- *What is the role of biofilms in the urban water cycle ?*
- *What is the impact of biofilms ?*
- *What can be done to improve detection & water treatment quality ?*

WELCOME

Biofilms in the Urban Water Cycle

20 August 2020, Thursday, 10:00am – 11:00am

SWA
SINGAPORE WATER ASSOCIATION

SCELSE
Singapore Centre for Environmental Life Sciences Engineering

Singapore National BIOFILM Consortium

Housekeeping

- ✓ To ensure a smooth webinar, please mute your microphone and turn off the camera. You may communicate with us after the webinar.
- ✓ Please share your questions in the chat where we will try to provide answers where possible in the Q & A Segment.
- ✓ Do identify yourself so we can respond to any unanswered questions after the webinar
- ✓ We will be recording this webinar session and reserve the rights to the video
- ✓ Please complete a post event survey which upon return, we will forward the recording and presentation deck to the respondents.

Disclaimer

- All information in this webinar is for general information only and does not contain or convey any legal advice or administrative assistance.
- Information shared today is true and accurate as of publication date.
- SWA and SNBC reserve all rights in the provided materials

Prof Staffan Kjelleberg
Centre Director, Singapore Centre for Environmental Life Sciences Engineering (SCELSE)
Director, Singapore National Biofilm Consortium (SNBC)

As SCELSE's centre director, Prof. Staffan Kjelleberg promotes interdisciplinary research that focuses on overall community structure, function and performance of microbial biofilms as well as mechanisms behind their communication and micro-ecological interactions. Commonalities in biofilm biology underpin this research. He brings together complementary top-down meta-omics/systems biology and bottom-up biofilm mechanism approaches, with translational outcomes in biotechnology and environmental/public health domains. Prof. Kjelleberg also leads SNBC, a technology consortium, that aims to foster significant interactions and close collaborations among IHLs, research institutes, government agencies and industry, from startups to MNCs in Singapore, to enable technology translation and deliver economic impact.

Dr Law Yingyu
Program Manager, Singapore National Biofilm Consortium (SNBC)

Ying joined the Singapore National Biofilm Consortium in September 2019. She started her Scientific career as a Research Fellow and later Senior Research Fellow at SCELSE since 2012. She has had experience in providing technical and regulatory solutions to water utilities and building collaborations both in Australia and in Singapore, during and after her PhD. She is also part of the International Water Association Nutrient Removal and Recovery Management Committee. She has worked with colleagues across different disciplines in SCELSE and have also provided consulting service to local startup in bioprocess and systems biological aspects of environmental biotechnologies and associated complex ecosystems. Ying holds a BSc Honours in Biotechnology from Murdoch University, and PhD in Chemical Engineering from The University of Queensland.

Dr Amit Kumar
Cofounder & CEO, Biopsin Pte Ltd

As a co-founder and director, Amit is responsible for leading business communication, strategy and innovation at BIOPSIN. Prior to this, he was working at Nanyang Technological University, Singapore on a PUB funded multidisciplinary project to understand and improve the safety and quality of surface water stored in underground rock caverns. As a Research Fellow at National University of Singapore, he led an A*STAR funded project to mitigate food spoilage by improving microbiological quality of food. Amit holds a PhD in Chemical & Biomolecular Engineering from National University of Singapore and has over a decade of experience working with industries and Government agencies on their microbial safety and detection needs.

.

Mr Andy Wirjawan
Director, United Water Technologies Pte Ltd

Andy has more than 23-years of professional experience in water and wastewater treatment industry. He started his career with GE Water & Infrastructure Inc. in Australia and Singapore, and later on established United Water Technologies Pte Ltd – Singapore in 2005. He has completed various process design improvement projects, and has overseen construction of numerous industrial and municipal scale water and wastewater treatment plants in a number of APAC countries. He holds B.Eng. Chemical Engineering (Hons) from Curtin University, and MBA from University of Western Australia.

