Design & Implementation of Integrated Electrochemical Wastewater Treatment and Recycling Systems for Onsite Sanitation

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Pasadena, California

Designed to Operates Off-Grid

PV

Clean Flush Water Holding Tank

Standard Flush Toilet

MicroFilter

Electro-chemical Reactor

Battery,

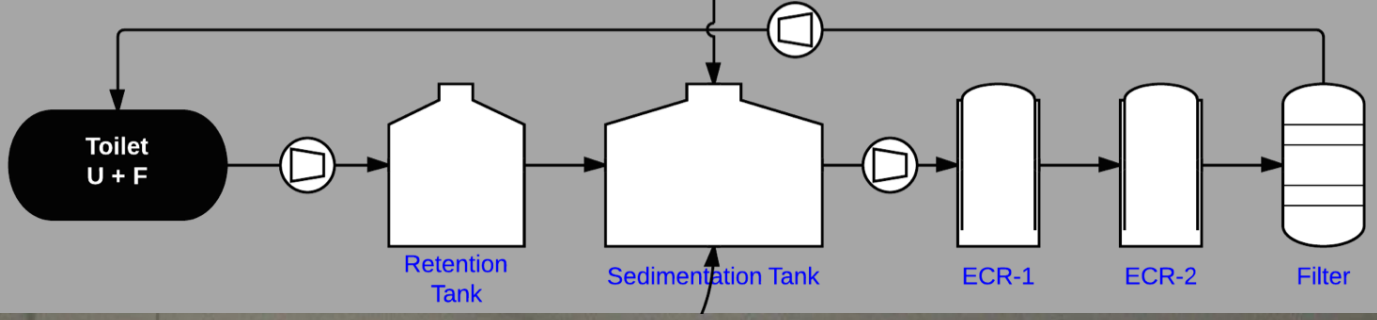
Macerator Pump

Water-Free Urinal

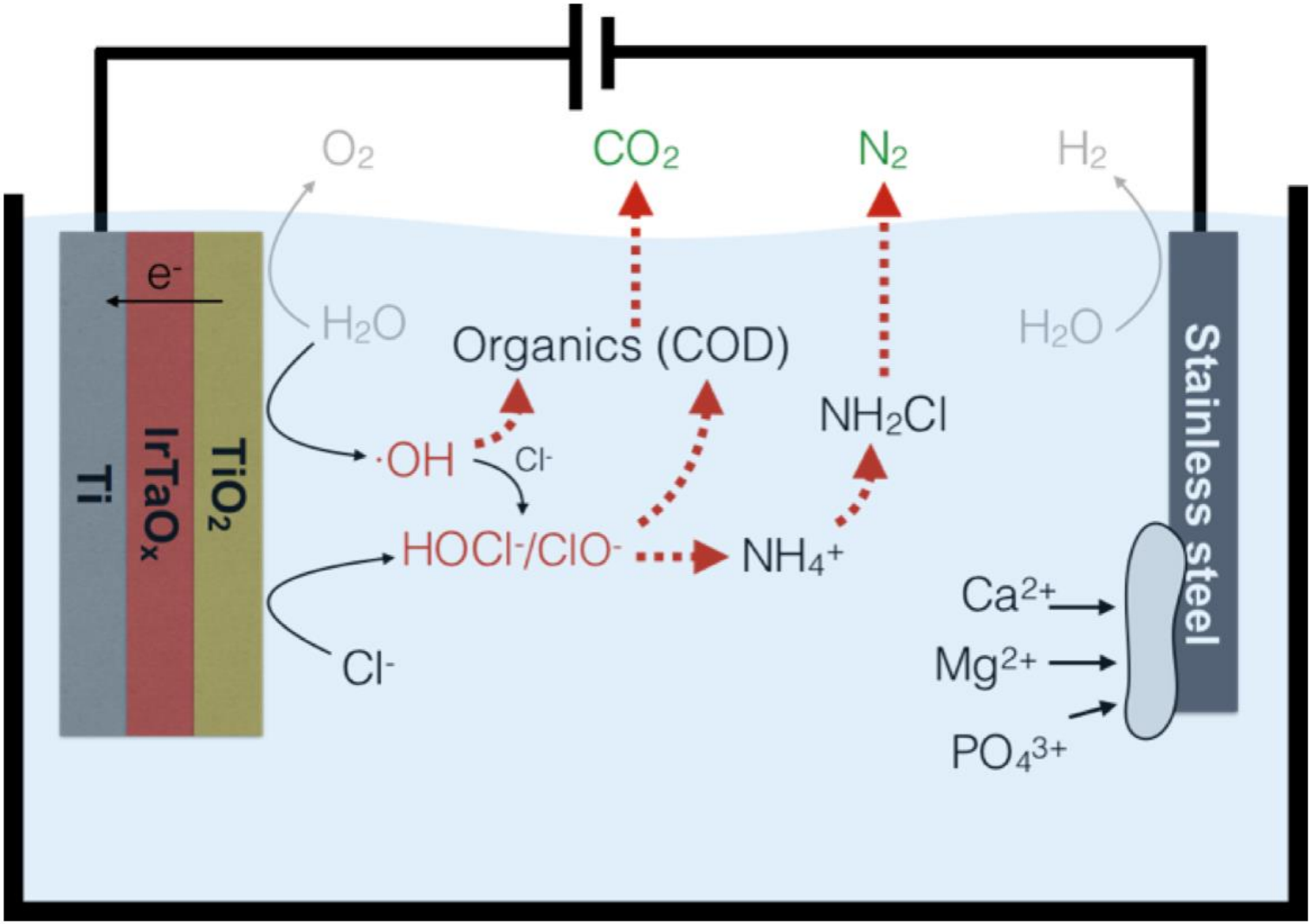
Microbial Fuel Cell

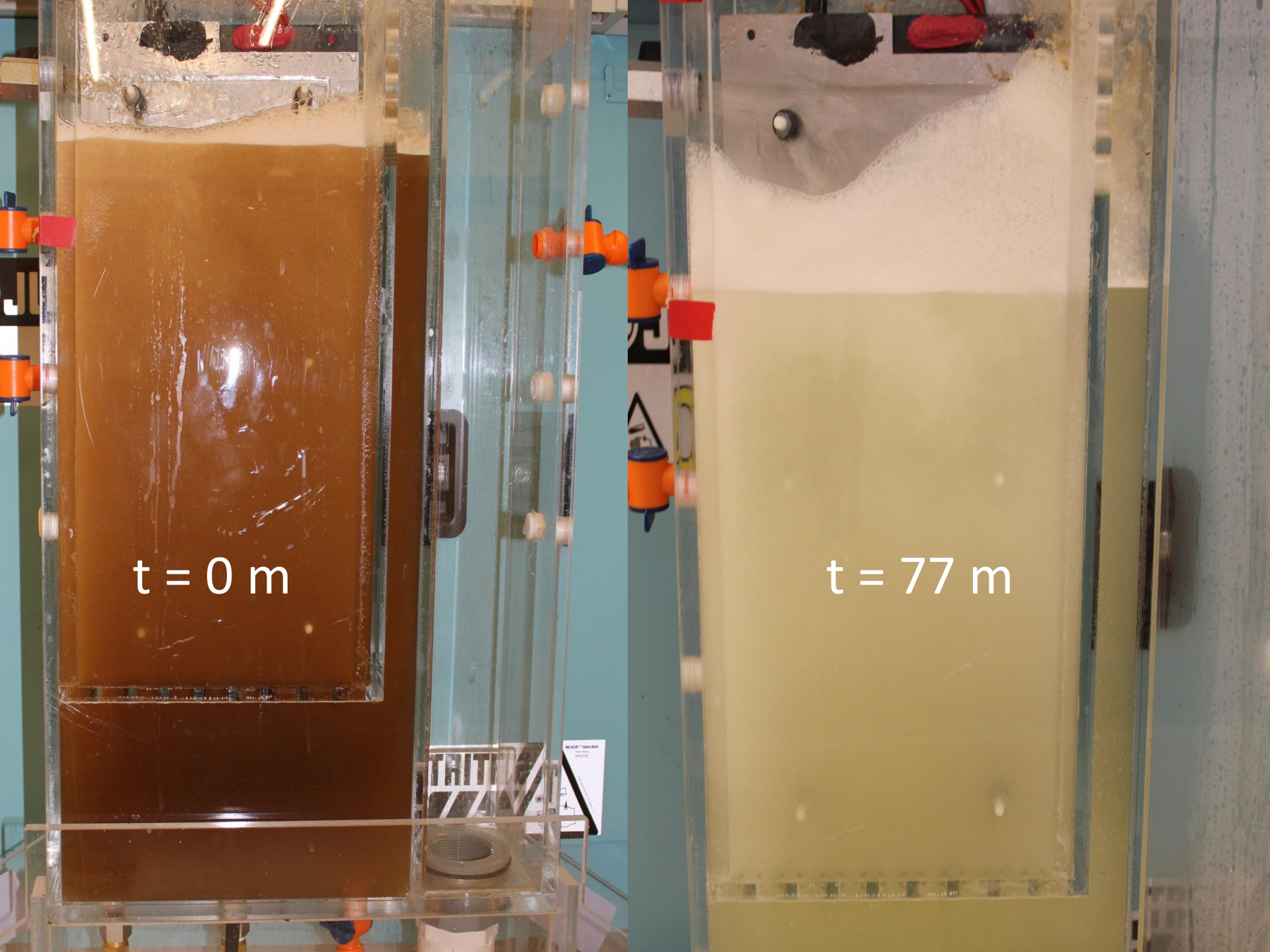
Anaerobic Bioreactor and Holding Tank

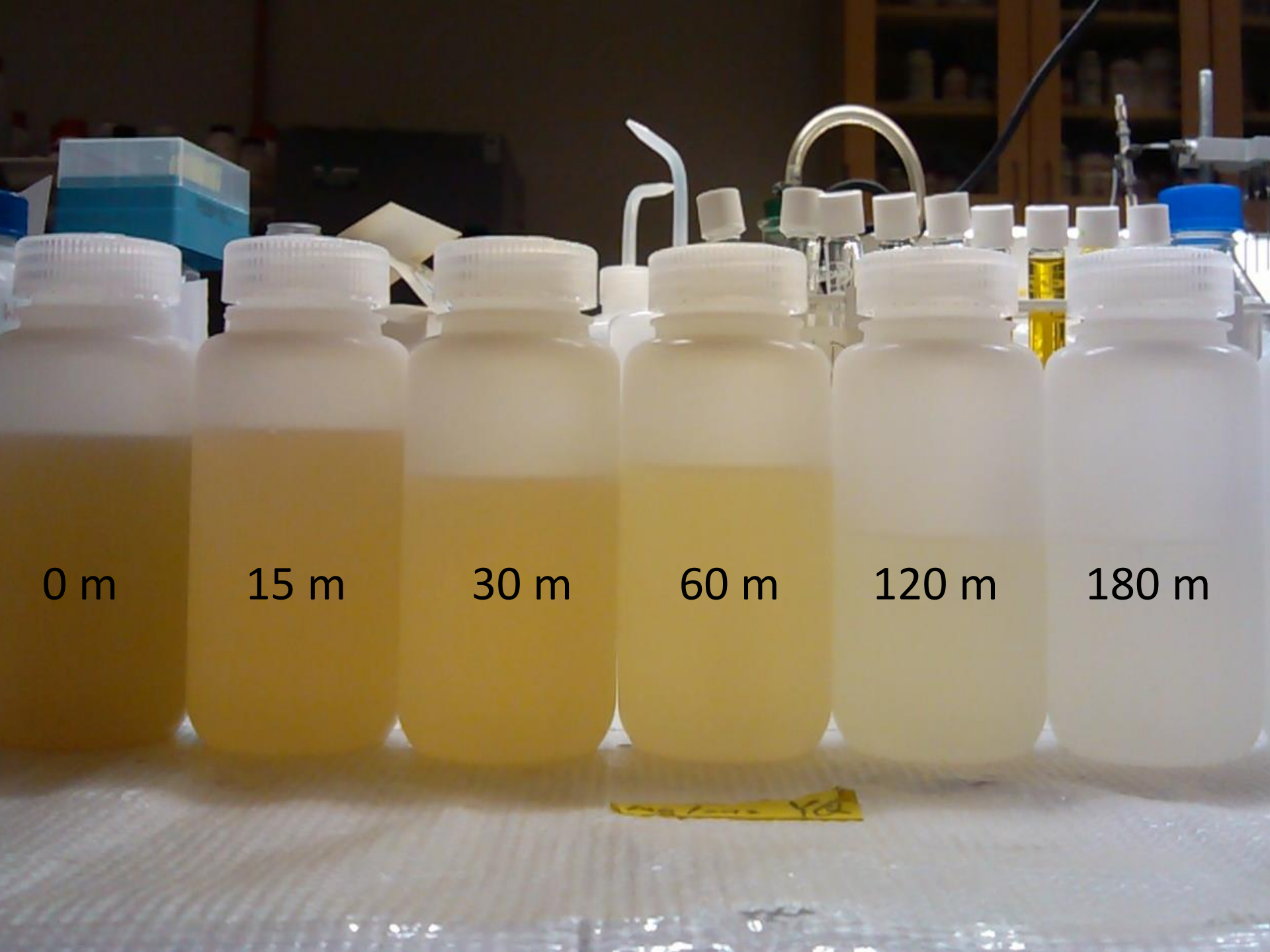
Prototype Toilet Room


Toilet
U + F
Retention Tank
Sedimentation Tank
ECR-1
ECR-2
Filter

Electrochemical Water Treatment




t = 0 m
t = 77 m


0 m
15 m
30 m
60 m
120 m
180 m

2nd Generation Prototypes


TOILET


ENTRY
ELECTRONIC PUBLIC TOILET
മരം ഒരു വരം
