DUCTOR'S BIOTECH SOLUTION FOR NITROGEN CONTROL AND PRODUCTION OF RENEWABLE ENERGY SUSTAINABLY

Agricultural waste and residue management for a circular bio-economy: Shared EU and China impact-oriented solutions

23.10.2018 Beijing, China

Minna Leppikorpi, Ductor Corp.

www.ductor.com

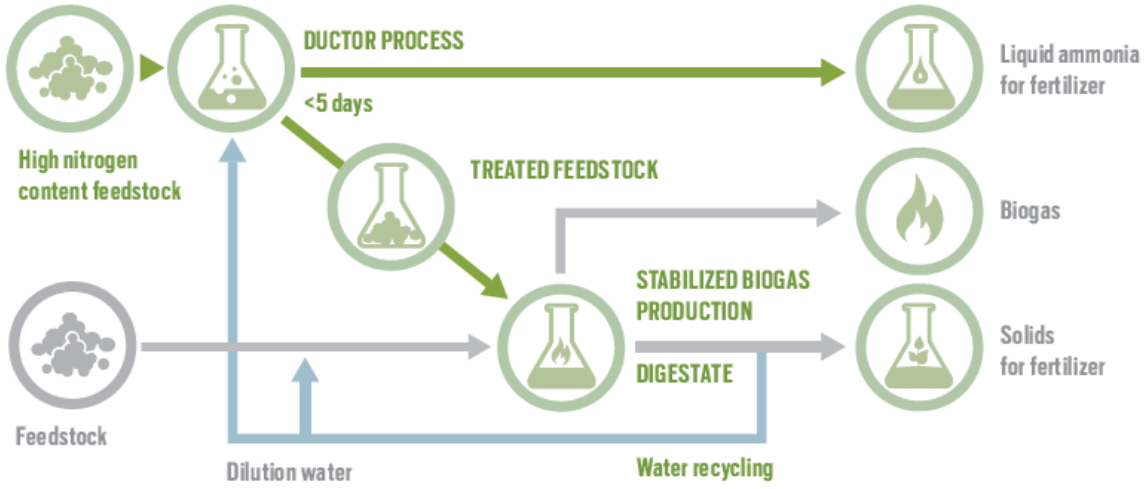
Ductor Corporation

Our task:

- Our mission is to mitigate the climate change, produce renewable energy and solve the increasing food demand and waste accumulations challenges.

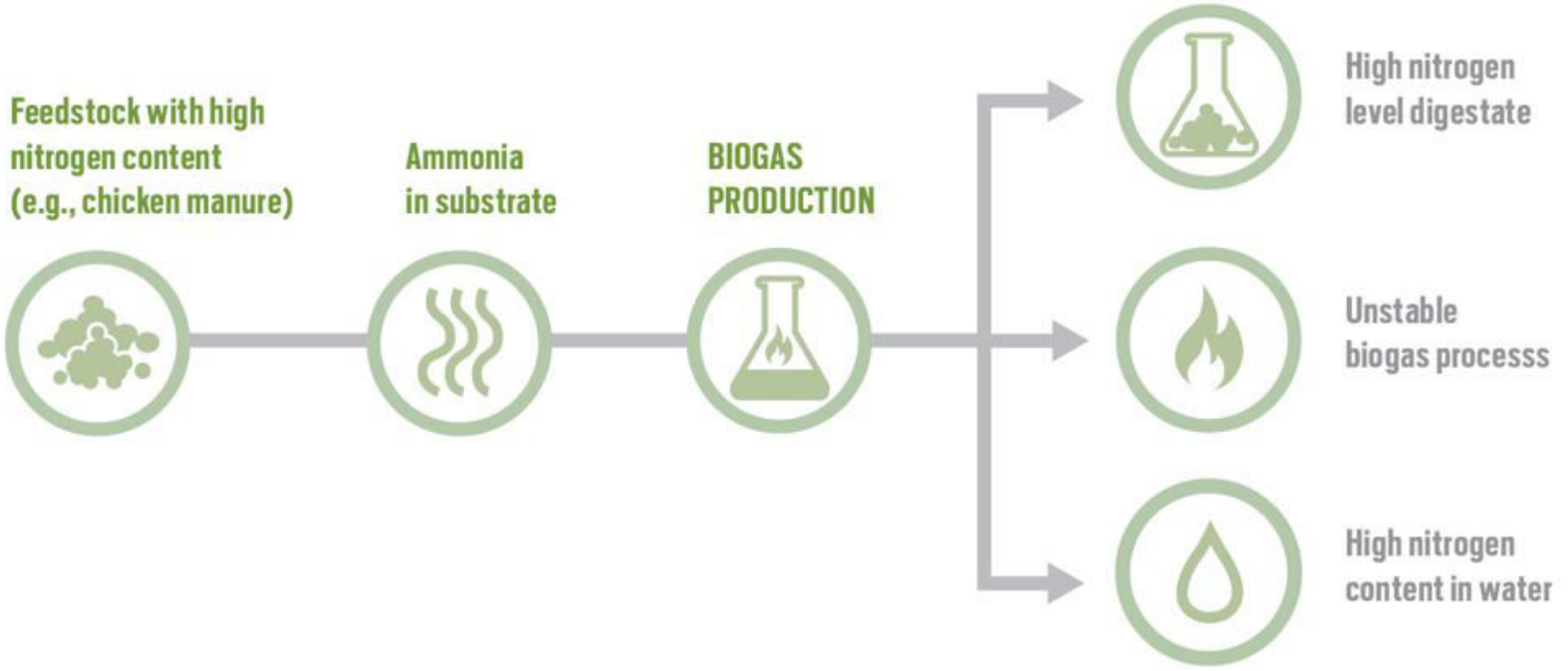
How do we do it?

- We do that by using our revolutionary biological fermentation technology that is easily adaptable to almost any biogas plant, which eliminates the nitrogen dilemma by turning problem waste into profitable recyclable goods.



The Challenge–Nitrogen Control

Ammonia can cause serious economic losses due to inhibition of methane formation. The problems are often derived from high nitrogen levels of feedstock.



Nitrogen Control–The Ductor Way

- **Process description**

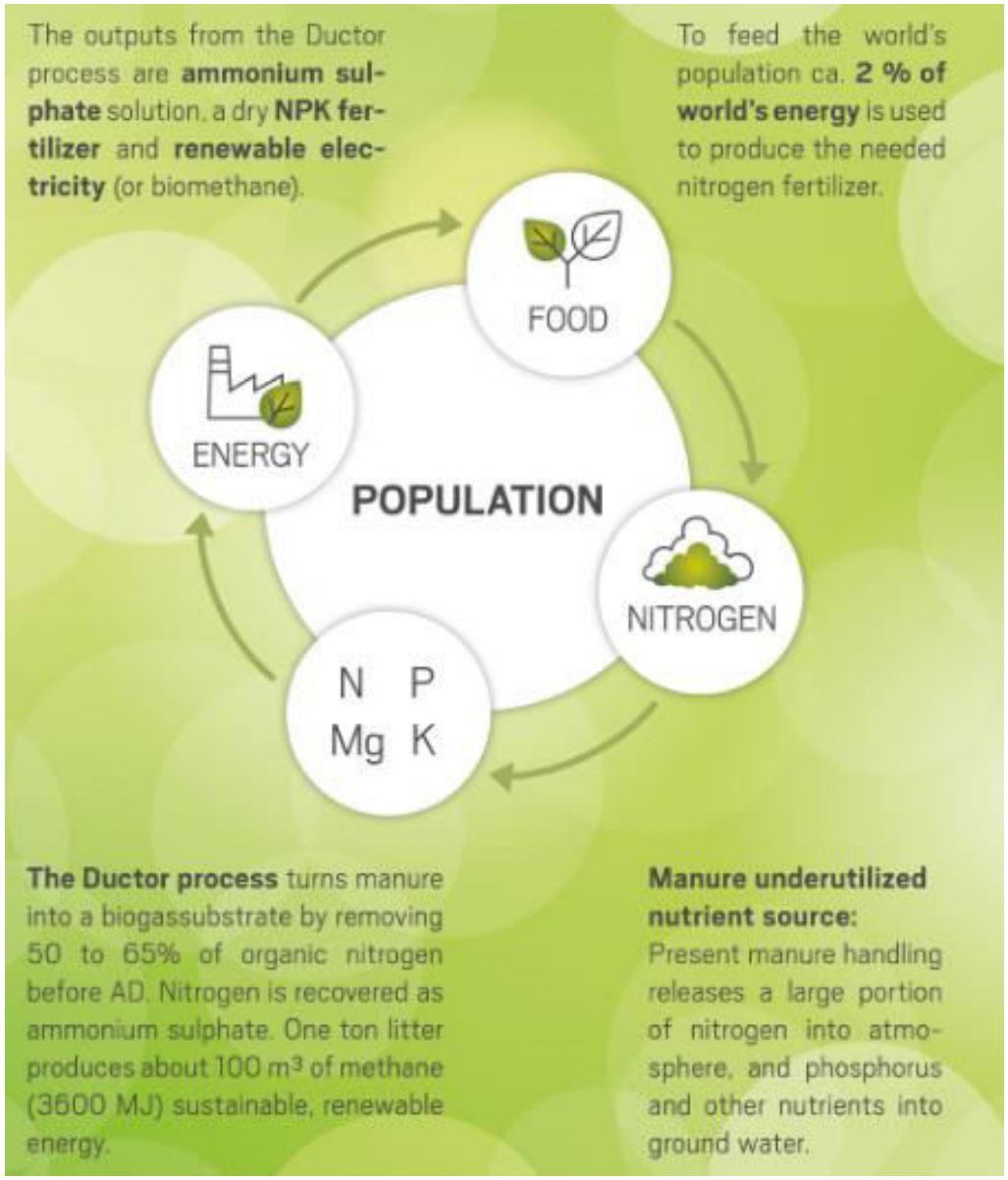
1. Poultry manure is fed into Ductor fermenter
2. Half of organic nitrogen is transferred from solid phase into liquid phase (ammonification with bacteria)
3. Fermented manure is fed into ammonia recovery system
4. Water is separated by decanter
5. Water goes to stripper feed tank
6. Treated manure is fed into biogas digester
7. Ammonia is removed by a stripping step as ammonium sulfate

Added Value Based On Ductor Fermentation

- **Key financial features of a typical 1 MWel biogas plant; example Europe**

Investment	
Capex 4,8M€	Includes standard 1MW Power Plant located in flat 10.000m2 square land plot Turn key
Options for Investment	• Traditional Sell and Purchase Agreement • B.O.T. (Build Operate Transfer) • JV (Joint Venture with Ductor)
Profitability 1MW Plant	
	Net Sales 1,62 M€ Opex 0,47 M€ EBITDA 1,15 M€ (71%) *Depreciations 0,24 M€* *EBITA 0,91 M€ (56%)* *ROI: 24,1%* *20-year IRR: 28,6%*

PRO Circular Economy



- Treating manure through anaerobic digestation prevents ammonia emissions to athmosphere or ground water, creates renewable energy and circulates nutrients. All this is possible because the microbial process removes 50% of organic nitrogen from many organic materials.