Programme

- *What is the role of biofilms in the urban water cycle ?*
- *What is the impact of biofilms ?*
- *What can be done to improve detection & water treatment quality ?*

Time	Agenda	Presented by
10.00 – 10.02 am	**Opening & Housekeeping**	**SWA**
10.02 – 10.10 am	**Welcome address**	**Mr Charles Quek** Vice-President (Finance), SWA
10.10 – 10.20 am	**Introduction to SCELSE and SNBC**	**Prof Staffan Kjelleberg** Centre Director (SCELSE) & Director (SNBC)
10.20 – 10.35 am	**Role of biofilms in the overall urban water cycle**	**Dr Law Yingyu** Program Manager (SNBC)
10.35 – 10.45 am	**Rapid and Gold-standard Pathogen Detection**	**Dr Amit Kumar** Co-founder & CEO (Biopsin)
10.45 – 10.55 am	**Biofilm sensors and real-time application & benefits for water treatment.**	**Mr Andy Wirjawan** Director (United Water Technologies)
10.55 – 11.00 am	**Q & A and Closing**	**SWA**

Welcome Address

SWA Webinar : Biofilms in the Urban Water Cycle

20 August 2020

Mr Charles Quek

Singapore Water Association

Vice-President (Finance)

CEO, HSL Constructor Pte Ltd

SWA Initiatives

Since April 2020

SWAtch !

SWAssist

SG United Updates

SWA *Marketplace Assist Platform* (SWA-MAP)

Introduction to SCELSE and SNBC

Prof Staffan Kjelleberg
Centre Director, Singapore Centre for Environmental Life Sciences Engineering (SCELSE)
Director, Singapore National Biofilm Consortium (SNBC)

SINGAPORE WATER ASSOCIATION

SCELSE
Singapore Centre for Environmental Life Sciences Engineering

Singapore National BIOFILM Consortium

SCELSE

Singapore Centre for Environmental Life Sciences Engineering

A biofilm and microbiome Research Centre of Excellence

SCELSE's Mission

To discover, control and direct the behaviour of microbial biofilm communities and microbiomes for sustainable environmental, engineering, public health and medical applications.

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

NUS National University of Singapore

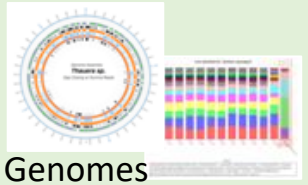
NATIONAL RESEARCH FOUNDATION
PRIME MINISTER'S OFFICE
SINGAPORE

Ministry of Education
SINGAPORE

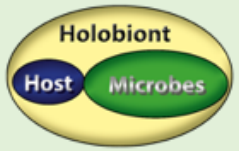
SCELSE's research approach & clusters

Meta-'omics & Microbiomes

Metagenomics
metatranscriptomics



Genomes



Holobionts &
Microbiomes

Environmental Engineering

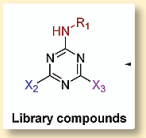
Used water
treatment

Urban
waterways

Bioreactor
ecology

Public Health & Medical Biofilms

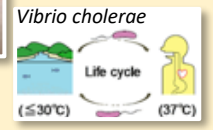
In vivo
models



Chemical
biology

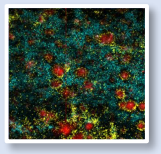
Chronic
disease

Pathogen
life history



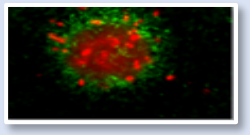
Microbial Biofilms

Multispecies
communities

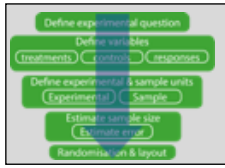


Matrix

Mechanisms

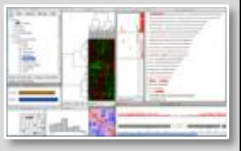


Integrative Analysis Unit



Experimental
design

Data handling
& analysis



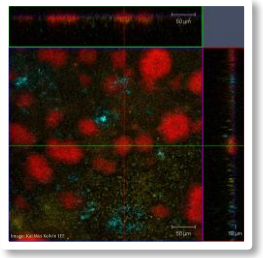
SCELSE Integrated Research Themes (SIRTs)

Urban Water Cycle

Air
Microbiomes

Marine Biofilms &
Microbiomes

Host
Microbiome
Interactions



Experimental
Biofilm
Communities

Biofilm Matrix

SIRTS emerge from cluster-based research and align well with the development of research priorities in Singapore.

