into n-Caproic acid, which is a basic industrial chemical widely used in artificial flavour, medicine, and lubricant manufacturing. Its energy density is 700 times higher than that of gas methane, and is 1.2 times that of liquid ethanol. That its water solubility (1.1 g/100 mL at 20 ℃) is low makes it easily recovered by distillation. At the same time, another high value chemical 1,3-propanediol is produced, which is used in polymers manufacture.

In addition to converting wastes into high value raw materials, this green fermentation process can also be used to treat wastewater.

Product	Specific density (MJ/kg)	Energy density (MJ/L)	Market price (US$/ton)
Ethanol	23.4 - 26.8	18.4 - 21.2	400 - 600
Butanol	36	29.2	1,450 - 2,450
Biodiesel	37.8	33.3 - 35.7	400 - 1,500
Methane	55.5	0.0364	-
Methane	55 - 55.7	(Liquefied) 23.0 - 23.3	3500 - 5600
n-Caproic acid	30 - 31	27.5 - 28.5	3,600 - 5,800

Energy density and market price of selected bio-products



Green fermentation process

Special Features and Advantages

- A value-added chemicals production from waste feedstock
- The anaerobic undefined mixed culture system reduces the costs and energy for sterilization and aeration
- Product recovery is simple and cost-efficient

Applications

- This green fermentation process can be applied to municipal or industrial wastewater treatment process for resource recovery
- This process can also solve the by-products treatment and disposal problem

Escherichia coli Removal in Bioretention System

Motivation

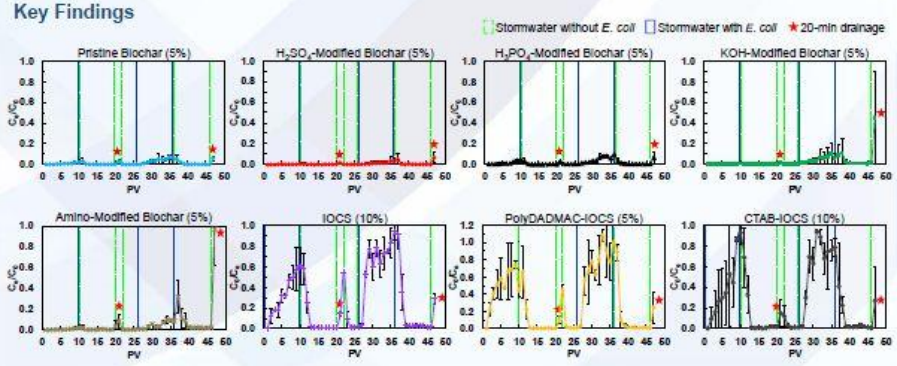
- Promotion of Blue-Green Infrastructure for Sustainable Urban Drainage Systems in New Development Areas (NDAs);
- Bioretention system as an *at-source, passive* stormwater treatment facility;
- Provision of sustainable water supply by reclaiming water for non-potable reuse while reducing reliance on Dongjiang water.

Research Interest

- Developing high-performance bioretention filter media to cater for high rainfall intensity (2400 mm) in Hong Kong;
- Surface-modification to iron oxide-coated sand (IOCS) and biochars for improving *E. coli* removal from stormwater.

Iron Oxide-Coated Sand | Biochar Made at Kadoorie Farm | Amino-Modified Biochar | Column Experiments | Column Experiments | Plates

Key Findings



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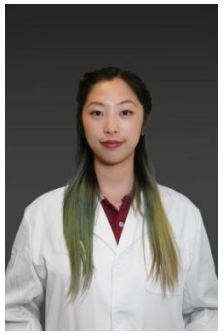

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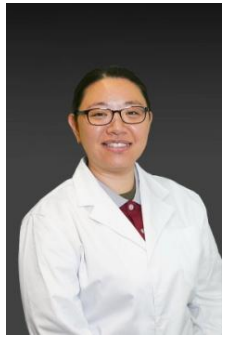

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