Changing The World Through Biotech

- **Ductor® fermentatiton technology**
  - Solves global food, waste and energy challenges
  - Improves the economics of biogas production
  - Demand for solutions to improve the profitability of biogas production is tremendous

- **Global market**
  - The estimated number of chickens in the world is 21 billion
  - For example, in Malaysia 800 million chickens generate almost 80 000 tons of chicken manure per day
    - Electricity potential ~ 1000 MWel/a i.e. could provide energy to ca. 650 000 households
    - Solid fertilizer potential ~ 8 800 000 tons/a
  - In Germany chicken litter is used in many of the ca.10 000 biogas plants, but only ca. 15-20 % of the total feed

- **Historical breakthrough**
  - Ductor was founded in 2009 in Helsinki, Finland
  - Global roll out started in 2016 and now we operate in North America, Europe and Asia
  - Fraunhofer (UMSICHT) analyzed and confirmed the advantage in an independent evaluation

Thank You

Minna Leppikorpi

Director

Marketing and Business Development

Ductor Corp.

Viikinkaari 4. 00790 Helsinki

FINLAND

minna.leppikorpi@ductor.com

南京工業大學
NANJING TECH UNIVERSITY

Biogas Production from Agro-waste in Nanjing Tech University: Research and Practice

Prof. & Ph.D Honghua Jia

Bioenergy Research Institute

College of Biotechnology and Pharmaceutical Engineering

Nanjing Tech University

Beijing 10/23/2018

Outline

- **Background**
- **Research progress in Nanjing Tech University**
- **Commercial projects**
- **Acknowledgements**

Background

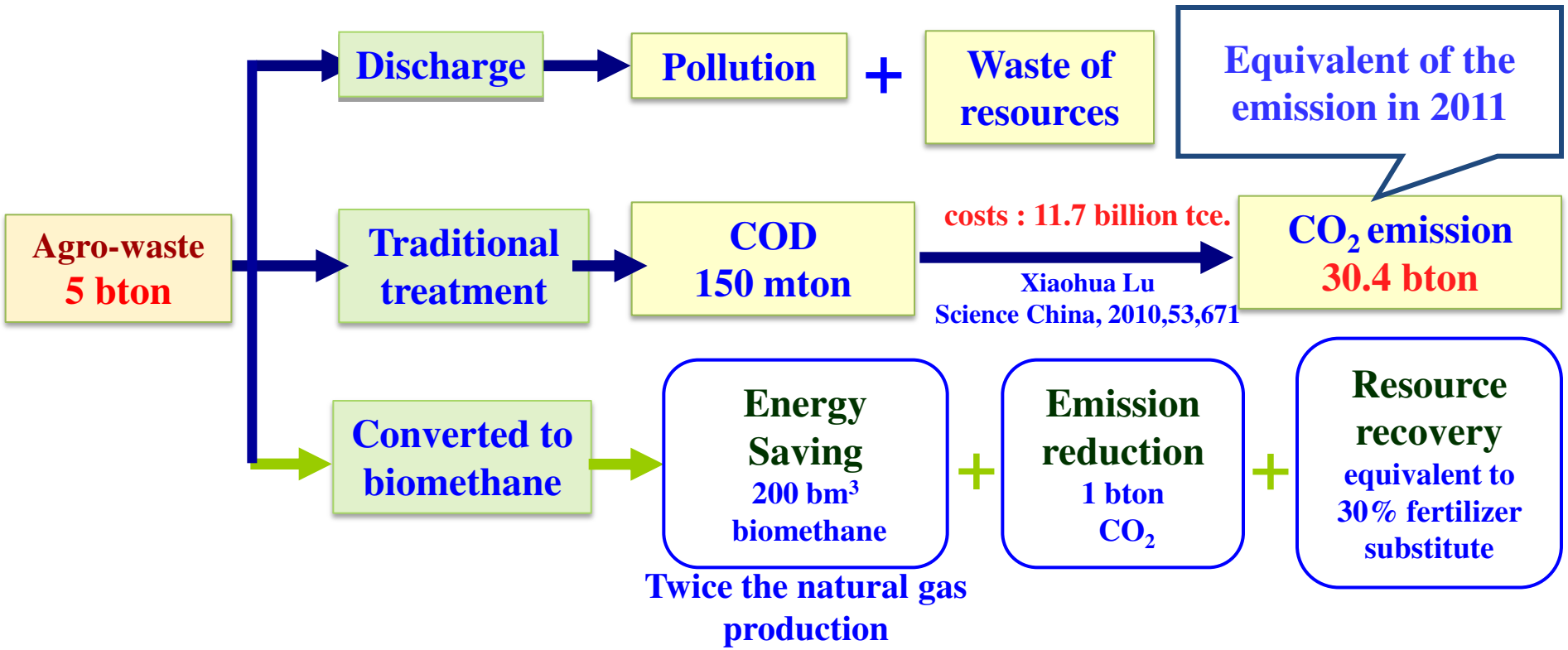
Agro-waste: important source of pollution in China

- **In China, around 5 billion tons of agro-waste was produced and discharged, and more than 40% of them were not disposed effectively.**

Agro-waste	Output (Mt/a)
Straw	700
Manure	3800
Kitchen waste	100
Municipal sludge	50
Fruit and vegetable waste	100

How to deal with agro-waste efficiently?

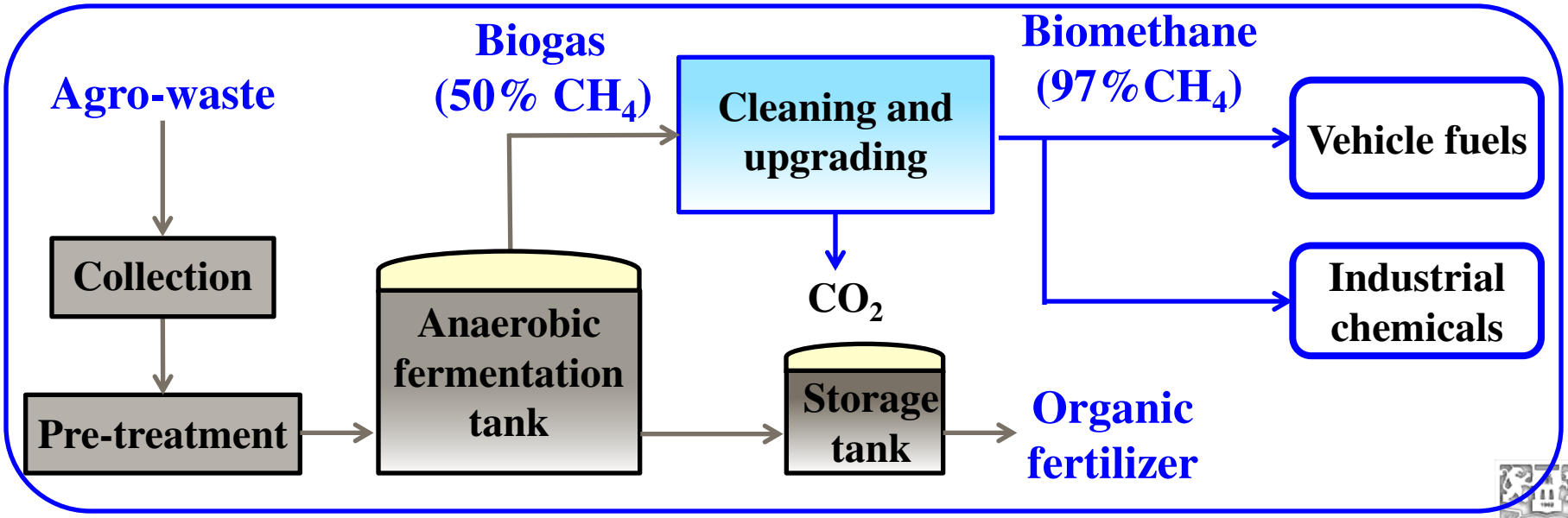
A sustainable way: Converting agro-waste to bioengergy



Strategic significance of high-efficient conversion of bioenergy:
energy-saving, emission mitigation, and resource recovery

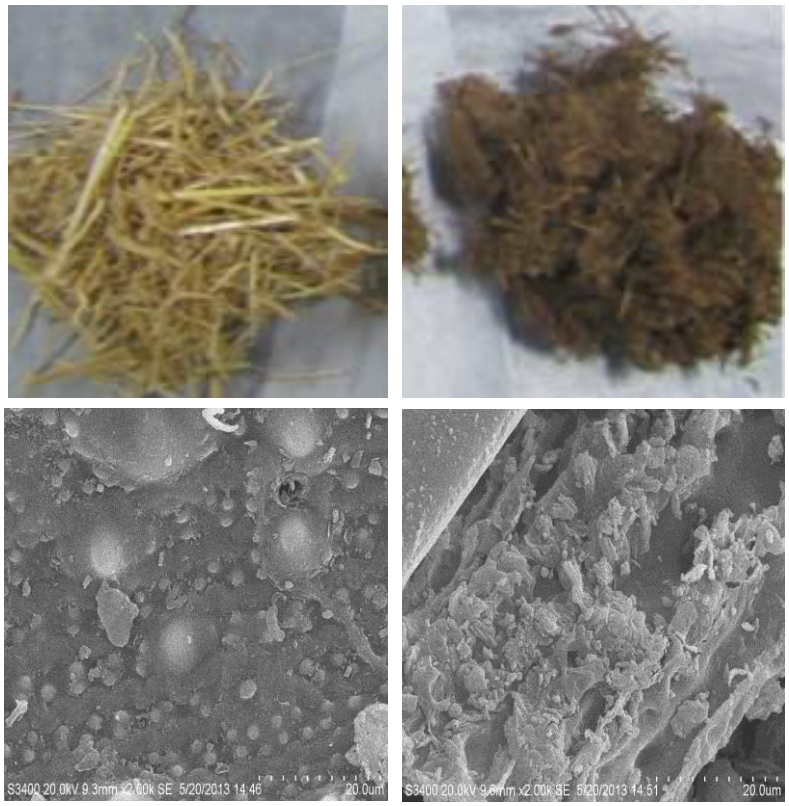
Agro-waste to biomethane

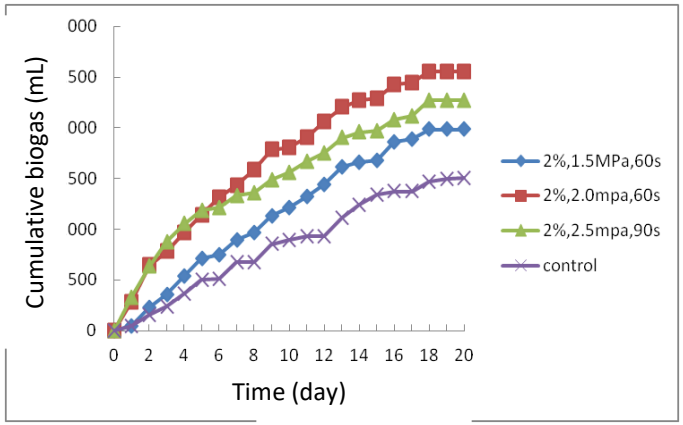
- It is well-known to all, agro-waste can be converted to biogas via anaerobic digestion.
- Biogas was readily upgraded to biomethane and digestate was used in organic fertilizer via composting.