SCELSE's catalytic role in Singapore

Clinical

Singapore General Hospital
SingHealth

NUH
National University Hospital

Tan Tock Seng Hospital

Changi General Hospital

National Neuroscience Institute
SingHealth

Singapore Eye Research Institute

Agencies & Institutions

Housing & Development Board

Agency for Science, Technology and Research
Singapore

SMART CAMP
Critical Analytics for Manufacturing Personalized Medicine

Singapore Food Agency

AMR

National Parks

PUB Singapore's National Water Agency

SinBerBEST

ehi Environmental Health Institute

An Institute of
National Environment Agency
Safeguard · Nurture · Cherish

National Centre for Infectious Diseases

Industry

P&G

mundipharma

ZEISS

PACBIO

L'ORÉAL

Danone Nutricia

Leica

Swift Biosciences

DHI

Ferrero

Roche

illumina

ExxonMobil
Energy lives here

Agilent Technologies

kikkoman

Oxford Nanopore Technologies

mr bean
life's simple pleasures

Verti Vegies

Apollo Marine

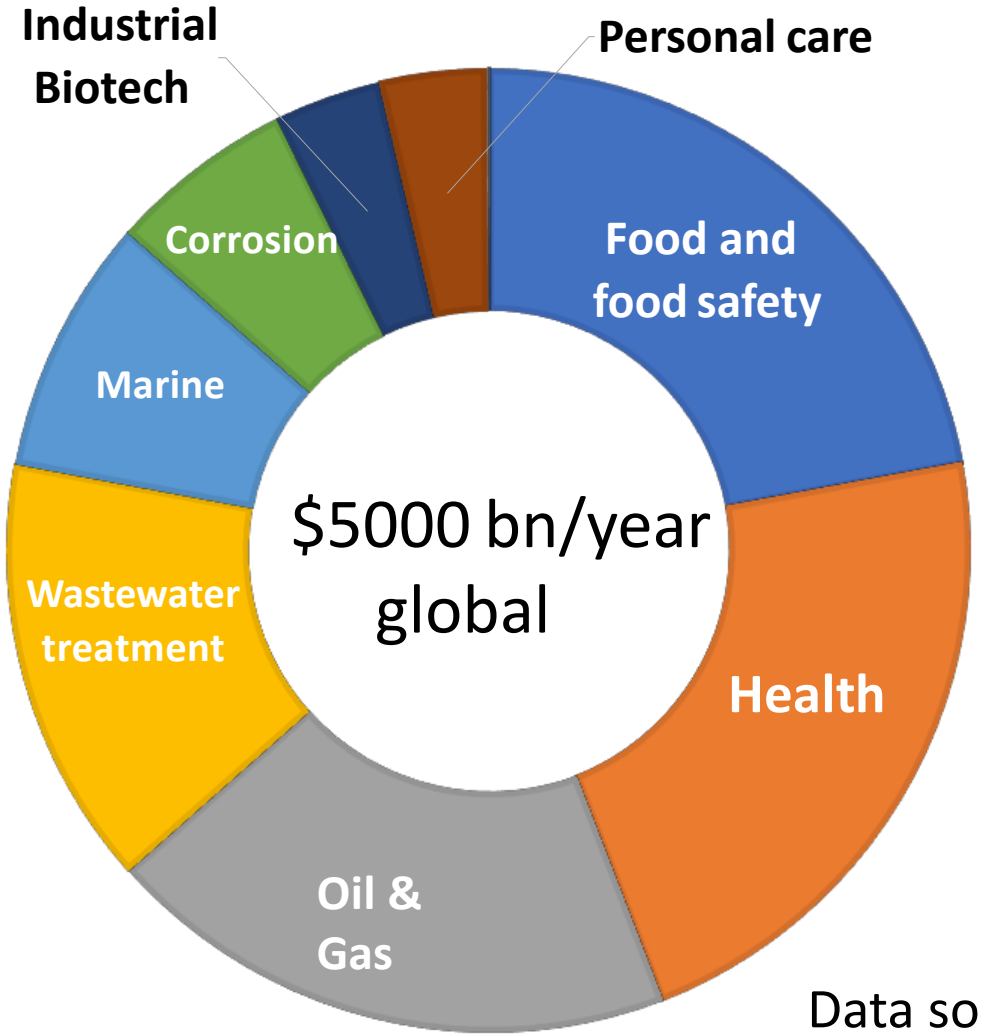
SGS

Hitachi

SINGAPORE NATIONAL BIOFILM CONSORTIUM (SNBC)

National Research Foundation technology consortium, established Feb 2019

Biofilms & microbiomes: Market sectors



- **CF respiratory biofilm infections** biofilm burden: $3.99bn/p.a. globally (UK £330m)
- **Marine Shipping:** Biofilm fouling burden global $ 5.7bn/p.a.
- **Biorefining** e.g. bioethanol, global $38bn, UK £390m
- **UTI infections**: Biofilms cause an estimated global cost of $ 3.9bn/p.a.
- **Food poisoning**: Estimated global burden due to biofilms $315 bn/p.a.

Data source: NBIC
(NBIC-SCELSE MOU 2019)