ഓക്സിജൻ കൃത്രിമമായി
ഉത്പാദിപ്പിക്കേണ്ടിവന്നാൽ?
മനുഷ്യരാശിക്കു മാത്രം, 6 മാസത്തേക്ക്
1700 ലക്ഷം കോടി രൂപ വേണ്ടിവരും.
സസ്യജാലങ്ങൾ ഇത് നമ്മുക്ക്
സൗജന്യമായി ചെയ്തുതരുന്നു.
മരങ്ങളെ സംരക്ഷിക്കൂ
നട്ടു വളർത്തൂ
Venpakal


eToilet
Eram Scientific
Krishna
eToilet
Full cycle approach in
sustainable sanitation by integrating
convergence of electronics,
mechanical,
web-mobile technologies
thereby controlling entry,
cleaning and
remote monitoring
capabilities with multiple
revenue options.
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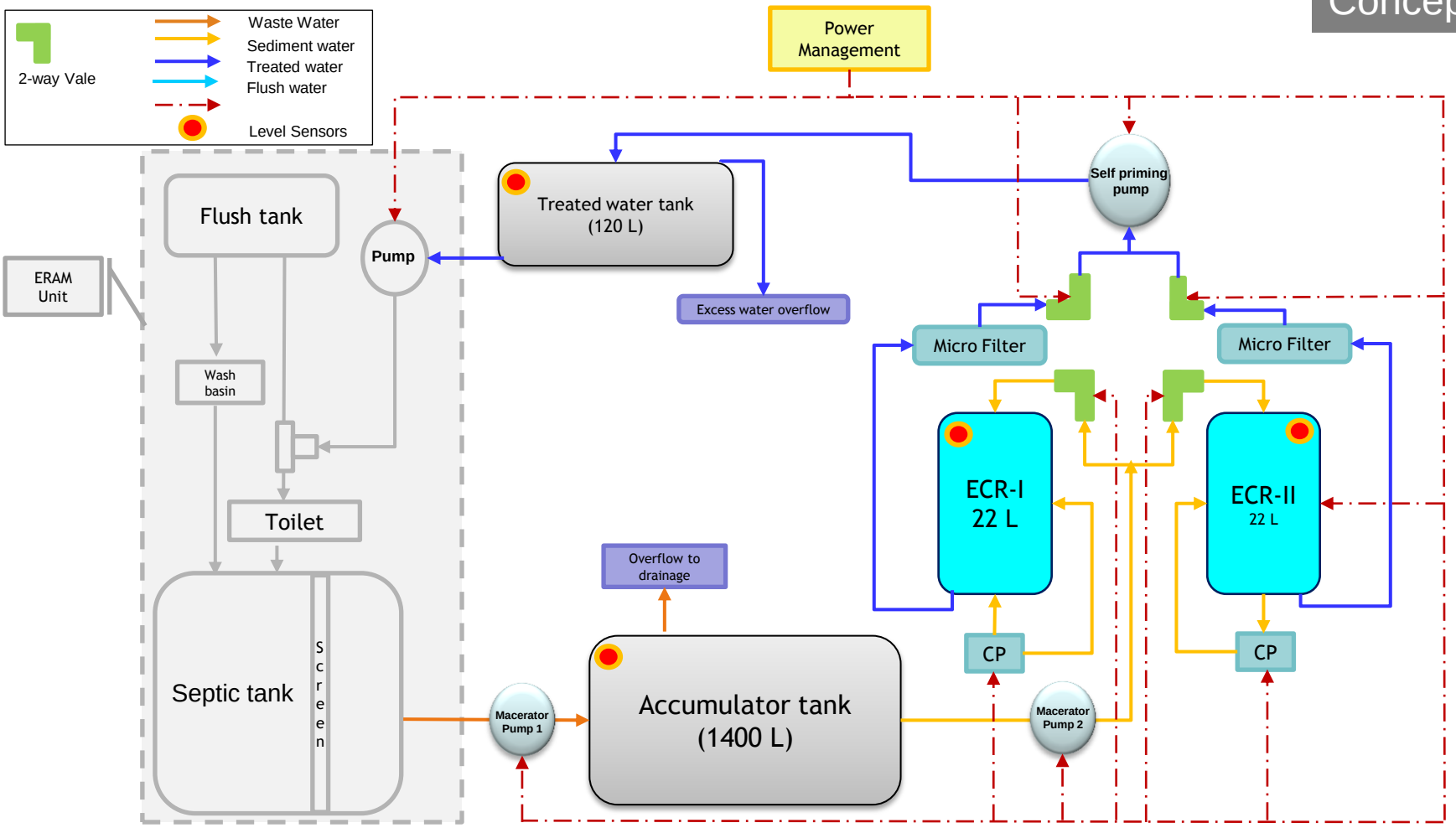

SR no.	Advantage	Disadvantage
1	Accumulator tank to hold excess of effluent	High volume of accumulator tank, need more space to accommodate
2	Use of separate 2 way valves will act as backup for each other incase of failure of one valve	Number of components will increases.