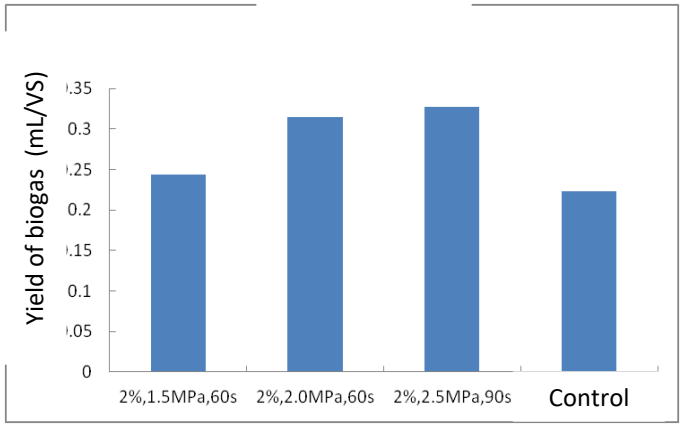


Research progress in Nanjing Tech University

Straw pretreated by steam explosion





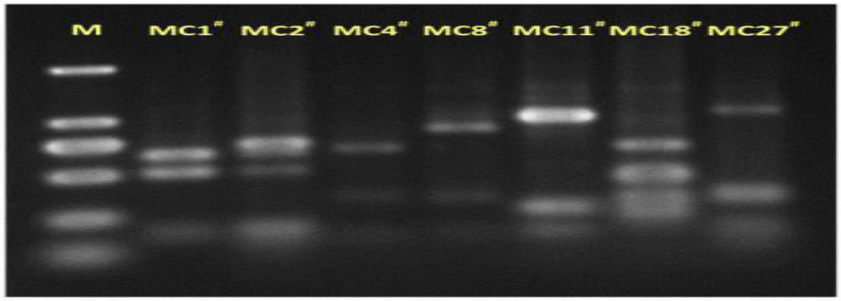


- **After steam explosion, the biogas production from straw increased by 70%, biogas production rate increased by 40% in the condition of 2.0 MPa, 60 s.**

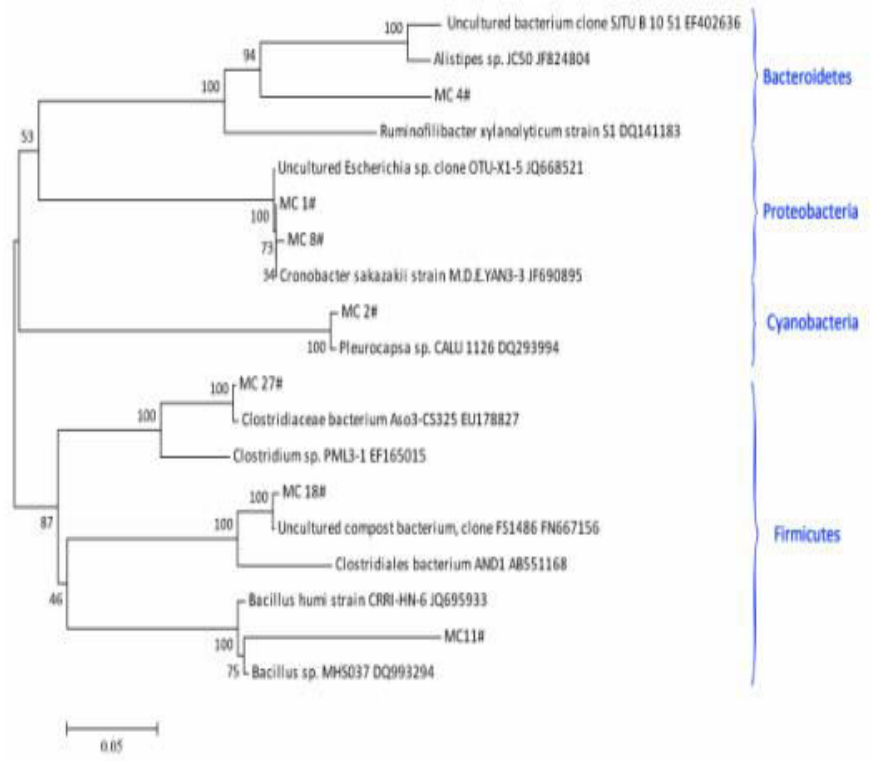
Identification and artificial construction of straw degrading microbial consortium

1st Day

14th Day

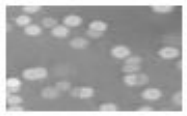
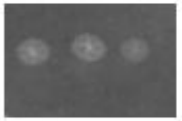


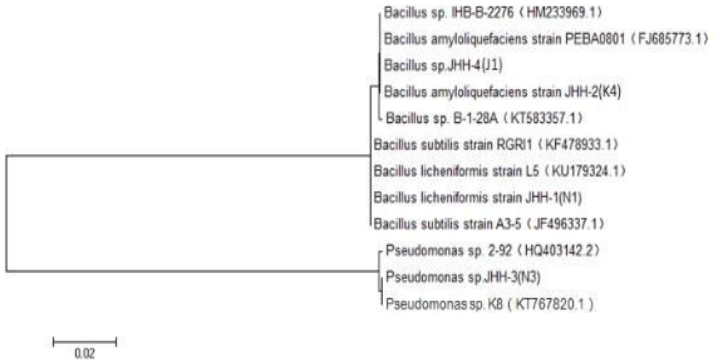
M stand for Marker (DL2000); MC stand for microbial consortium



- **A straw degrading microbial consortium was screened and some lignocellulosic degrading strains were identified.**

Identification and artificial construction of straw degrading microbial consortium

	N1	N3	K4	J1
Colony				
Size	1-3 mm	3-5 mm	1-3 mm	2-5 mm
Shape	Round	Round	Round	Round
Color	White	White	White	White
Transparency	Translucent	Translucent	Translucent	Transparent
Viscosity	Non-viscous	Viscous	Non-viscous	Viscous
Cellulose decomposing test				
Hemicellulose decomposing test		/		



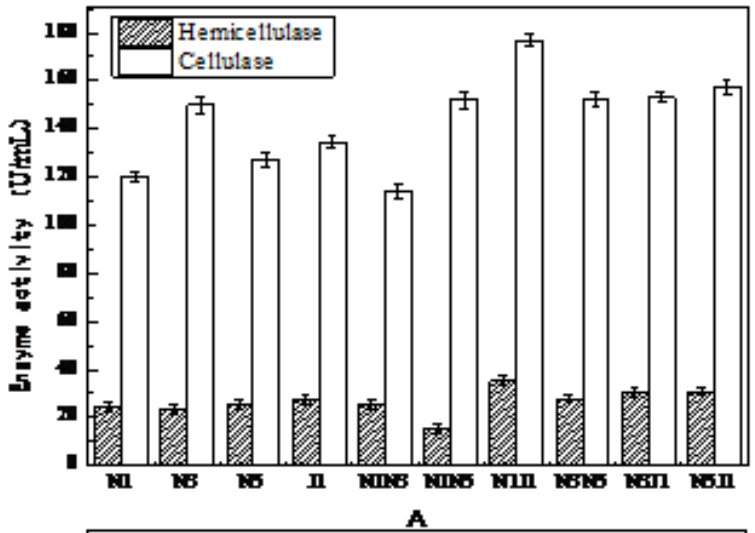
N1: ***Bacillus licheniformis***

N3: ***Alcaligenes faecalis***

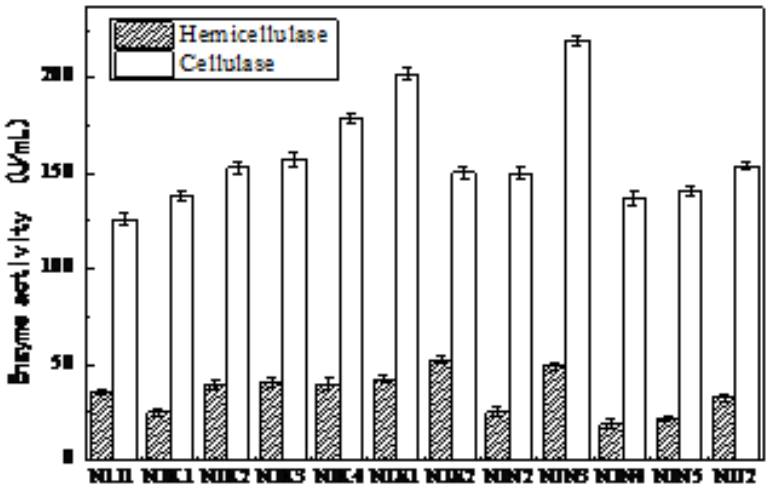
K4: ***Bacillus amyloliquefaciens***

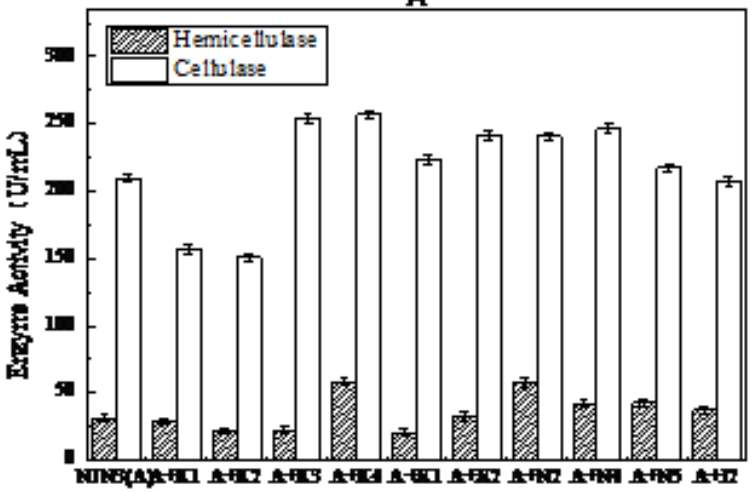
J1: ***Bacillus subtilis***

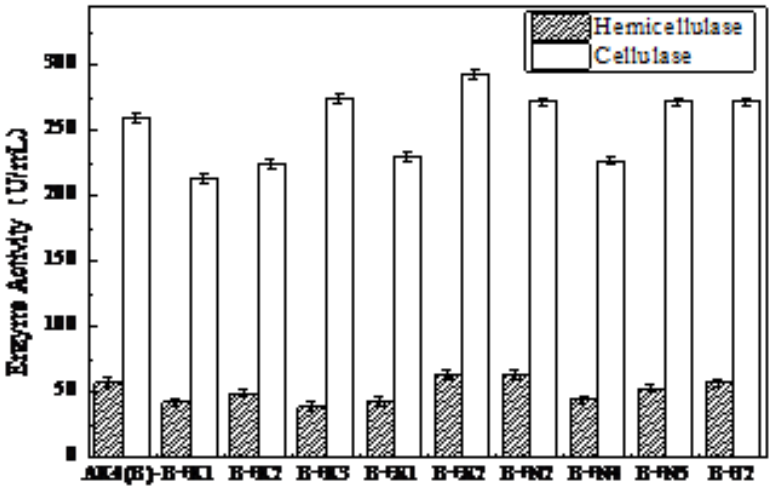
Identification and artificial construction of straw degrading microbial consortium