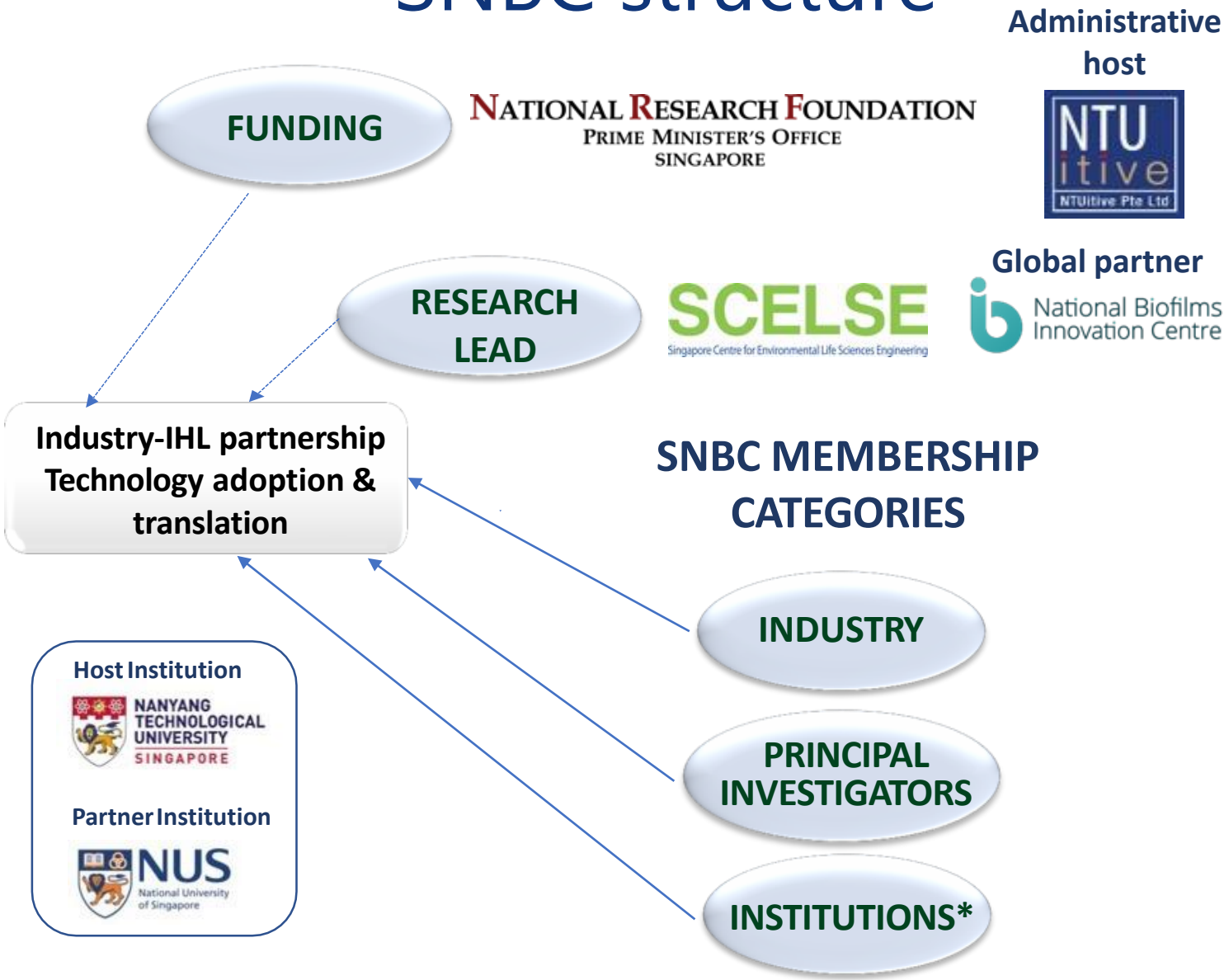
Singapore National BIOFILM Consortium

Mission & vision

To **foster significant interactions and close collaborations** among IHLs, research institutes, government agencies and industry in Singapore.