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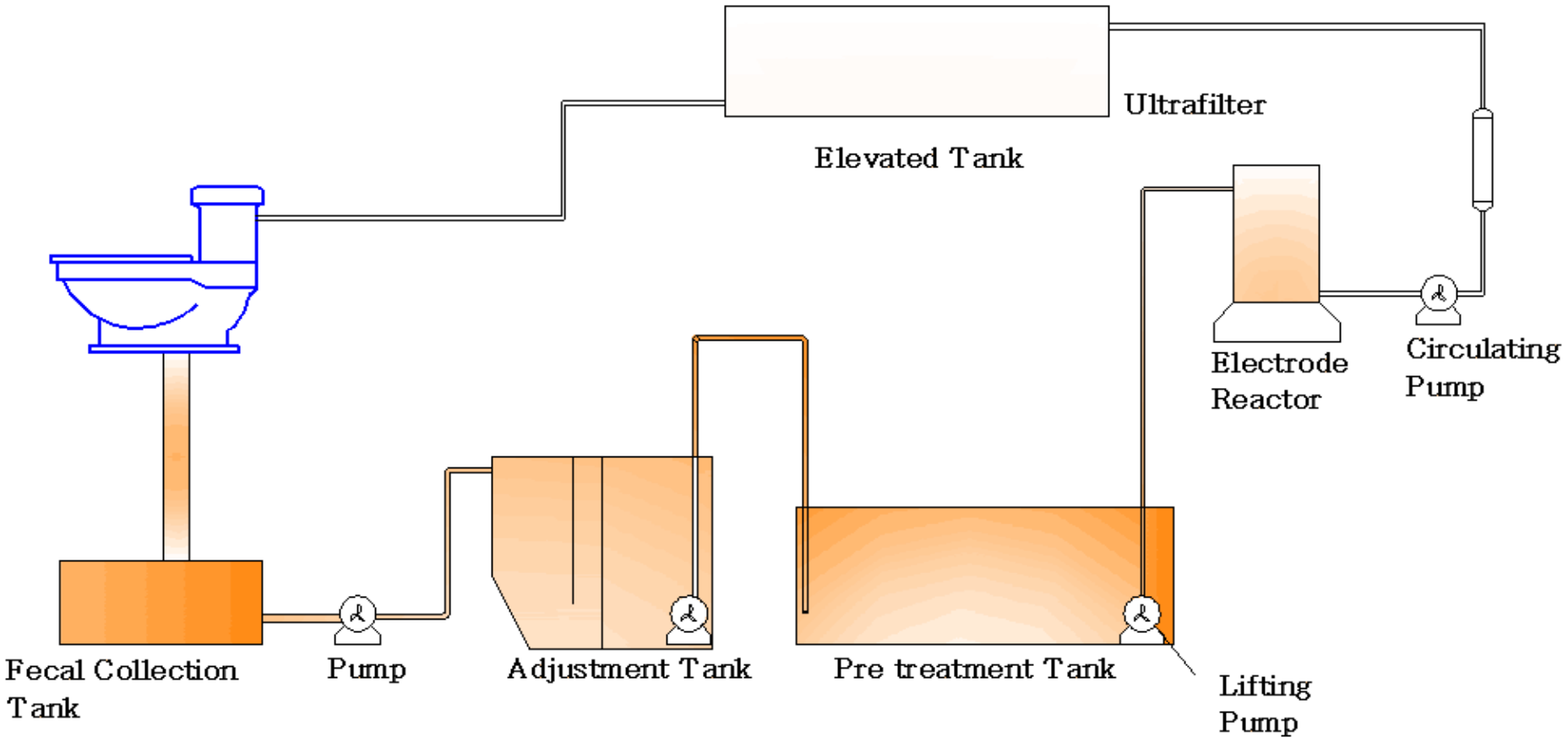
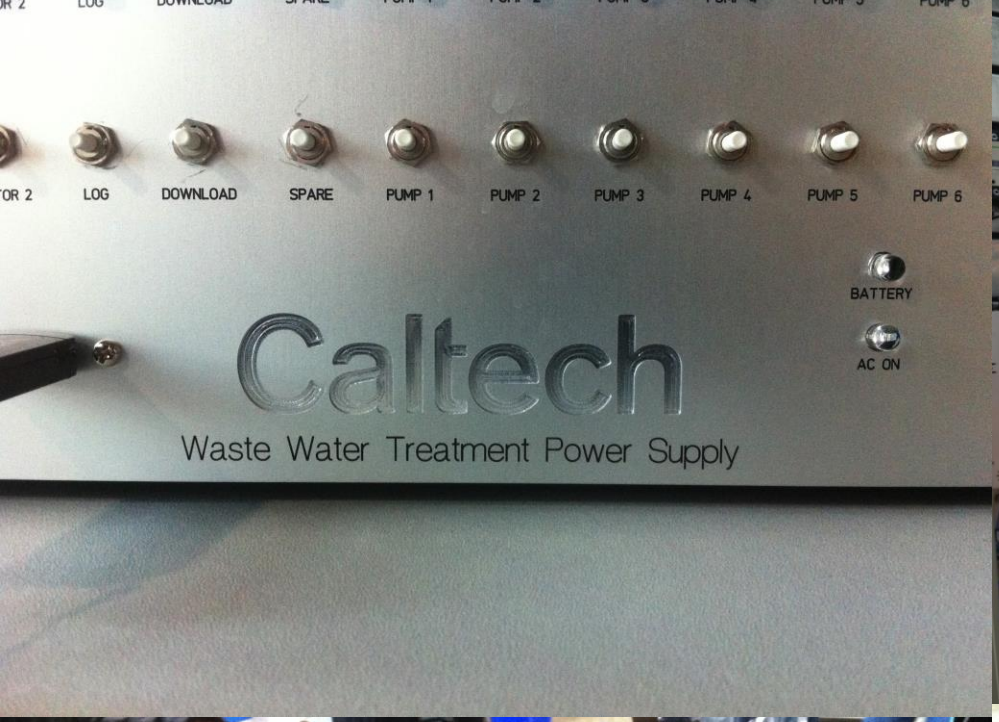
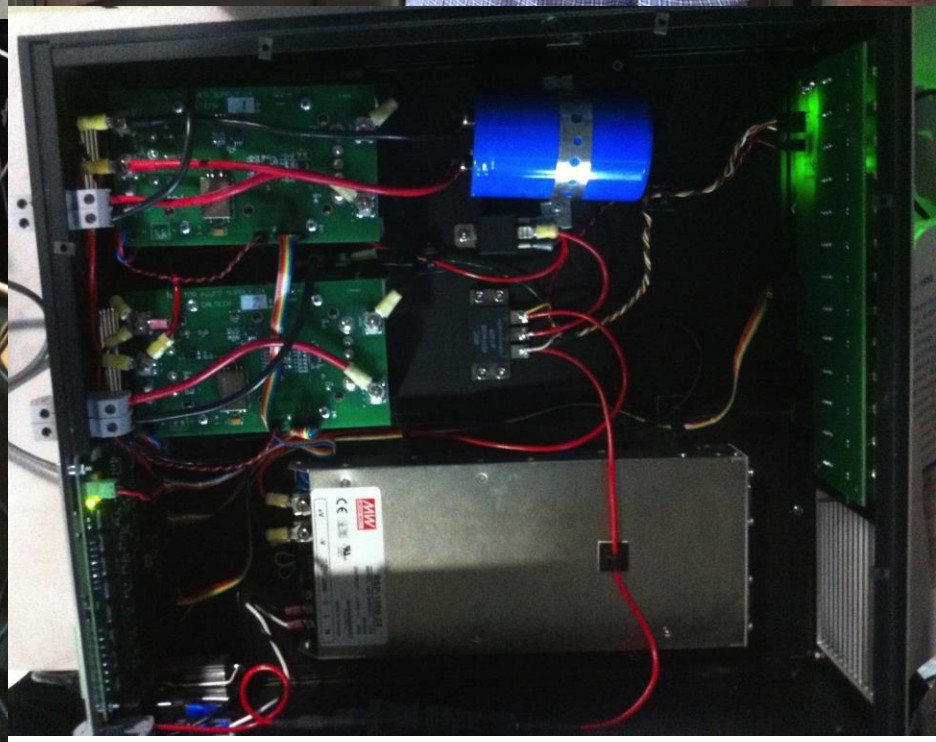
2014 Elementary School Test Site, Yixing (Wuxi), China

Process Flow Diagram

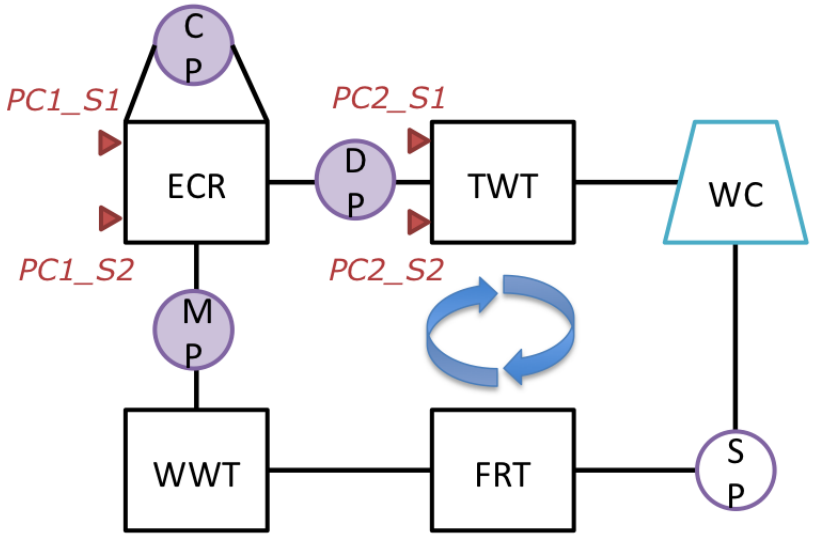


Bio-solids sludge discharged 1~2 timesper year < 400 kg (99% water)


LOG
DOWNLOAD
SPARE
PUMP 1
PUMP 2
PUMP 3
PUMP 4
PUMP 5
PUMP 6
BATTERY
AC ON
Caltech
Waste Water Treatment Power Supply



Automatic Control Systems



CP = PC1_P2 circulation pump
MP = PC1_P1 macerator pump
DP = PC1_P4 drain pump

SP = Saniflo macerator Pump
WWT = Wastewater Tank
ECR = Electrochemical Reactor
TWT = Treated Water Tank
FRT = Flow Regulation Tank

Triggers

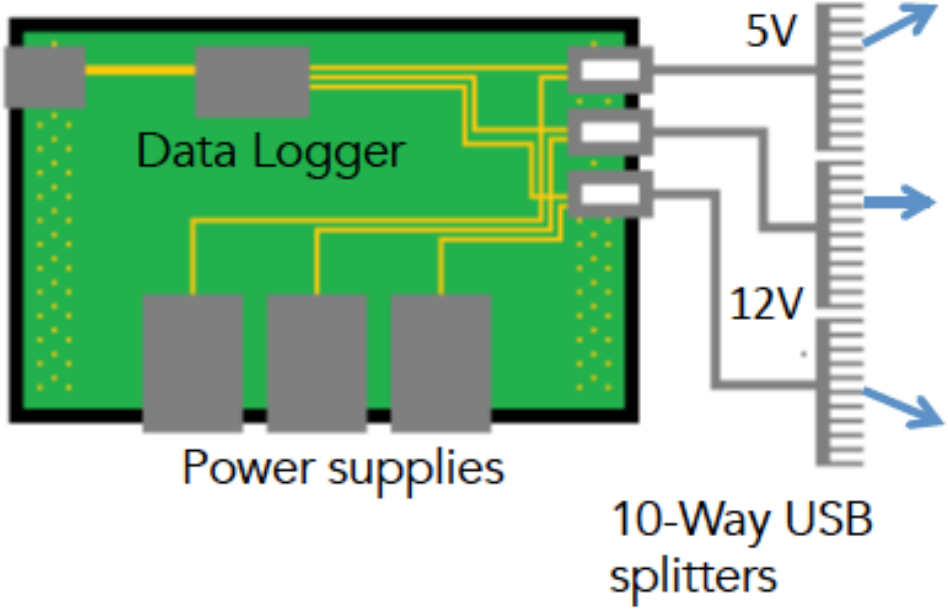
1. When the water level in the Treated Water Tank goes below PC2_S2, start the cycle:
   PC2_S1 (on ⟶ off) & PC1_S2 off ➔ PC1_P1 starts
2. When the reactor is drained, start a new batch:
   PC1_S2 (on ⟶ off) & PC2_S1 off ➔ PC1_P1 starts
3. Same as 1. whith PC2_S1:
   PC2_S2 (on ⟶ off) & PC1_S2 off ➔ PC1_P1 starts