A

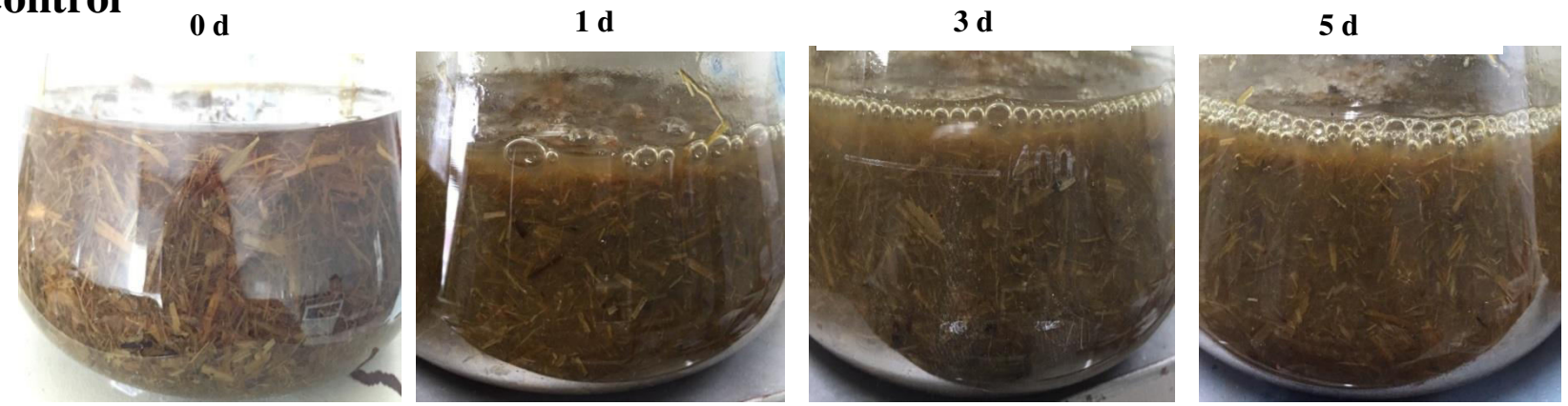




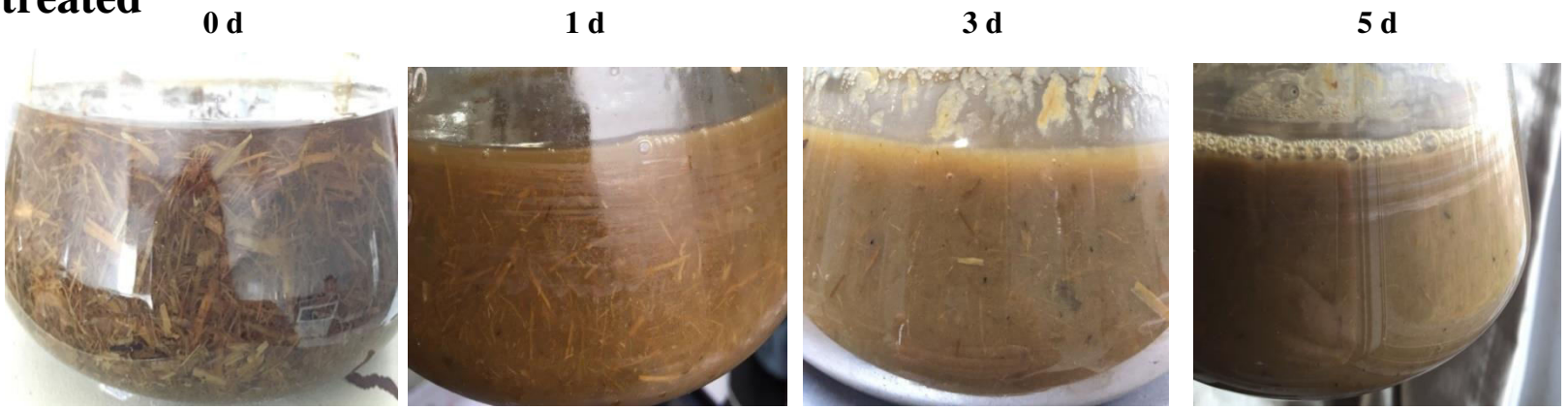


Identification and artificial construction of straw degrading microbial consortium

Control

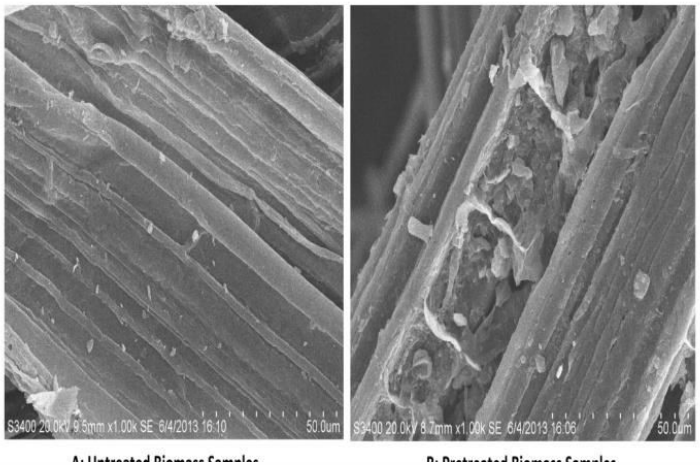


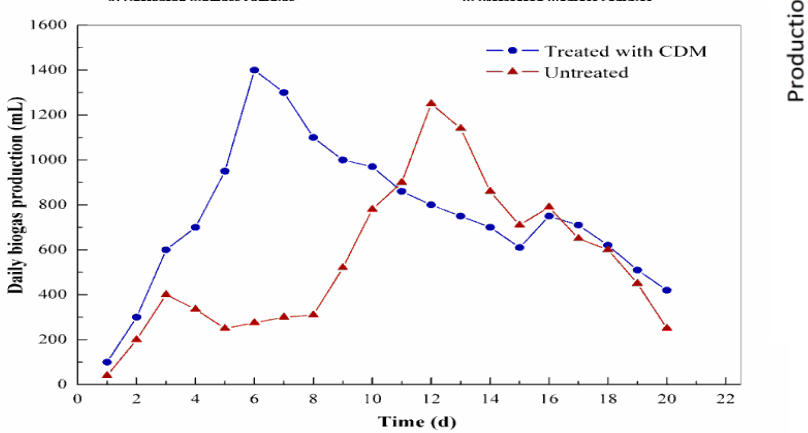
Pretreated

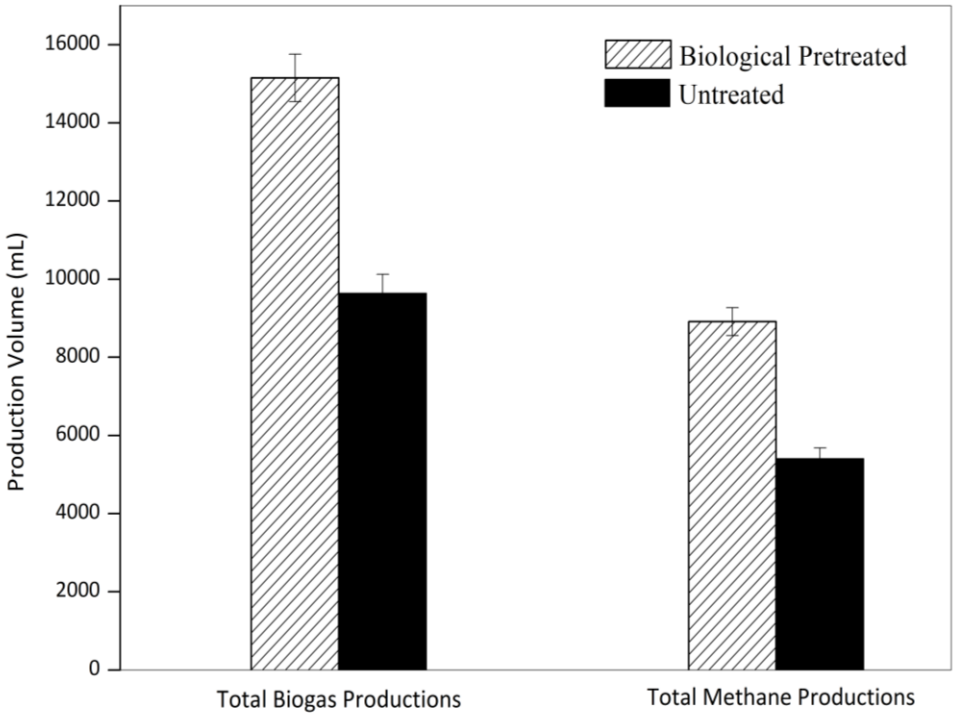


- **Artificial microbial consortium decomposed straw into fragments efficiently.**