Leveraging the **multidisciplinary expertise at SCELSE and beyond** to effectively deliver scientific and translational outcomes.

SNBC structure



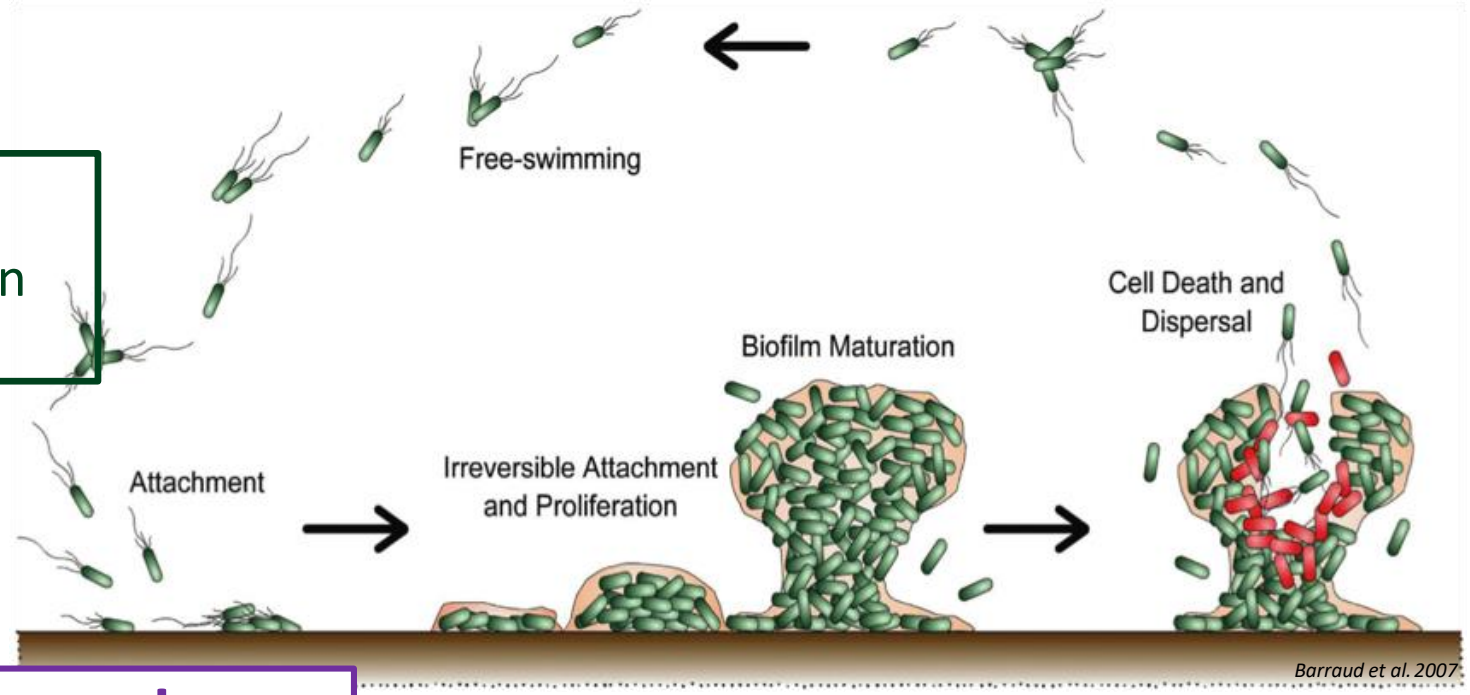
* agencies, research centres, associations, platforms etc