Cycling

PC2_S2 (off ⟶ on)	➔	RM1 starts	*Electrolysis starts when filling the reactor*
RM1 (off ⟶ on)	➔	PC1_P2 starts	*When electrolysis starts, the circulation pump starts*
RM1 (on ⟶ off)	➔	PC1_P2 stops	*When electrolysis is over, the circulation pump stops*
RM1 (on ⟶ off)	➔	PC1_P4 starts	*When electrolysis is over, the reactor is drained*
PC2_S2 (on ⟶ off)	➔	PC1_P4 stops	*At the end of the drainage, the drain pump stops*

Engineered to Handle All Wastewater Treatment Data Classes

Inexpensive, low-power, open source "Raspberry Pi"



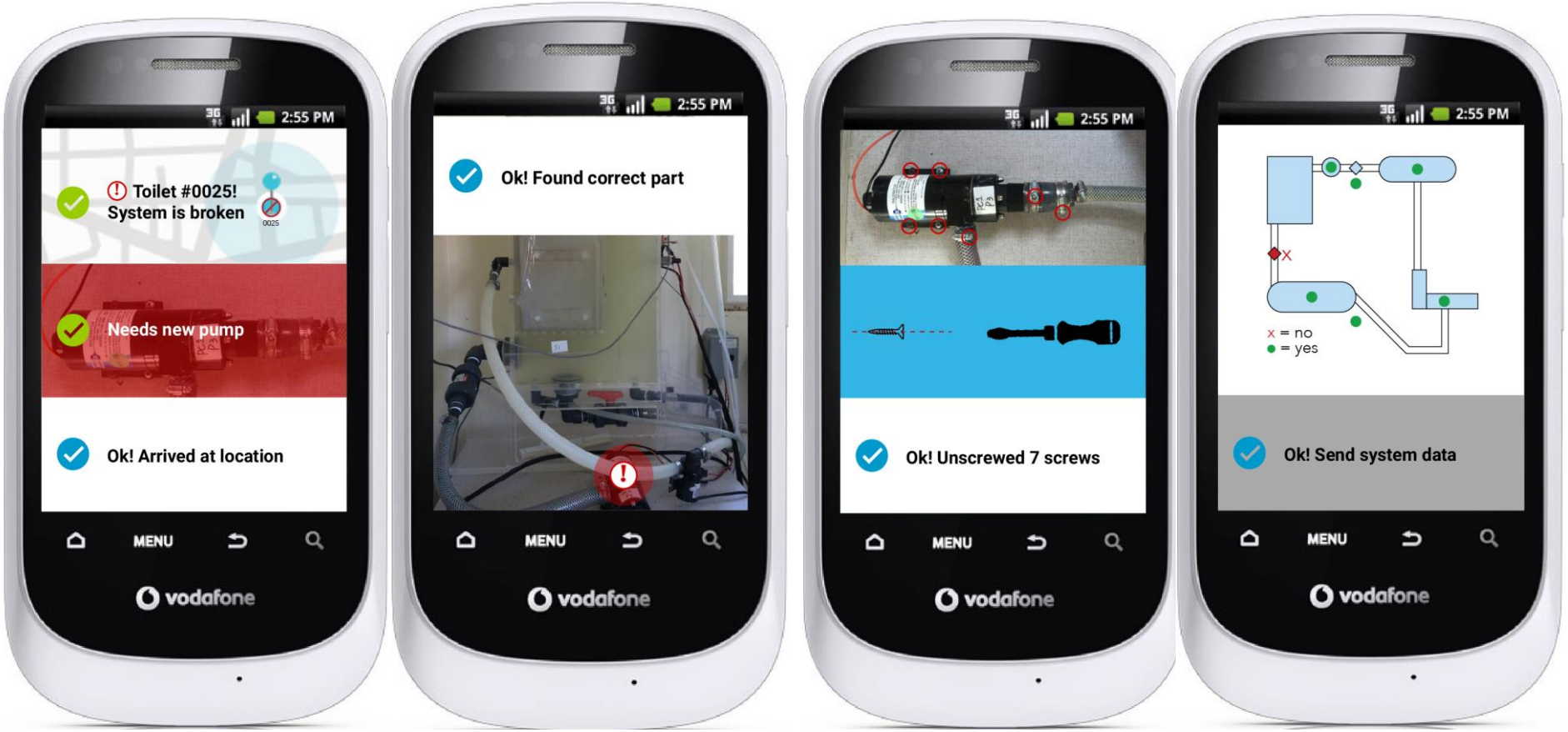
Electrochemical Treatment System (Caltech)

- 8 water sensors
- 2 pressure sensors
- 2 Turbidity probes
- 1 Chlorine probe
- 1 Adsorption probe
- 1 Multimeter

Anaerobic Bioreactor (Duke)

- 2 O_2 probes
- 1 CH_4 probe
- 1 pressure sensor
- 1 pH probe
- 3 thermocouples
- 1 Multimeter

Smartphone Screen Shots: Maintenance Protocols




出品单位：中国宜兴环保科技工业园
China Yixing Industrial Park for Environmental Science &Technology
CIES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移动式太阳能厕所