Biogas production from straw pretreated by microbial consortium

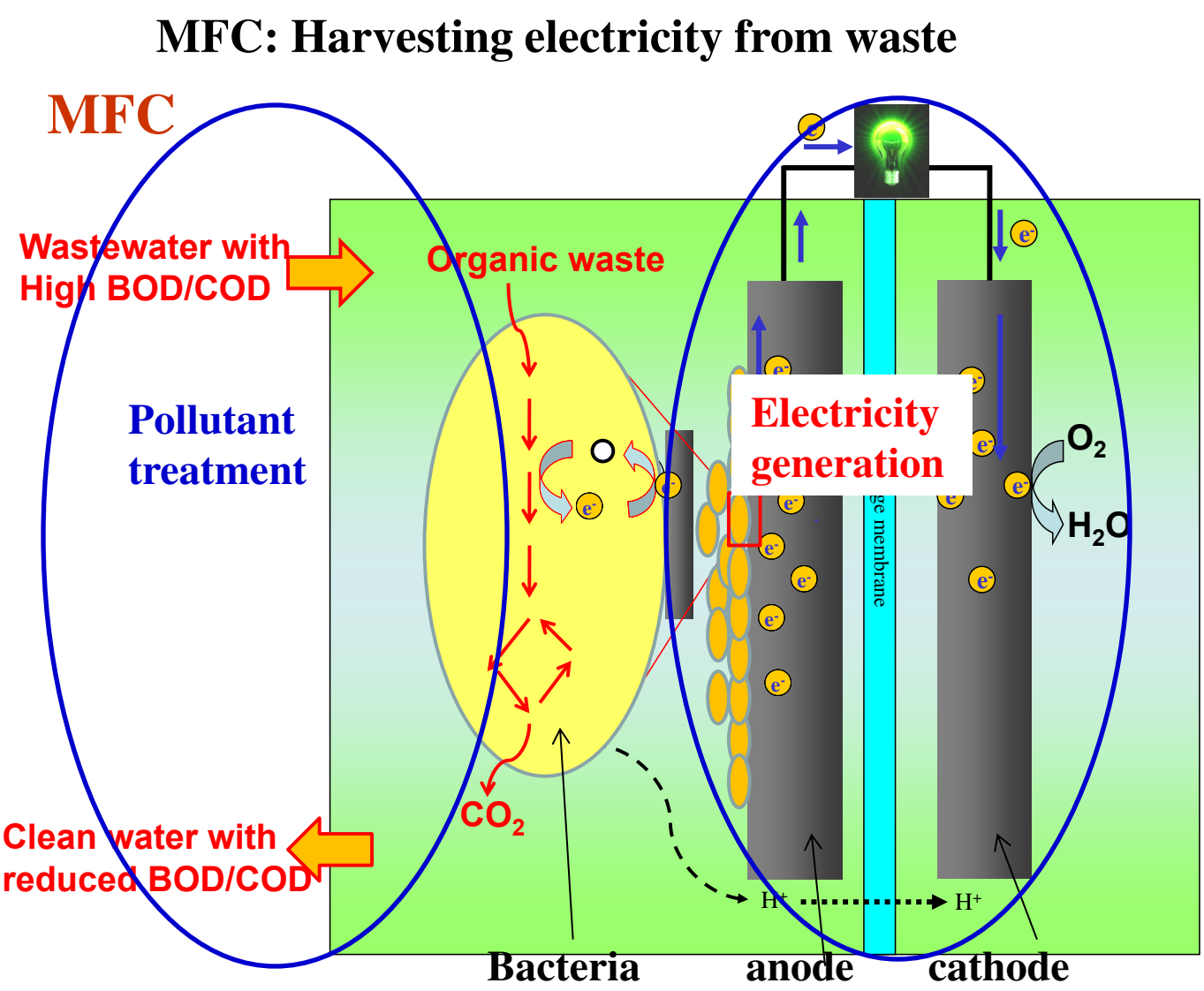


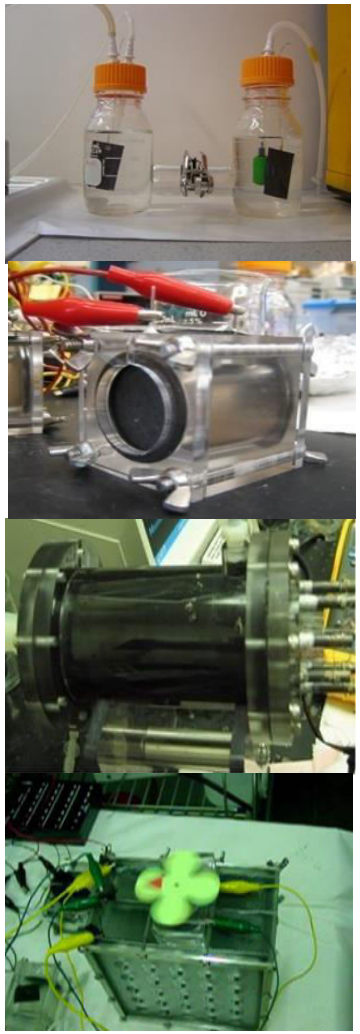




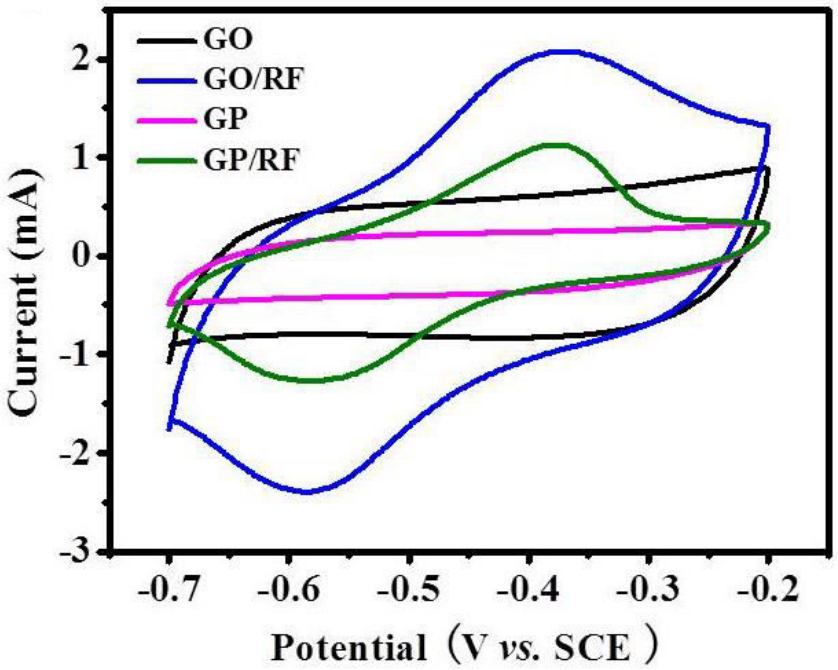
- **Compared to untreated straw, the biogas production from straw pretreated by microbial consortium increased by 40% after 40 days of anaerobic digestion.**

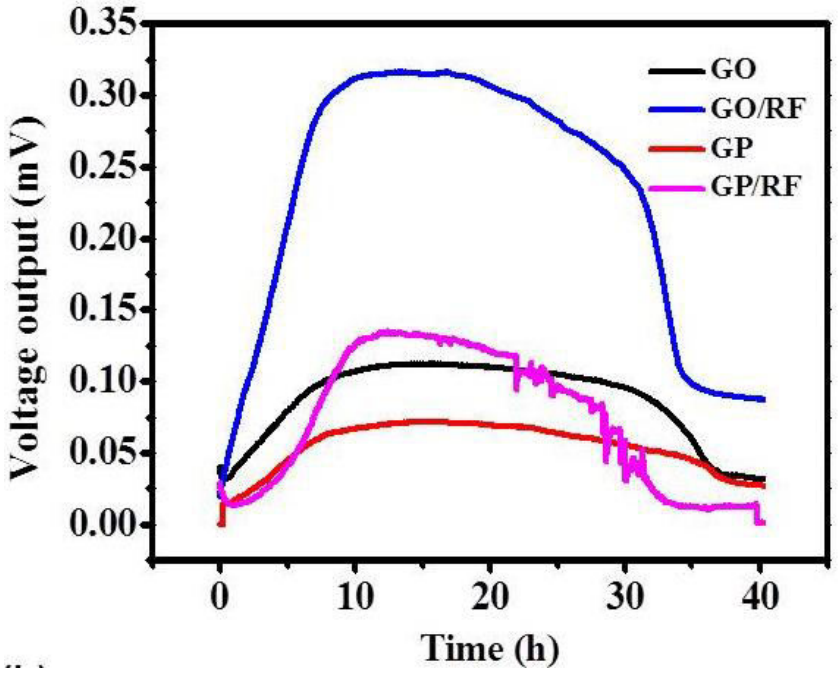
Integration of biogas production with microbial fuel cell (MFC)





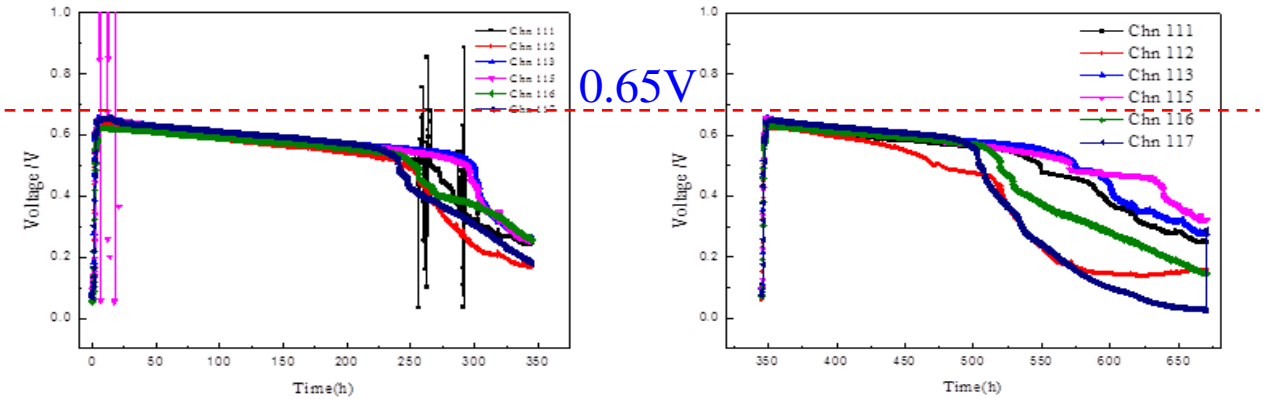
Graphene modified electrode in MFC



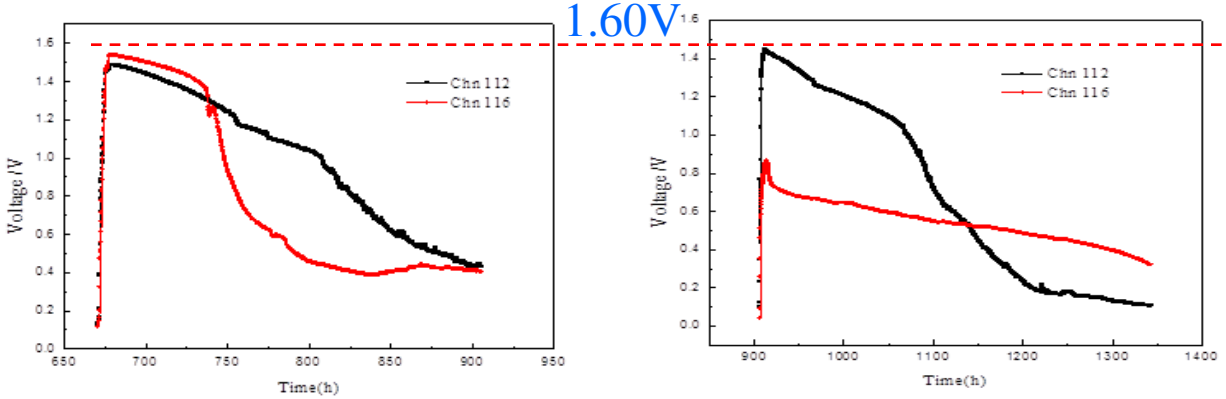


- **A novel graphene/riboflavin (RF) composite electrode was developed, the graphene/RF electrode greatly decreased charge transfer over-potential, which in turn delivered about 5.3 and 2.5 times higher power output than that by bare graphite paper electrode and graphene electrode, respectively.**

Electricity generation by MFC using anaerobic digestion slurry



The highest voltage topped at 0.65 V with single MFC.



