Transforming waste recycling systems

Research achievements in ENVIRONMENTAL, MARINE AND BIOMEDICAL areas exemplify the growing strength of Tsinghua SIGS.

As the southern seat of Beijing's Tsinghua University, Tsinghua Shenzhen International Graduate School (Tsinghua SIGS) has witnessed rapid expansion of its research and graduate education platforms since 2011, much as the city itself undergoes continual urban renewal. Efforts to enable better source separation for municipal solid waste (MSW) management in Shenzhen are important for sustainable development and ecological progress in the Greater Bay Area (GBA), and China's commitments to fight global climate change and marine plastic pollution, according to Jianguo Liu, an environmental science professor at Tsinghua SIGS.

"We have partnered with environmental enterprises to carry out a mega research project to innovate on MSW technology and strategy," says Liu. "Through mass and energy flow analysis from a life cycle perspective, we set out to reduce volume, and to optimize recycling and bio-conversion, while minimizing landfilling."

Controlling urban waste

Liu's team has identified targeted strategies for the four types of MSW: recyclables, food waste, residual waste, and hazardous waste. Under the plan, around 30% of food waste is to be diverted for anaerobic digestion, while residual waste is to be processed using the Waste-to-Energy (WtE) strategy through incineration. "The government's promotion of zero waste cities and MSW source separation provides an important opportunity to reorganize our traditional MSW management system," he says.

Through 'polluter pays' and 'extended producer responsibility' principles, Liu's team proposed a unified intelligent system based on the Internet of Things and big data to monitor and regulate the whole chain of MSW separation, collection, transportation, recycling, and treatment. An efficient thermal hydrolysis process was also established for anaerobic co-digestion of wastewater sludge and household food waste, achieving rapid conversion of the organic matter in the feedstock to methane.

"We have seen promising results in Shenzhen through coordinated local efforts. The recovery rate of MSW has reached 33% and is still rising, which includes approximately 10,000 tonnes daily of glass, metal, plastic, paper, fabric, food and garden waste," explains Liu. "The biochemical treatment of food waste produces more than 40,000 m^3 biogas per day for electricity and heat supply to the city, while nearly 20,000 tonnes of other waste is converted to energy each day in several incineration plants with the most advanced air pollution control systems."

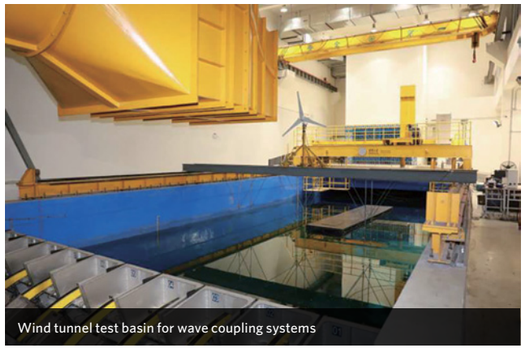
Liu also participated in the continuous improvement of a clean WtE plant in the Shenzhen Ecological Energy Park, a winner of the sixth Paulson Prize for Sustainability in 2019, which integrates renewable energy production and contributes to community building. It is estimated that this will enable at least a 40% reduction of carbon emissions from the MSW in Shenzhen.

Transforming marine research

Apart from above-ground conservation strategies, the GBA's diverse marine resources, including an ocean field in Shanwei Bay, rich in wind and wave energy, offers great research opportunities. Led by the team of Daoyi Chen, an ocean engineering professor, this ocean testing ground is unique in offering real ocean wind and wave conditions, and for the more realistic estimation of their potential impacts. Jointly operated with SIGS's state-of-the-art ocean basin research facilities, it extends the model scale ratio from 1:50 to 1:3.

In 2019, a dedicated research vessel was commissioned to support ocean testing projects. The project is set to promote engineering and performance testing of fixed and floating offshore structures in harsh marine conditions, such as the coupled action of waves and wind on oil and gas platforms, cross-sea bridges, and wind turbines. Remotely operated vehicle (ROV) and autonomous underwater vehicle (AUV) operation can also be tested in the basin before sea trials are carried out.

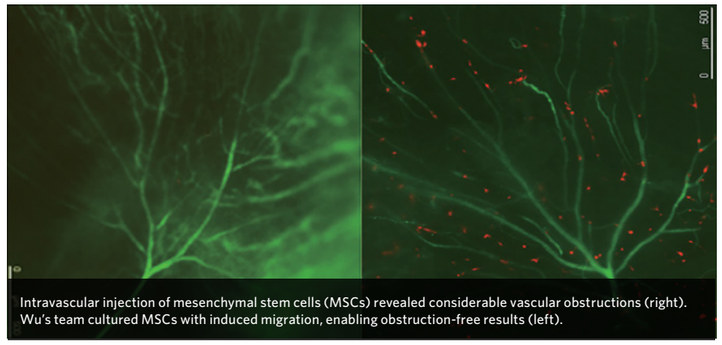
A pilot project jointly led by Tsinghua SIGS and China Construction Science and Industry Corporation focuses on upgrading the original M4 (Moored, Multi-float, Multi-Mode) wave energy converter to optimize power capture, in collaboration with its inventor, Peter Stansby, from the University of Manchester. Deployed in the South China Sea, it helps develop ocean testing capacity further to investigate the impact of typhoons on floating structures.



Wind tunnel test basin for wave coupling systems

The first expedition ship of Tsinghua SIGS *Qing Yan 1*

New equipment for next-generation sequencing assesses complex microbial communities.



Intravascular injection of mesenchymal stem cells (MSCs) revealed considerable vascular obstructions (right). Wu's team cultured MSCs with induced migration, enabling obstruction-free results (left).

Accelerating biotechnological innovations

As well as structural safety, a new SIGS institute promotes human health and safety. Established in December 2019, the Institute of Biopharmaceutical and Health Engineering (IBHE) integrates academic exchange in life sciences, physics, chemistry, biology, medicine, biological engineering, and information and mechanical engineering. The vice director of IBHE, Xinhui Xing, a biochemical engineering professor, has been leading the development of high-throughput biotechnology. His team has worked with more than 20 universities and companies in the GBA.

"The School of Life Science at Tsinghua SIGS and Tsinghua Department of Chemical Engineering have laid a solid foundation for the future development of IBHE," says Xing. "Dedicated to enhancing therapies for chronic diseases such as cardiovascular and cerebrovascular diseases, cancer, and diabetes, we use omics data to support the development of drugs, vaccines, health engineering, and translational medicine."

For example, both intravenous and intra-arterial injections of mesenchymal stem cells (MSCs) have been found to cause considerable vascular obstructions. To overcome this, Xing's colleague, Yaojiong Wu, has developed a 3D-based cell culture method, which gives rise to MSCs with markedly reduced size, thus reducing vascular obstructions, and improving their therapeutic efficacy.

Another team member, Yonghong He, has led in the field of optical coherence tomography (OCT) imaging, for use in everything from cardiovascular and gastrointestinal endoscopy, to the measurement of the nacre layer of pearls from OCT images. OCT ophthalmic products developed by He's team have gained a domestic market share of 35%, with exports to Europe and the US.

IBHE also fosters international academic exchange, for example, a joint innovation centre for vaccine R&D and manufacturing with Imperial College London. Academic partnerships on engineering in life sciences and postgraduate training have also been established with the University of California at Berkeley, the University of Tokyo, and Tokyo Institute of Technology, among other leading universities across the world. ■

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