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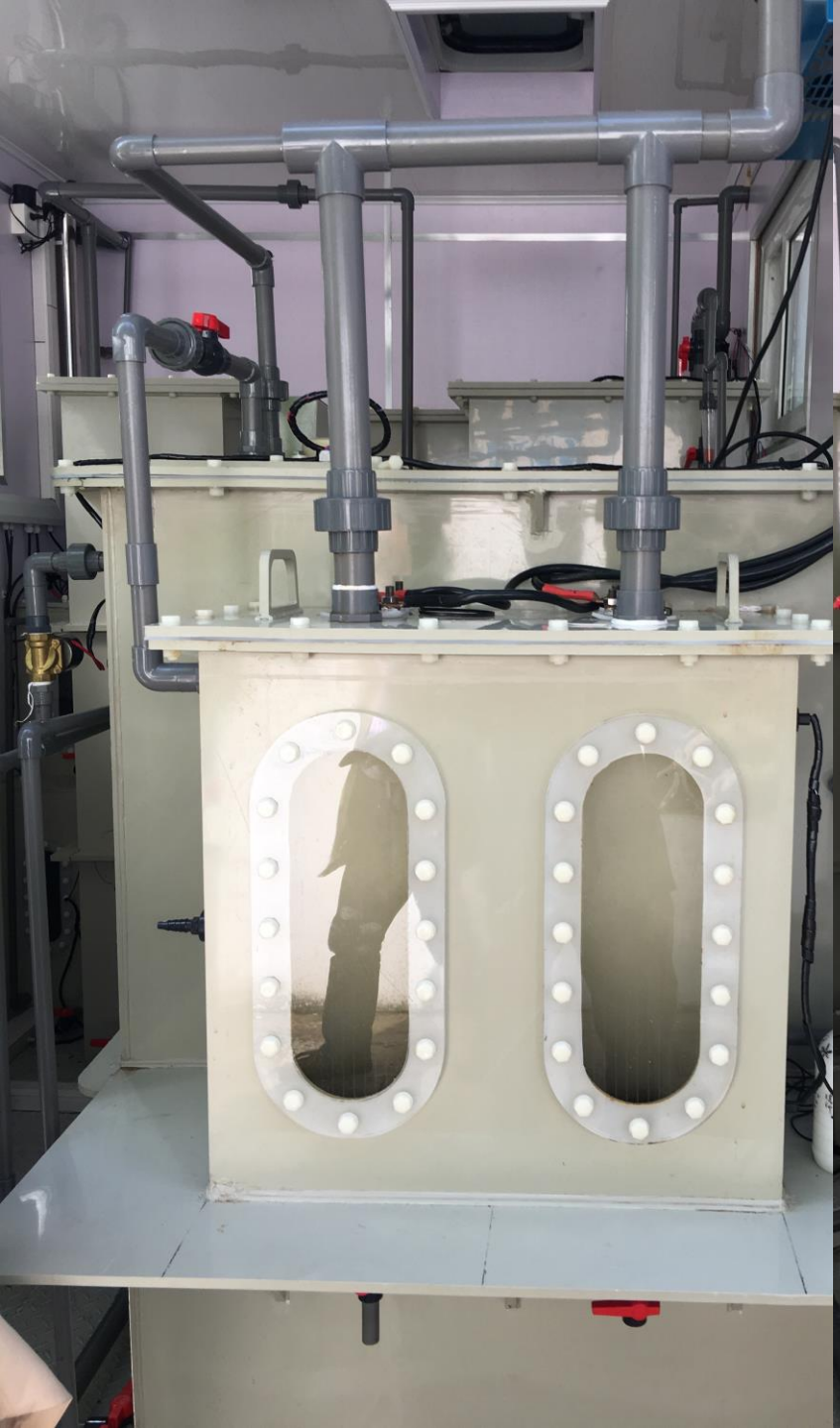
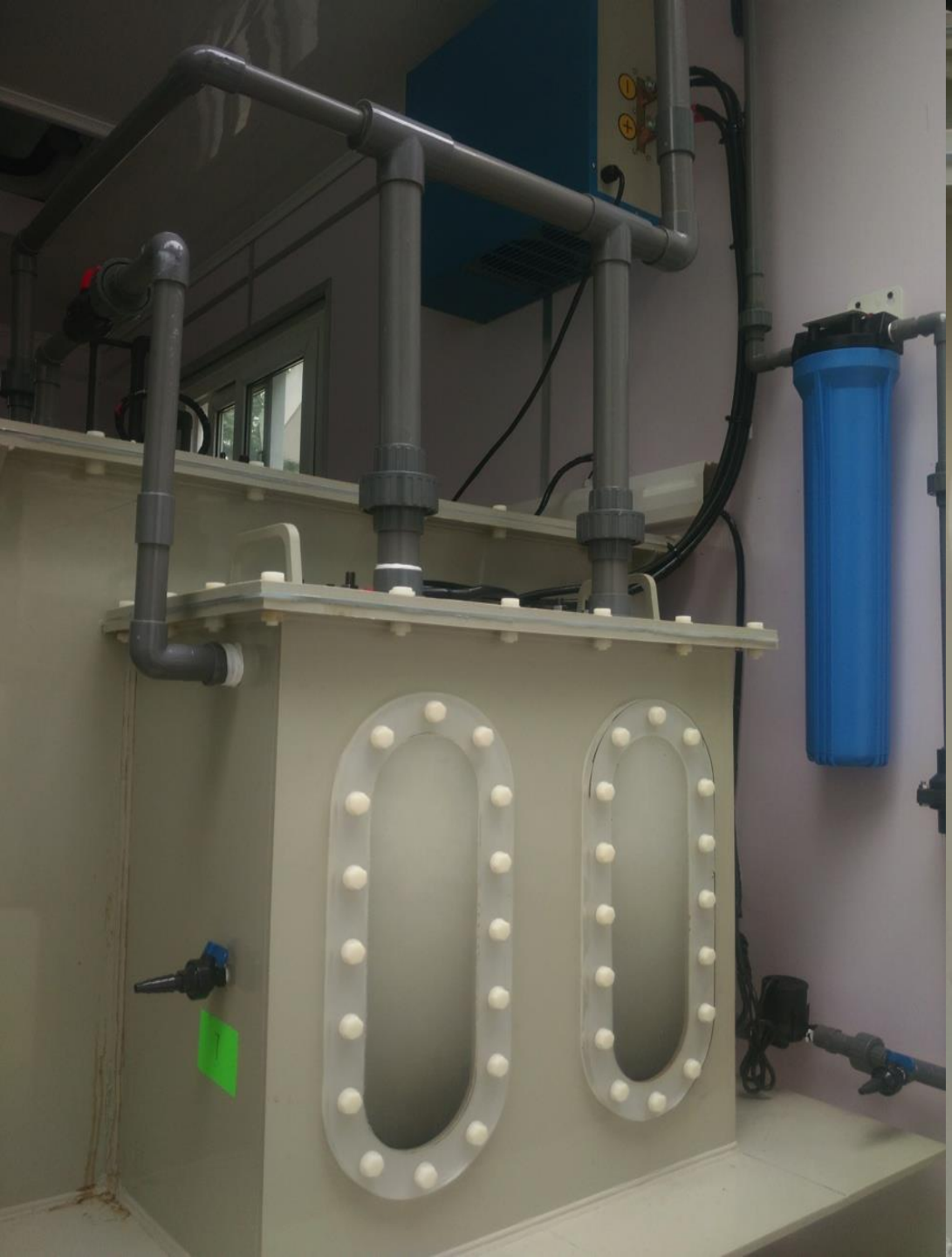
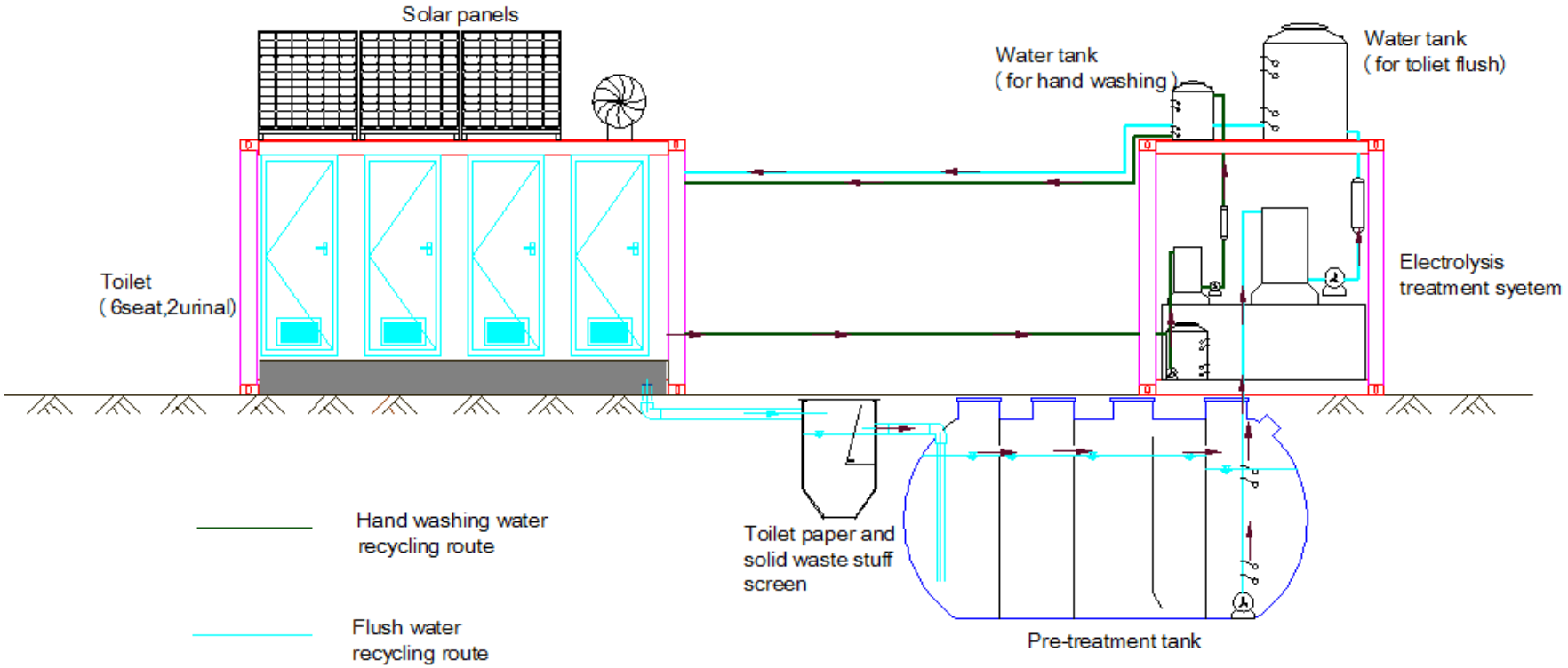
Ecological Toilet /生态厕所/
卫生间
Toilet