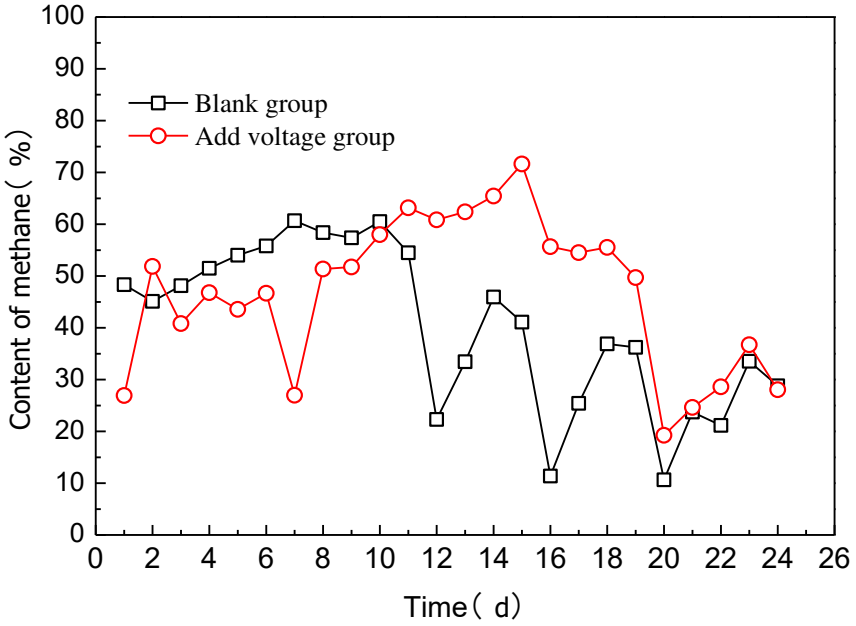
The highest voltage topped at 1.6 V with tandem MFC.

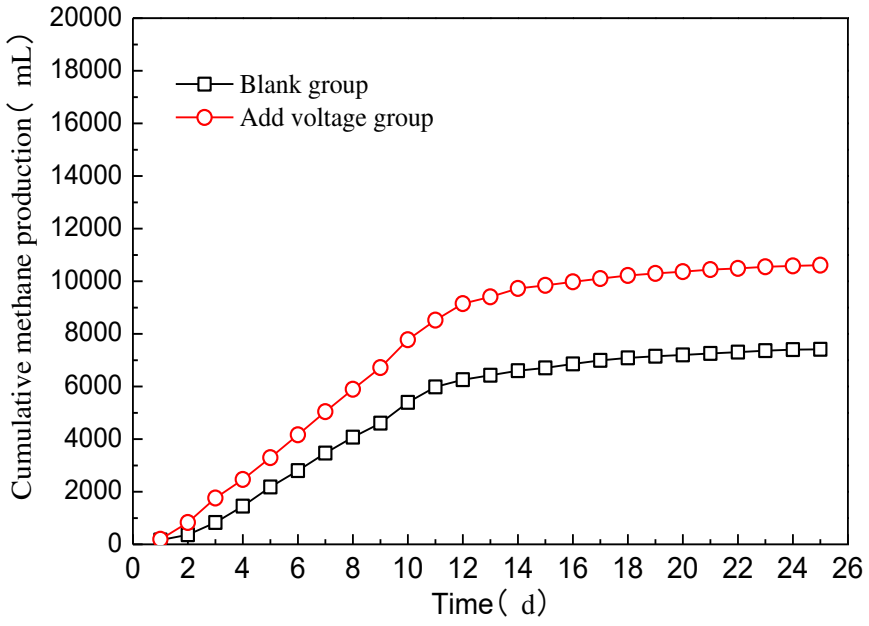
Electricity generation by MFC using anaerobic digestion slurry

Batch	COD/mg·L^{-1}	Removal rate	NH_3^+-N /mg·L^{-1}	Removal rate	P/mg·L^{-1}	Removal rate
material	7404±165		2708±78		92.19±11	
One	2206±68	70.21±1.34%	508±22	81.24±0.99%	26.72±6	71.02±1.68%
Two	2119±75	71.38±0.98%	405±19	85.04±0.85%	22.16±3	75.96±2.16%
Three	1912±56	74.18±2.13%	359±16	86.74±1.03%	20.68±5	77.57±1.97%
Four	1765±58	76.16±1.56%	373±12	86.22±0.78%	21.65±5	76.51±1.66%
Removal rate		72.98±1.48%		84.81±0.90%		75.27±1.68%

- **MFC can remove a great deal of COD, nitrogen, and phosphorus in anaerobic digestion slurry.**

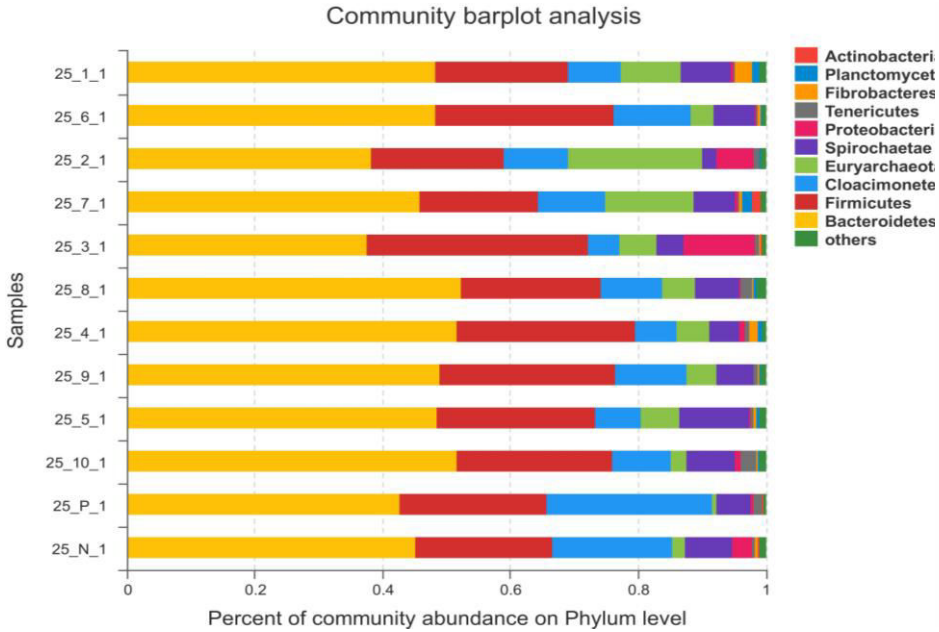
Anaerobic digestion combined with MFC system

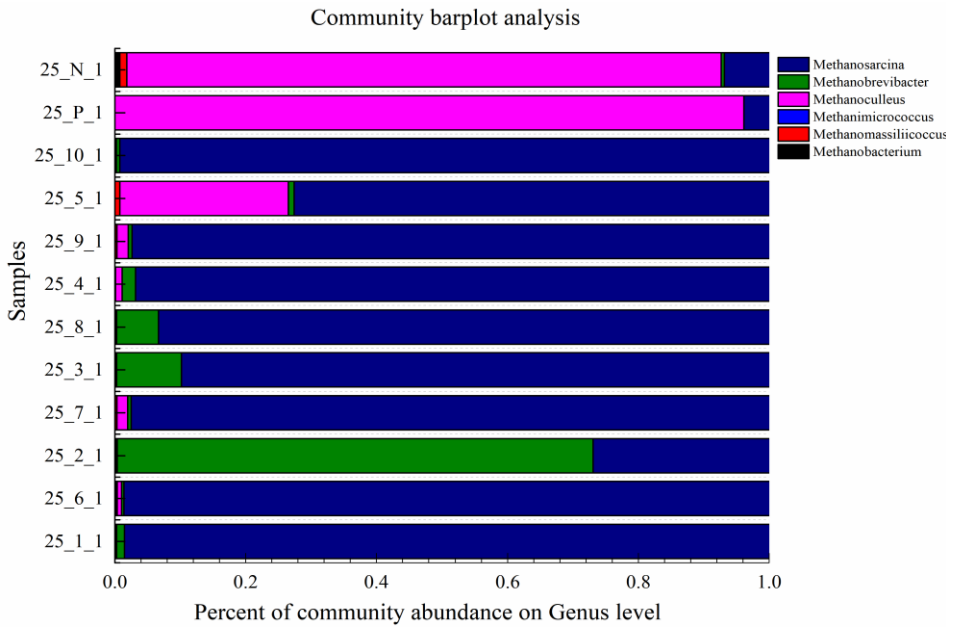




- **Total biomethane production increased by 43.47% compared with the control.**

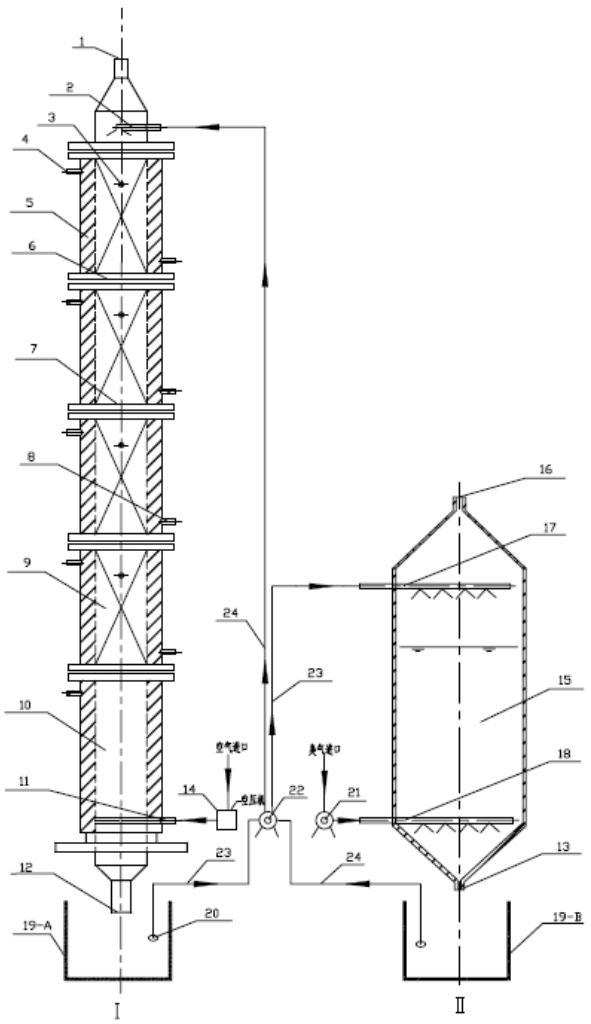
Anaerobic digestion combined with MFC system





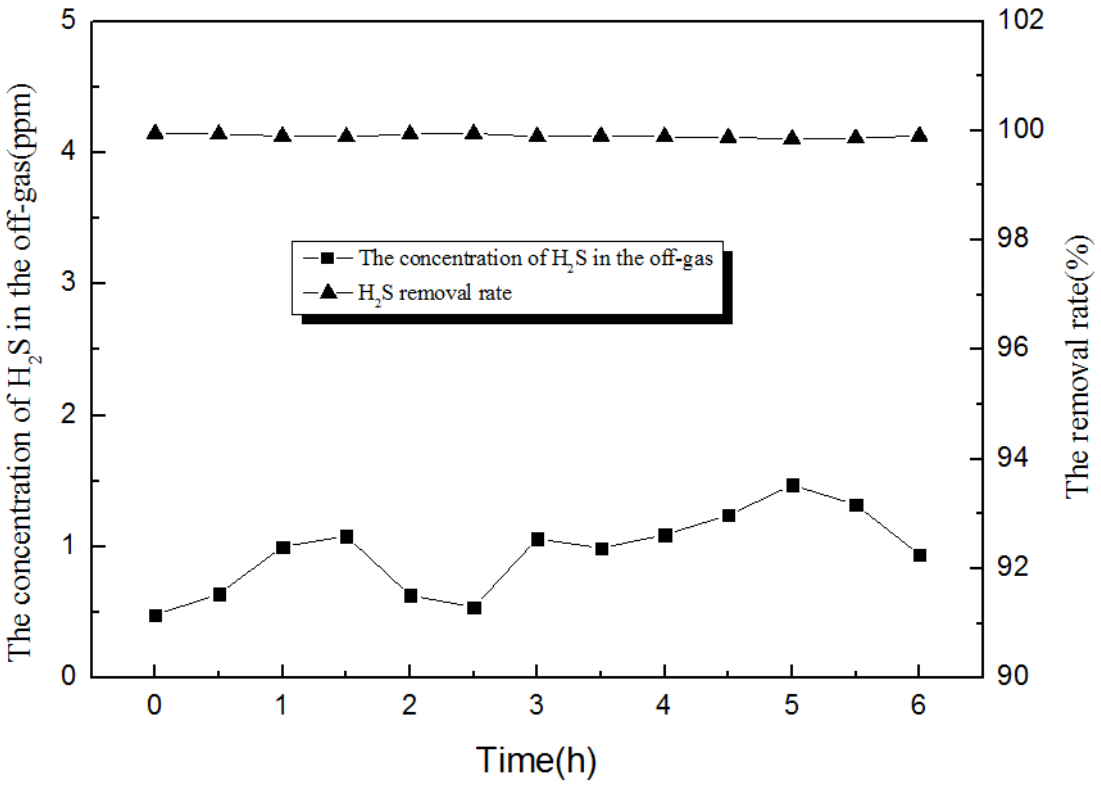
- **High-throughput sequencing analysis indicated that the dominant species at phylm level were Bacteroidetes and Firmicutes in AD of swine manure.**
- **The dominant methanogens were *Methanosarcina* and *Methanobrevibacter* in voltage group whereas those in control was *Methanosarcin*a.**

Biogas desulfurization



Biooxidation reactor

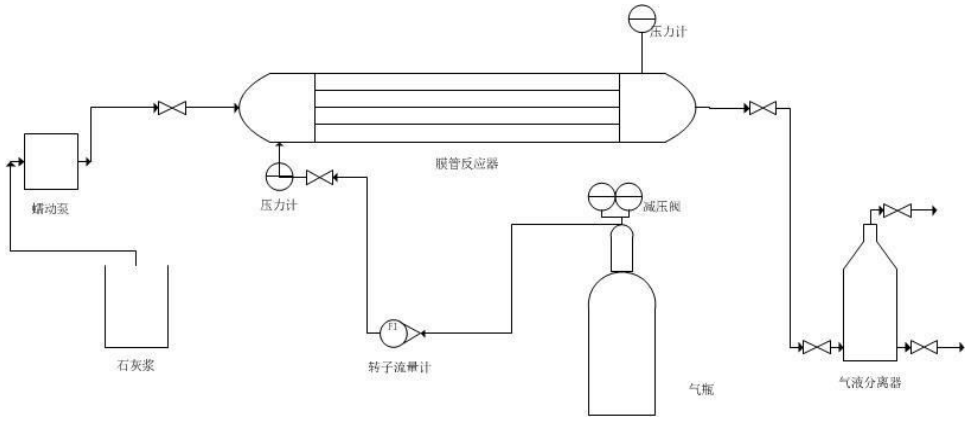
Chemical absorption reactor

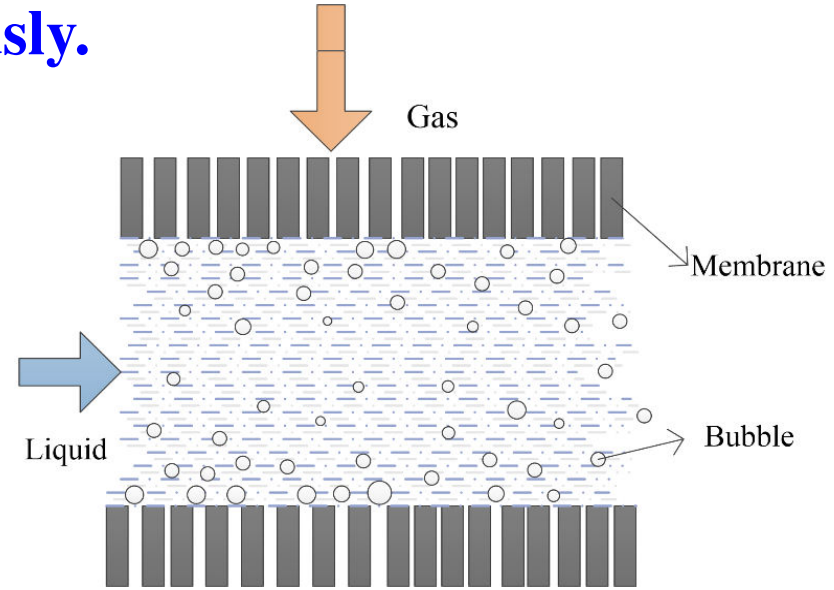


- **99% of H_2S can be removed by biooxidation combined with chemical absorption reactor.**

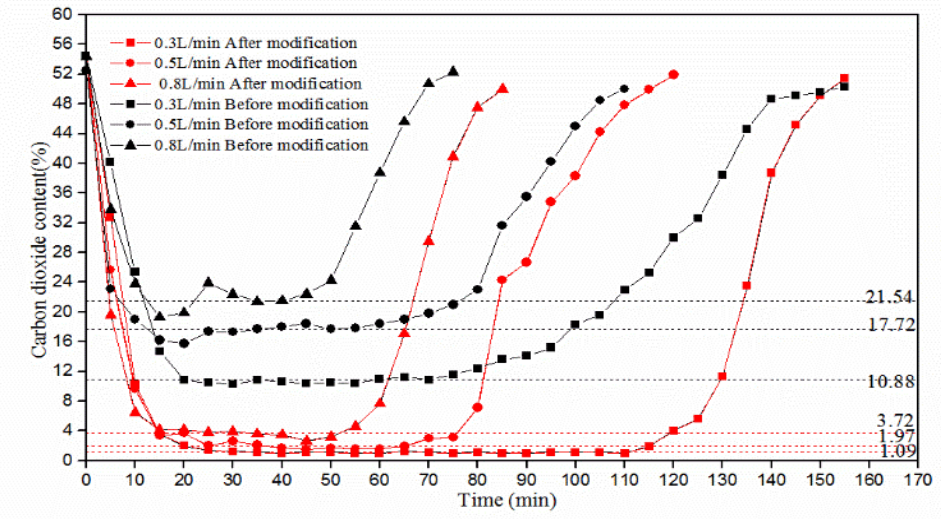
Biogas upgrading

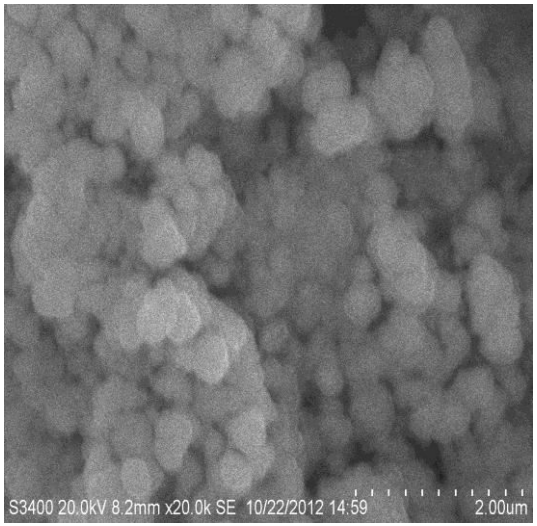
- **Biogas purification and nanoscale $CaCO_3$ synthesis in a membrane reactor simultaneously.**





Biogas upgrading

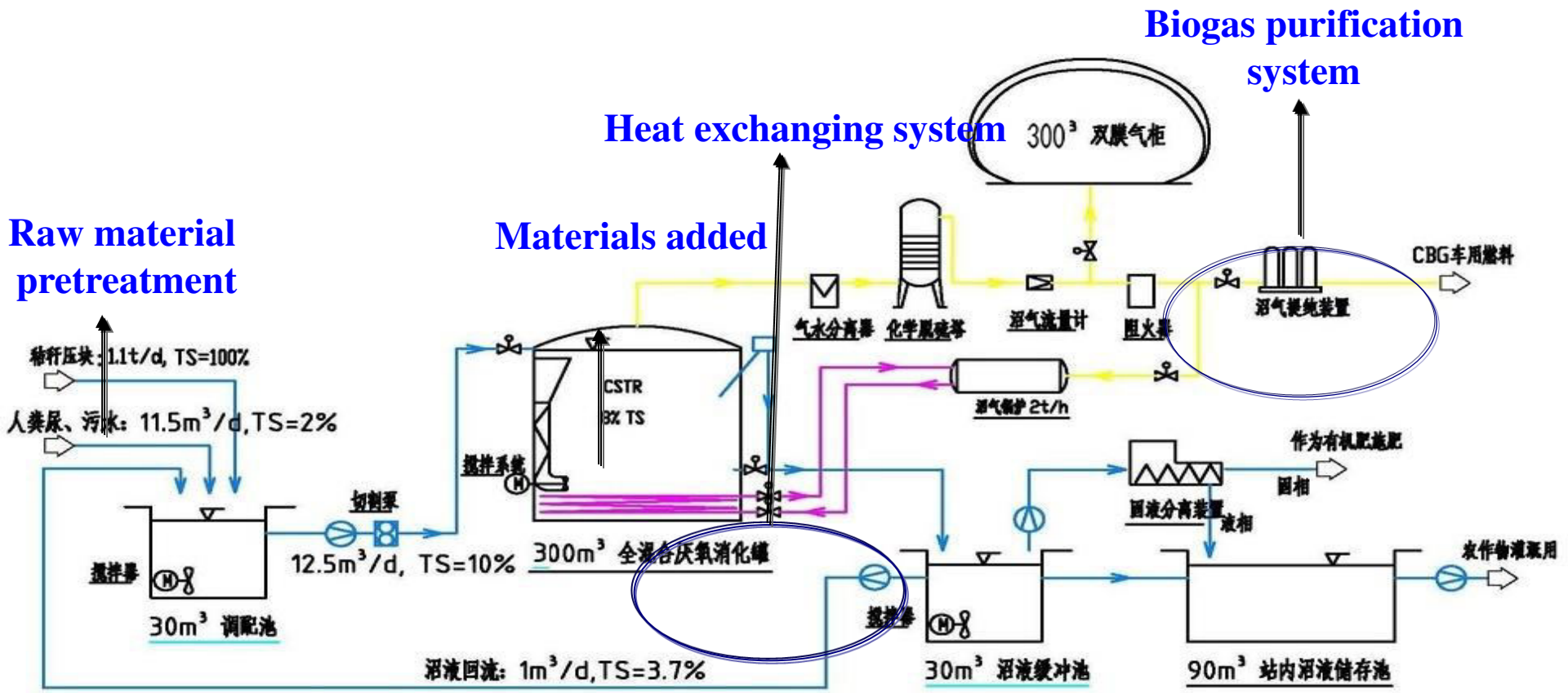




- **The methane content can be lifted to more than 97%, meanwhile produced nanoscale calcium carbonate with 72.8 nm average particle size.**