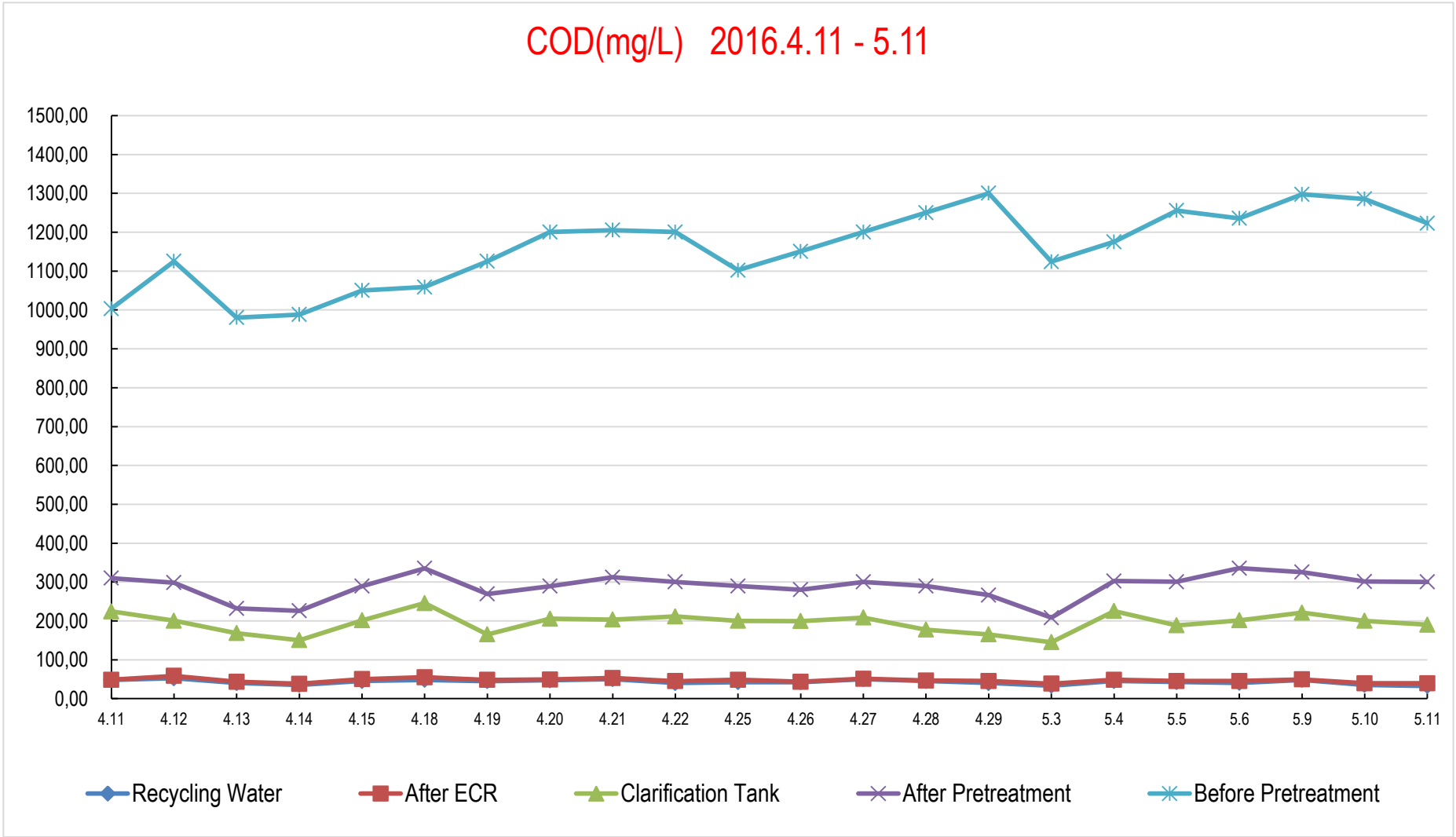


Third-Generation Prototype Flow Diagram

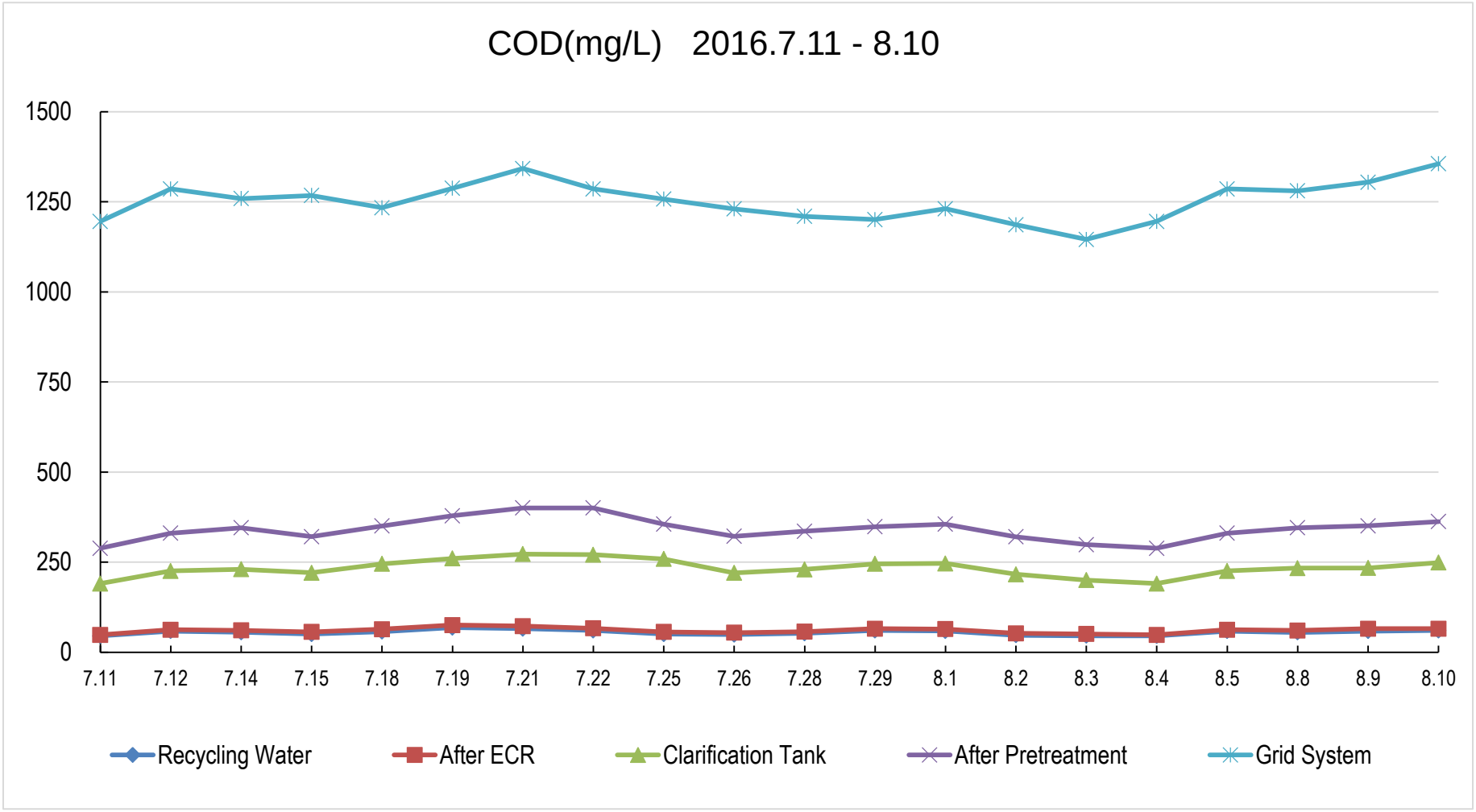


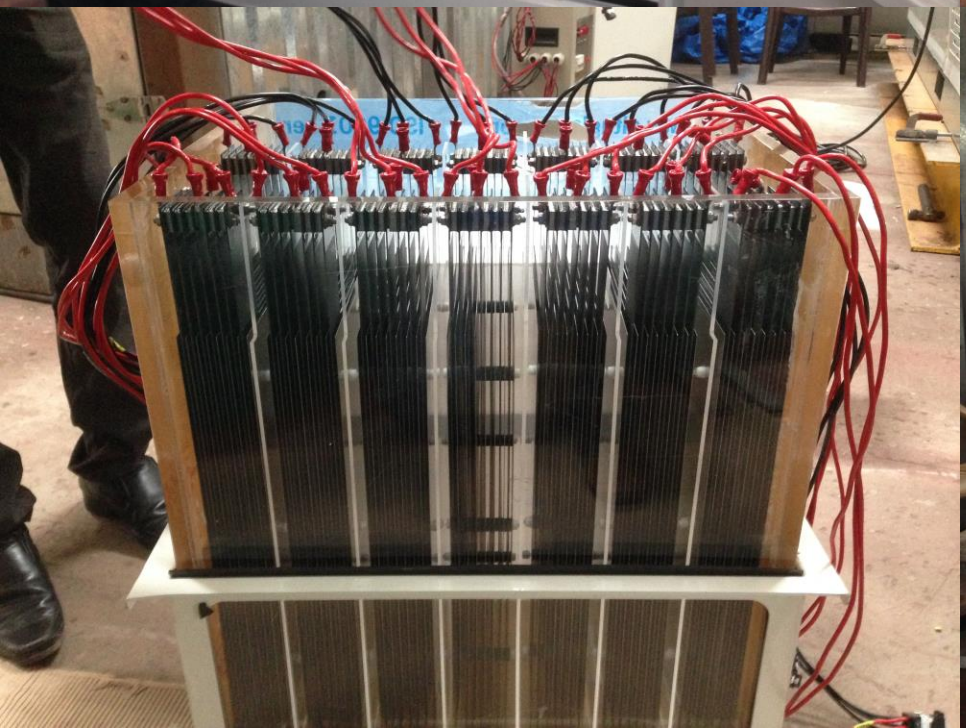

W/C

Elementary School Testing Results

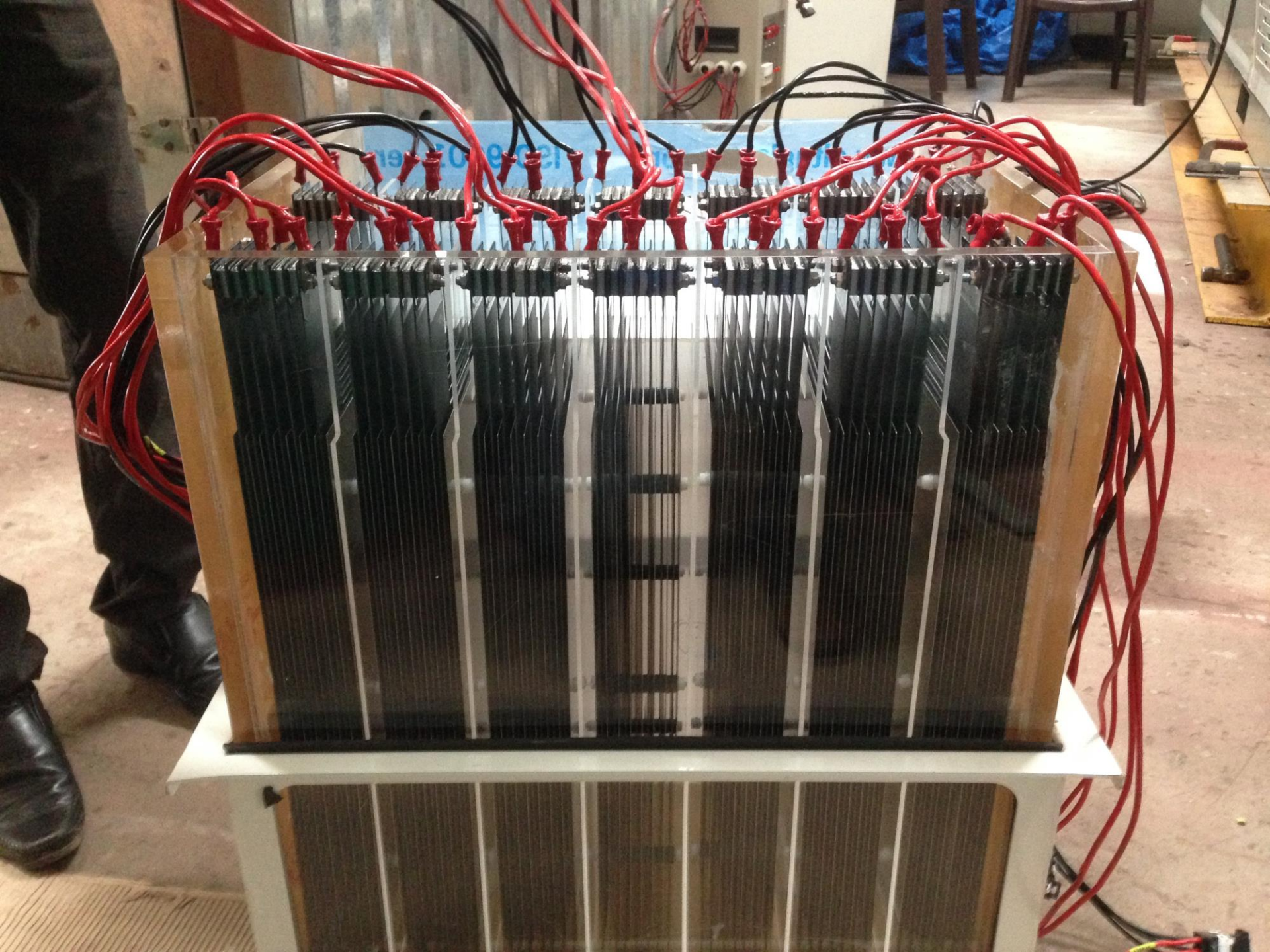


Prototype 2 Testing at Industrial Park

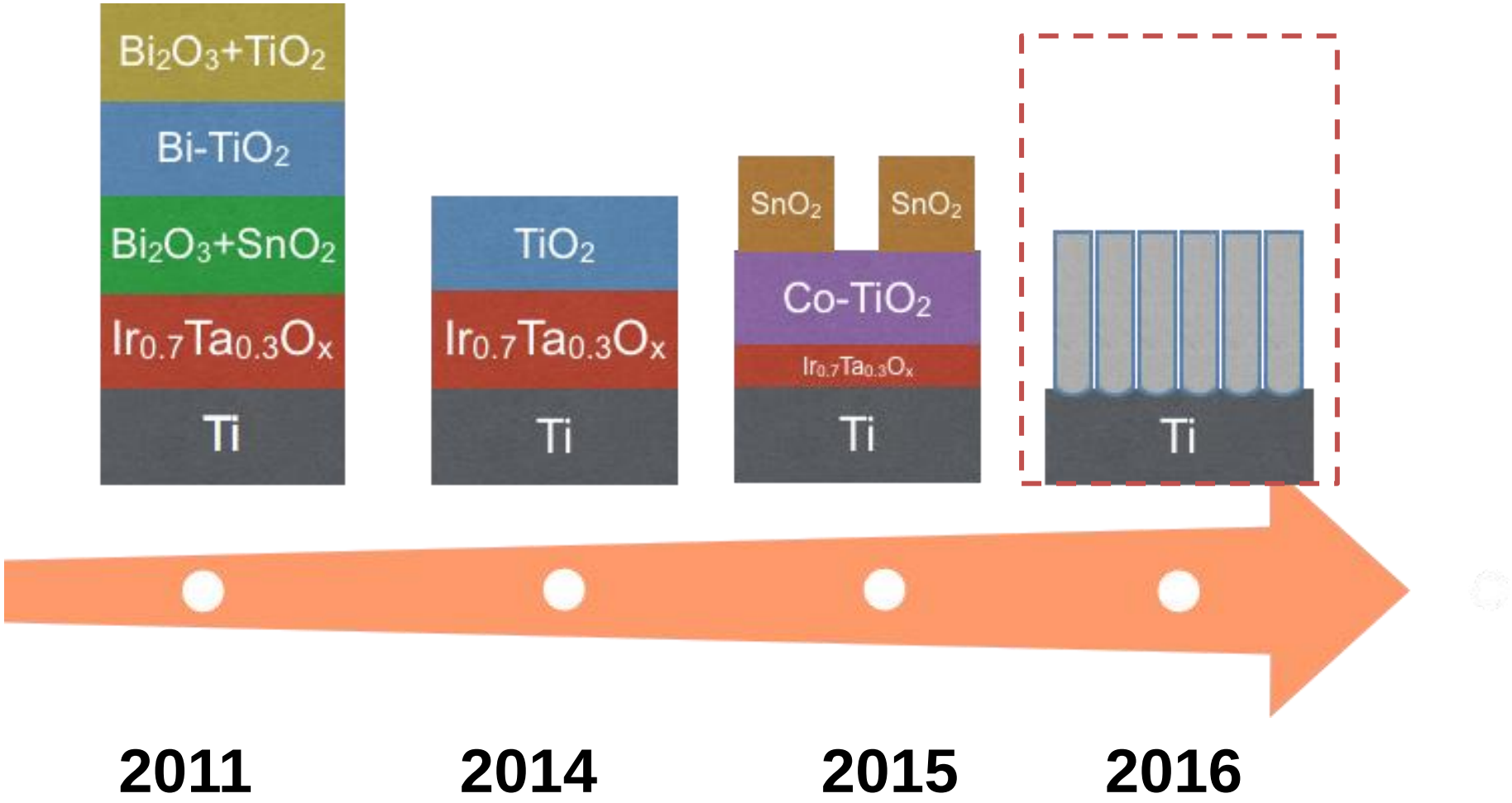




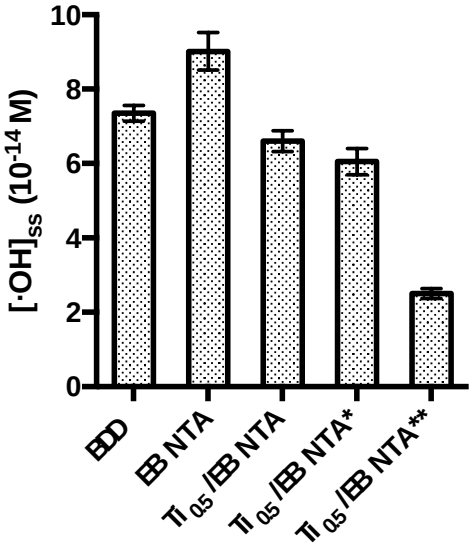

Dropbox

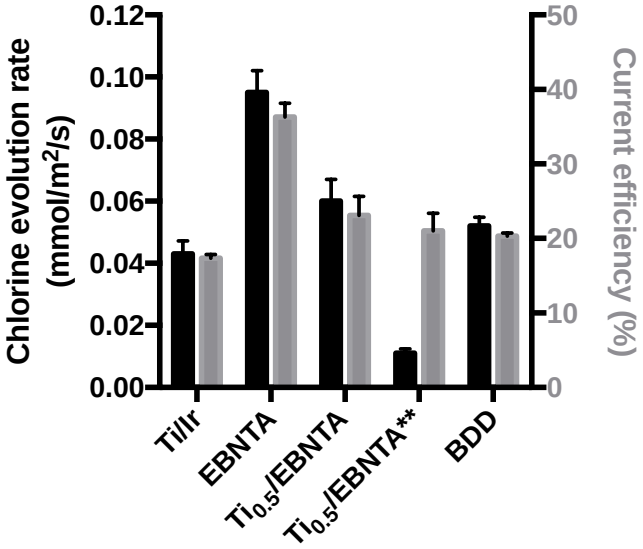


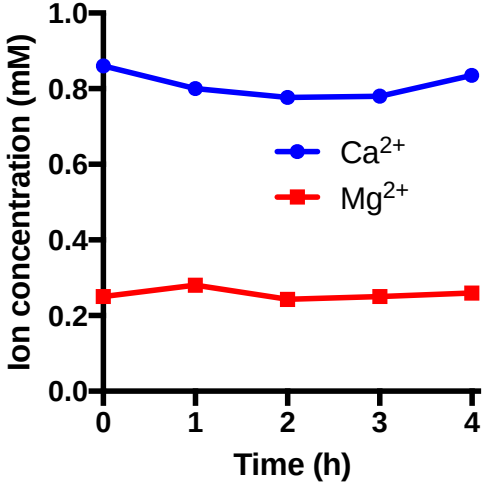
Anode Improvements 2011- 2017

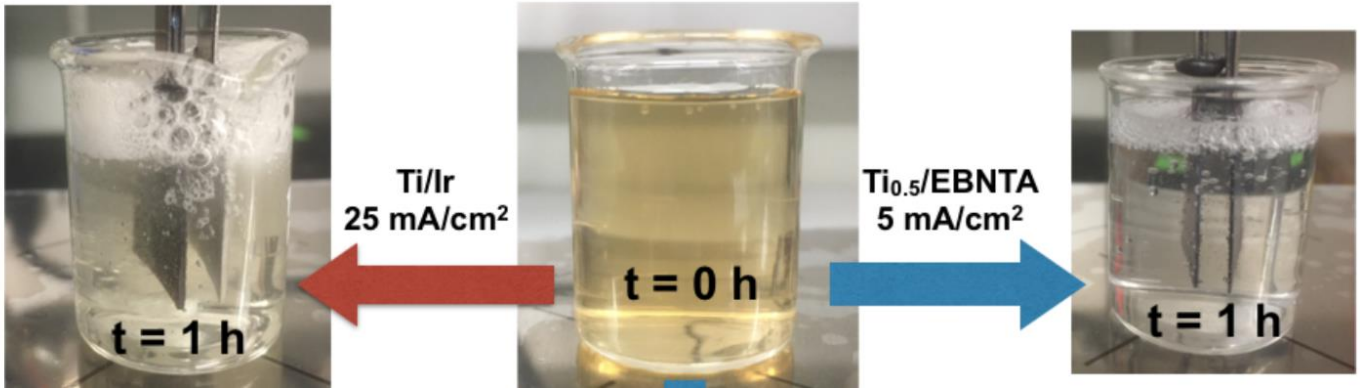