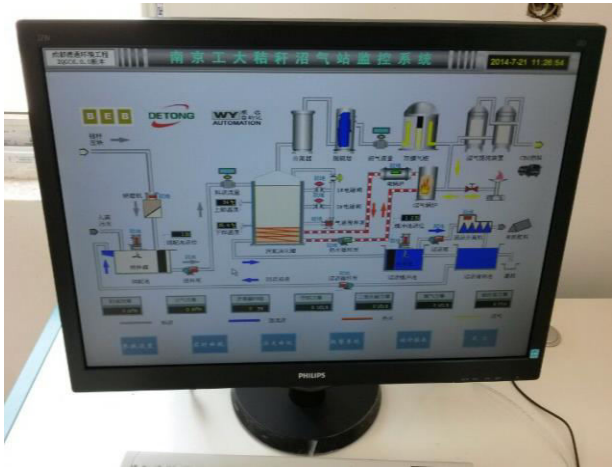
3. Commercial projects

Biogas demonstration project in NanjingTech



Biogas demonstration project in Nanjing Tech

Anaerobic digester and gas storage



Online control system

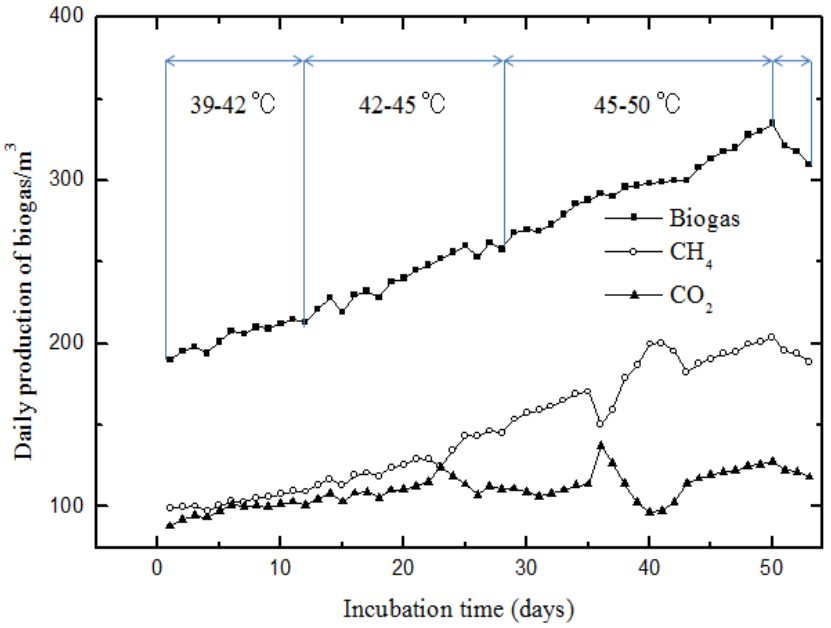
Heat exchanging system

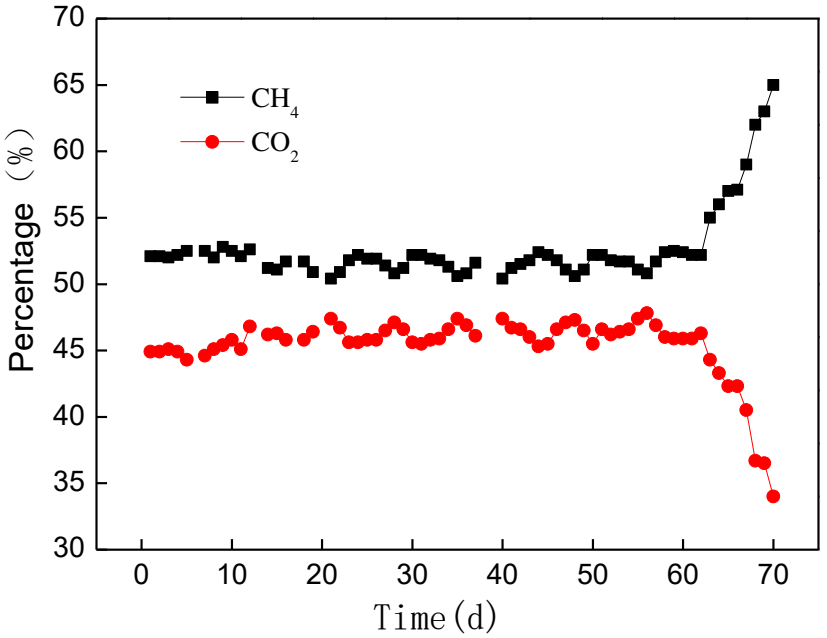
PSA

Biogas slurry dewatering system

Biomethane car in Nanjing Tech

Biogas demonstration project in Nanjing Tech





- **At 39 °C, the methane content was 53% and volumetric biogas production was 0.86 $m^3/m^3 \cdot d$ in a 300 m^3 anaerobic digester.**
- **At 50 °C, the methane content and volumetric biogas production were 65% and 1.1 $m^3/m^3 \cdot d$ respectively with 65% of conversion of straw and a yield of 400 m^3 per ton of straw.**

Biogas project in Nanyang, Henan province

Raw materials	Digester volume	Feeding	TS	Biogas capacity	Temperature	Biogas utilization	Founded year
Corn Straw	3,500 m^3	100 t/d	10%	6,000 m^3/d	42 °C	CHP	2015

Biogas project in Dafeng, Jiangsu province

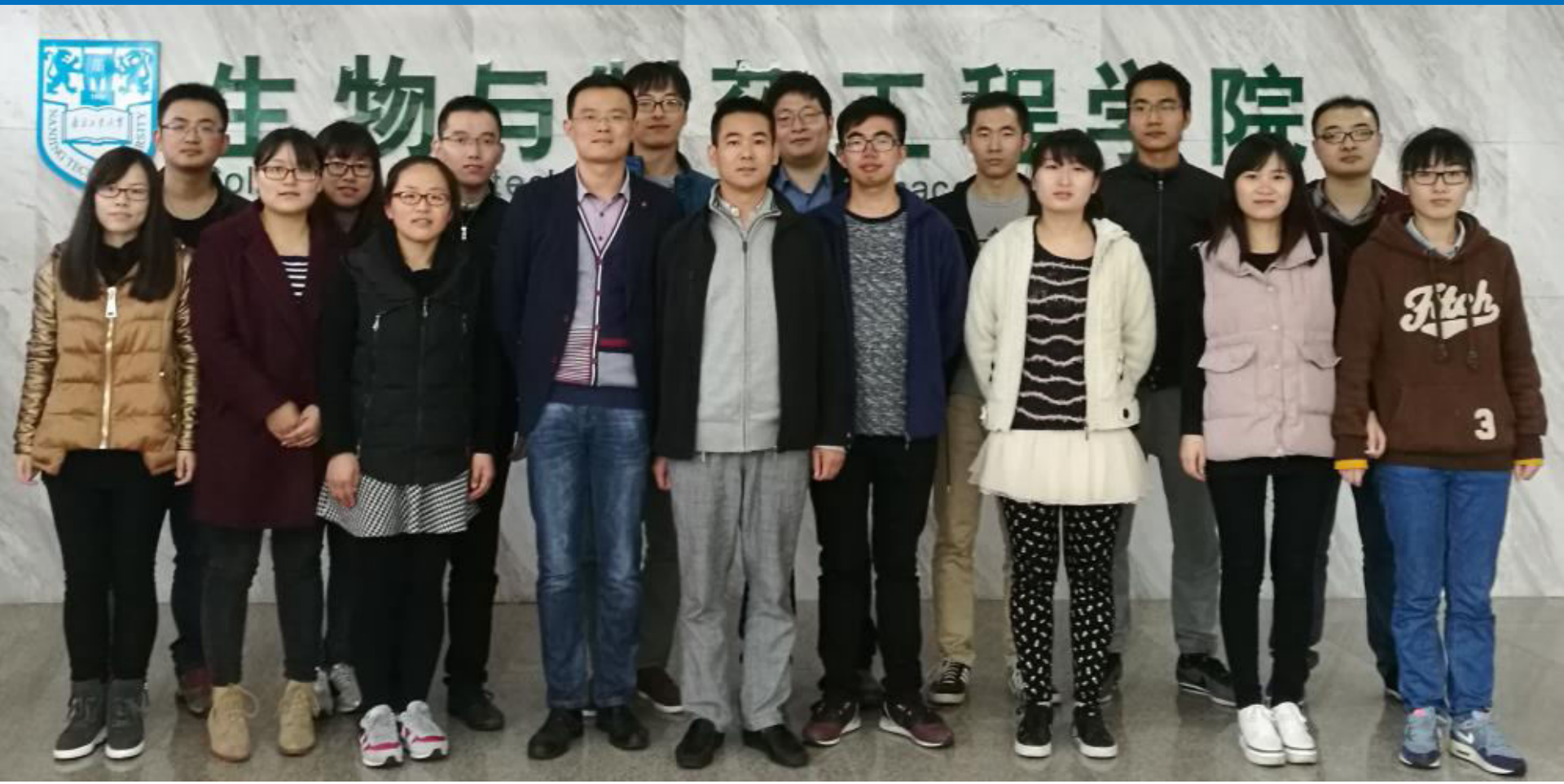
Raw Material	Digester volume	Feeding	TS	Biogas capacity	Temperature	Founded year
Chicken manure	20,000 m^3	500 t/d	10%	20000 m^3/d	38 °C	2014

Conclusions

- **Converting agro-waste to biomethane is a sustainable way for China.**
- **The technology for agro-waste pretreatment and biogas upgrading was developed in Nanjing Tech University.**
- **A biomethane demonstration project has been operated in our campus since 2014.**
- **Some our technologies are testing in several biogas projects in China now.**

Acknowledgements

- The European Union Horizon 2020 Research Innovation Program and MOST
- National Natural Science Foundation of China
- National Key Basic Research Program of China
- Nation Key Technology Support Program of China
- Other Financial Supports from MOE and Jiangsu Province



Thank you
for your attention!