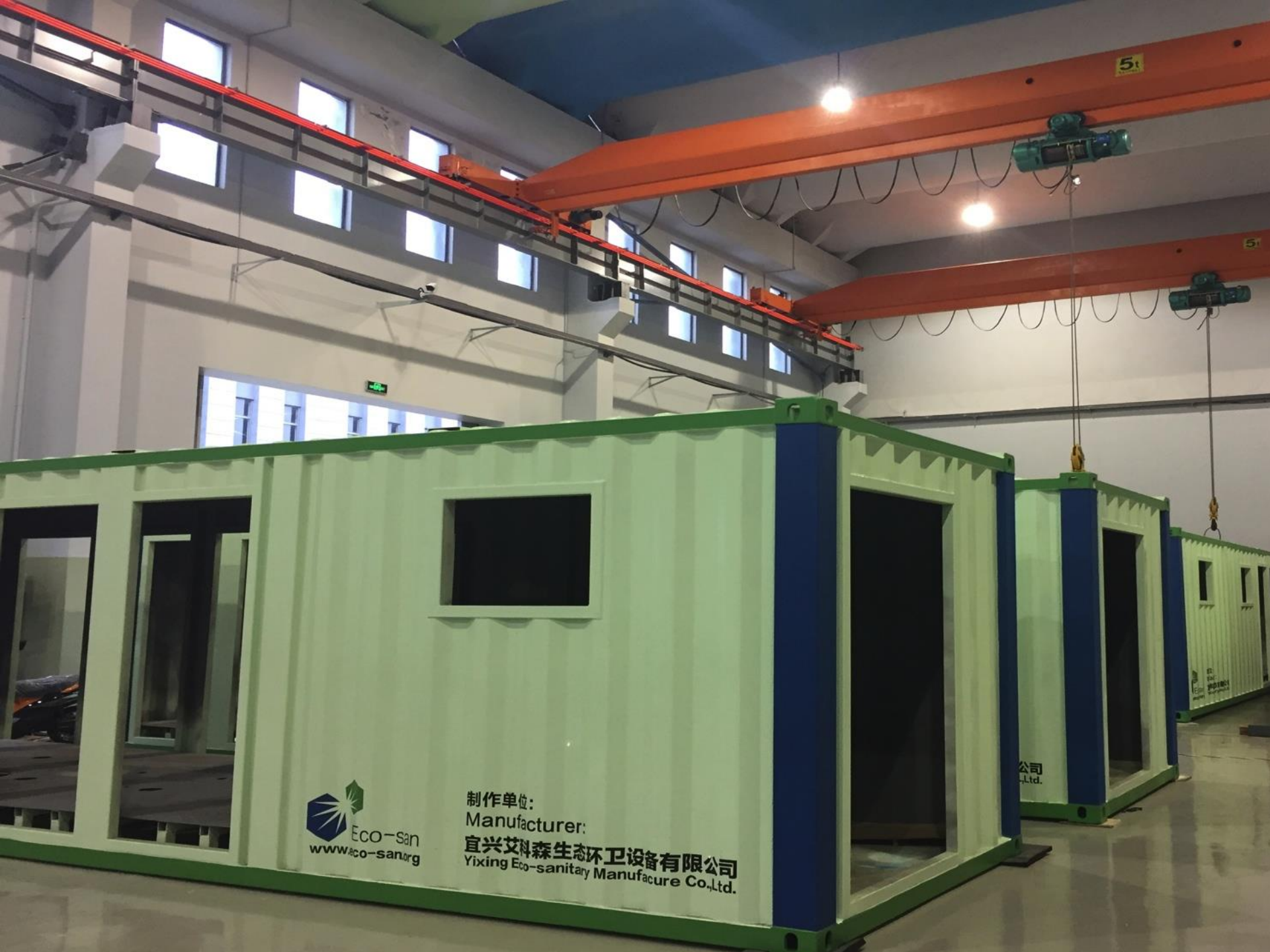
Blue TiO_2 Nanotube Electrodes







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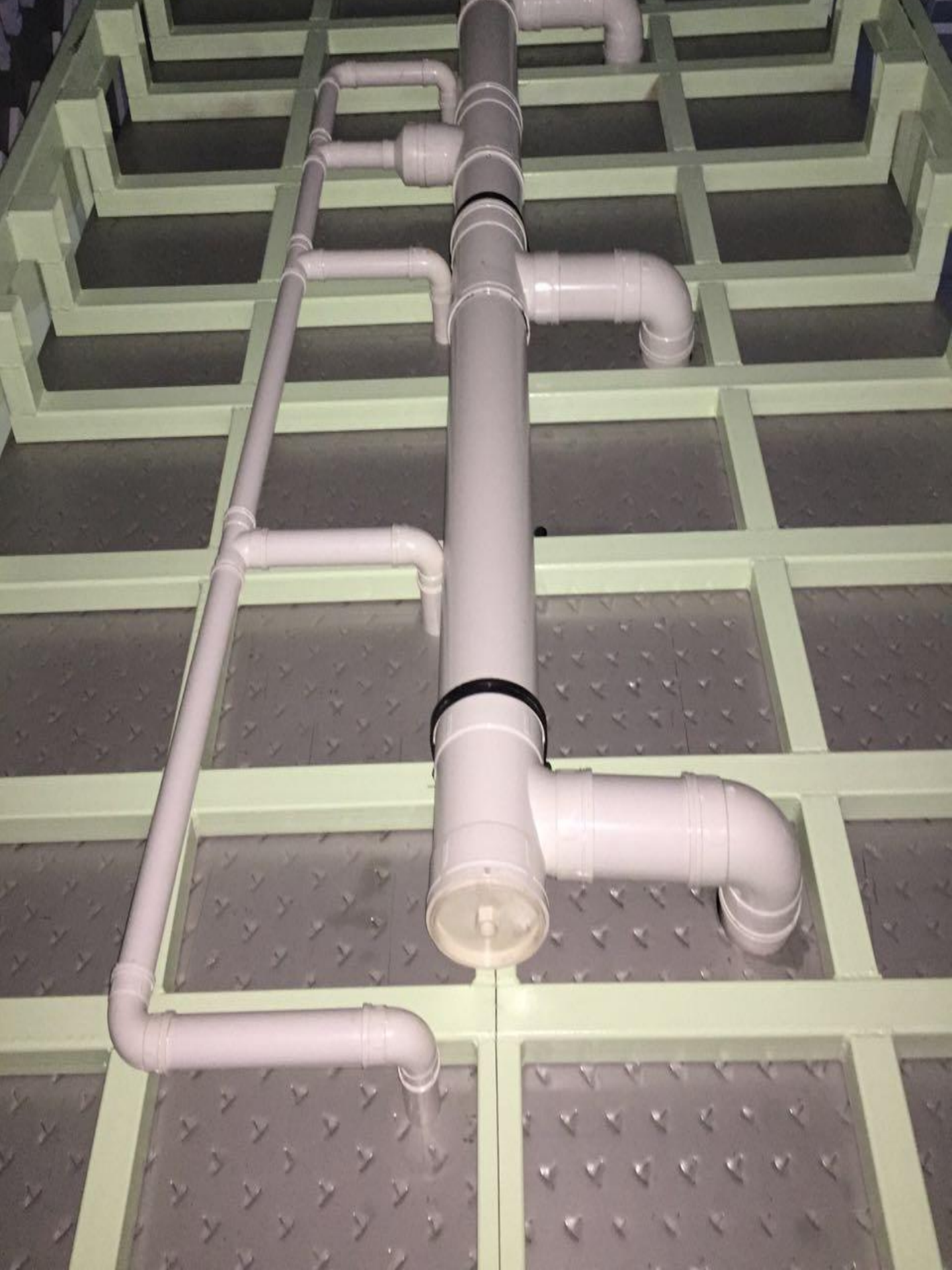
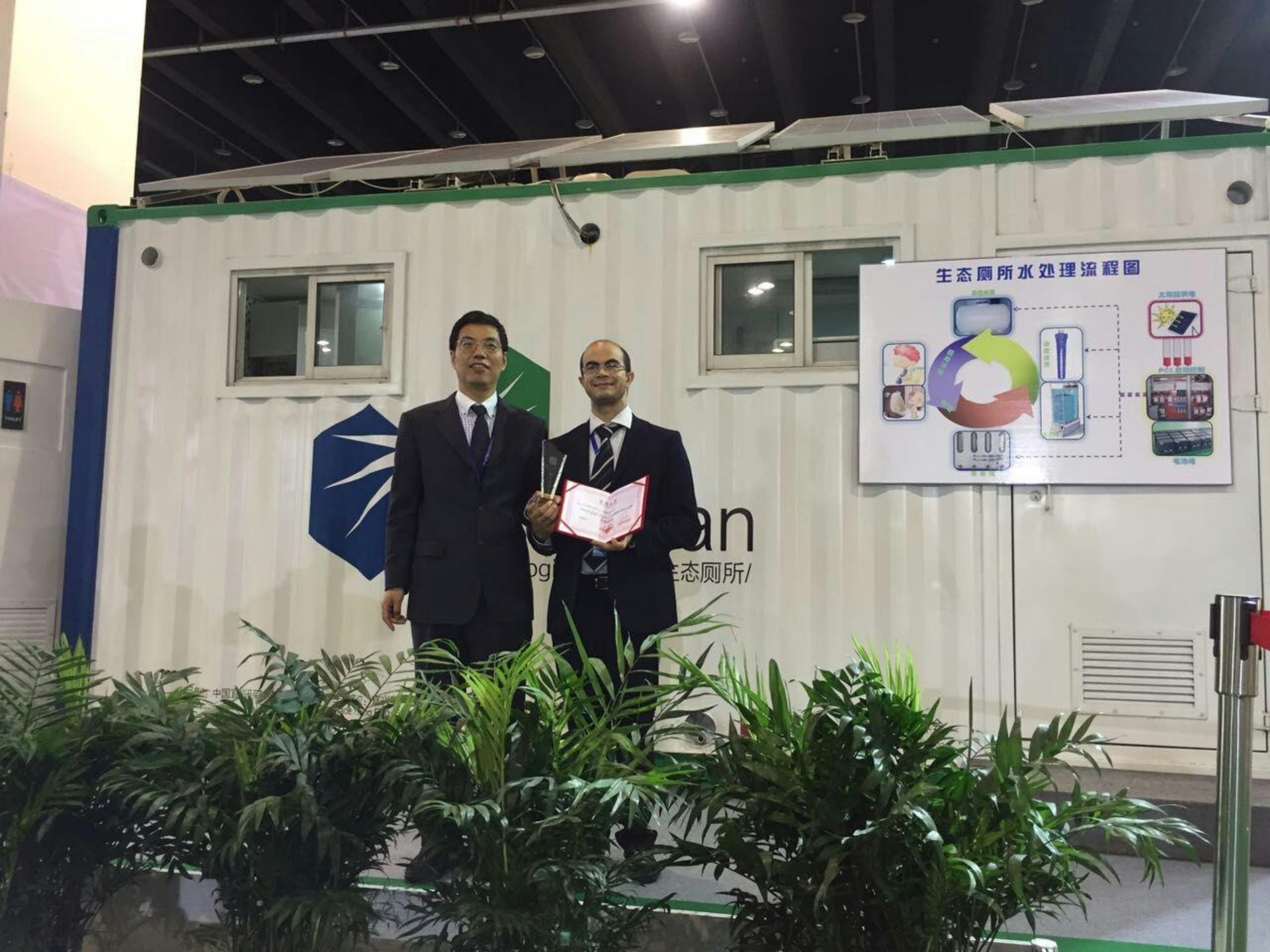


Caltech-Eco-San Toilets
Introduction to South Africa 2017
East Cape District


生态厕所水处理流程图

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Cho, K.; Hoffmann, M. R., $Bi_xTi_{1-x}O_z$ Functionalized Hetero-junction Anode with an Enhanced Reactive Chlorine Generation Efficiency in Dilute Aqueous Solutions. *Chem. Mat.* **2015,** *27*, 2224-2233.

Acknowledgements

Caltech Researchers: Clement Cid, Qu Yan, Kangwoo Cho, TK Lee, Daejung Kwon, Su Young Ryu, Yang Yang, Justin Jasper, Cody Finke, Asghar Aryanfar, John Naviaux, Xing Xie, Nina Bahnemann, Eric Huang, Siwen Wang, Jieun Shin, Xunyi Wu, Yanzhe Zhu, Laleh Kasmaee, Zara Chikneyan, Janet Kesselman, Chad Vecitis, Hyunwoong Park, Jina Choi, Oleh Weres, Michael Luettgen, Eco-San and Kohler.

Bill & Melinda Gates Foundation
Disney Family Foundation
Vodafone Foundation
Resnick Sustainability Institute
Eco-San, Yixing, China