Singapore National BIOFILM Consortium

Collaboration focus areas

Microbiome Engineering

- Manipulation or establishment of bacterial communities for functional applications



Environmental Monitoring

- Biofilm based real-time detection sensors

Assessment Framework: Tools & Technologies

- High-resolution assessment of microbiomes.

Clean Surface Technology

- Design surfaces that can disrupt or augment bacterial colonisation.

Singapore National BIOFILM Consortium

Governance & organisation

Steering Committee

Technology Management Committee

Industry Advisory Board

SNBC Program Office @ NTUitive and SCELSE

Chair
Prof Staffan Kjelleberg
Lead PI/Consortium Director

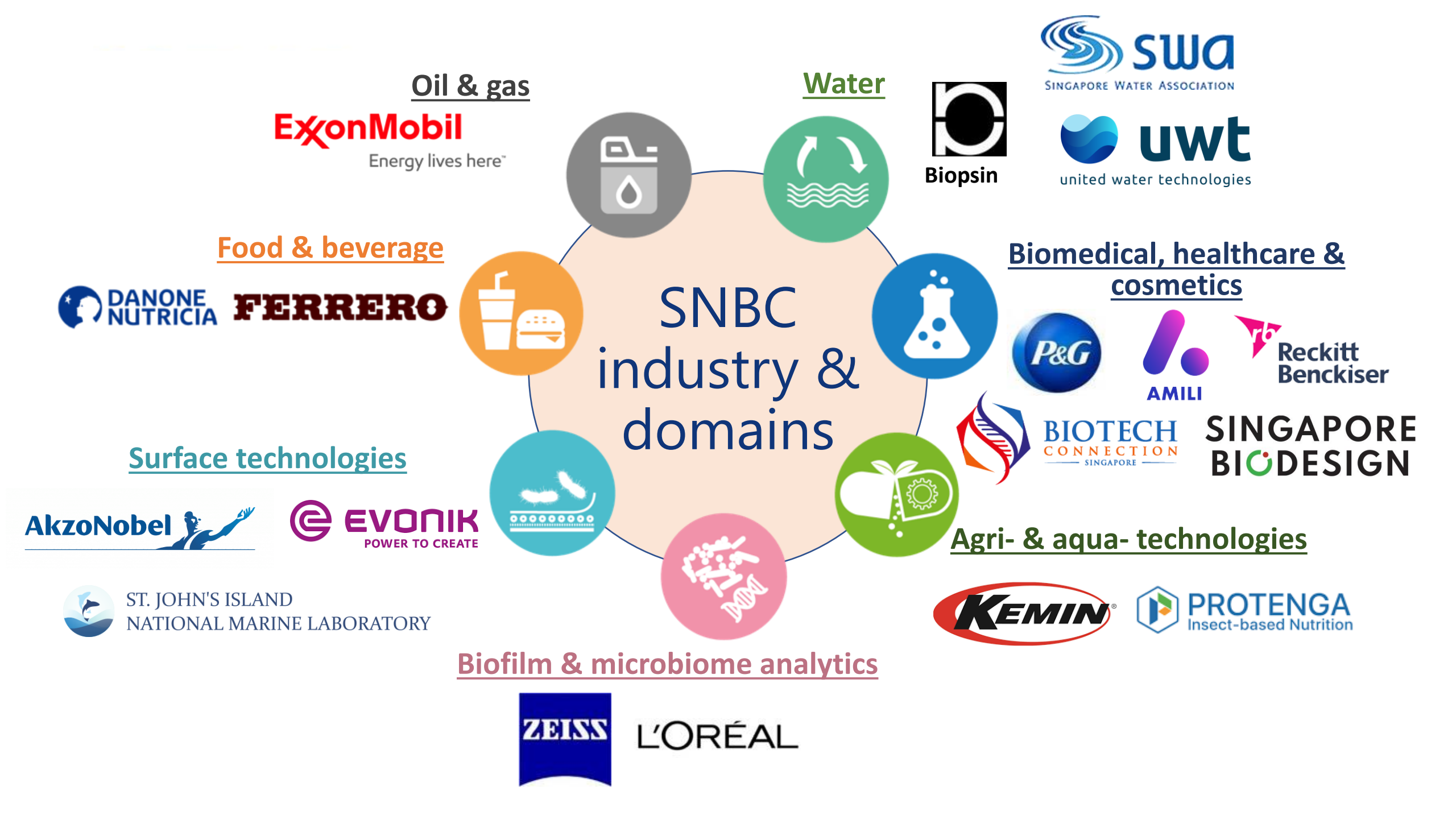
Industry liaison officers for key topics:

- High throughput sequencing
- Microscopy imaging
- Bioprocess engineering
- Surface technologies
- Plant & soil microbiome
- Urban & built environment
- Human microbiomes

Michel Birnbaum
Business Development

Yingyu Law
Program Manager, NTUitive

Smitha Sunildeep
Manager, SCELSE


Oil & gas
ExxonMobil
Energy lives here
Water
Biopsin
SWA
Singapore Water Association
uwt
united water technologies
Food & beverage
DANONE NUTRICIA
FERRERO
Biomedical, healthcare & cosmetics
P&G
AMILI
Reckitt Benckiser
BIOTECH CONNECTION SINGAPORE
SINGAPORE BIODESIGN
SNBC industry & domains
Surface technologies
AkzoNobel
EVONIK
POWER TO CREATE
Agri- & aqua- technologies
KEMIN
PROTENGA
Insect-based Nutrition
ST. JOHN'S ISLAND
NATIONAL MARINE LABORATORY
Biofilm & microbiome analytics
ZEISS
L'ORÉAL

SNBC membership support and activities

Funding

- Seed funding
- Collaborative grants

Expertise

- Technical expertise and consultancy

Facilities & resources

- World class facilities and equipment
- Library e-resources

Cutting-edge know-how

- Tailored courses, seminars and workshops by local and international expert instructors

International collaboration

- Global biofilm R&D academic and industry networks

SNBC access to international biofilm network

SCELSE, Singapore

National Biofilms Innovation Centre, UK

Costerton Biofilm Centre, Denmark

Center for Biofilm Engineering, USA

Role of biofilms in the overall Urban Water Cycle

Dr Law Yingyu
Program Manager, Singapore National Biofilm Consortium (SNBC)

SINGAPORE WATER ASSOCIATION

Singapore Centre for Environmental Life Sciences Engineering

Singapore National BIOFILM Consortium

Role of biofilms in the overall urban water cycle

Yingyu Law, SNBC Program Manager

SNBC-SWA Joint Webinar

20th August 2020

Singapore National BIOFILM Consortium

Fostering Synergistic Interactions **Enabling** Technology Translation

What are Biofilms?

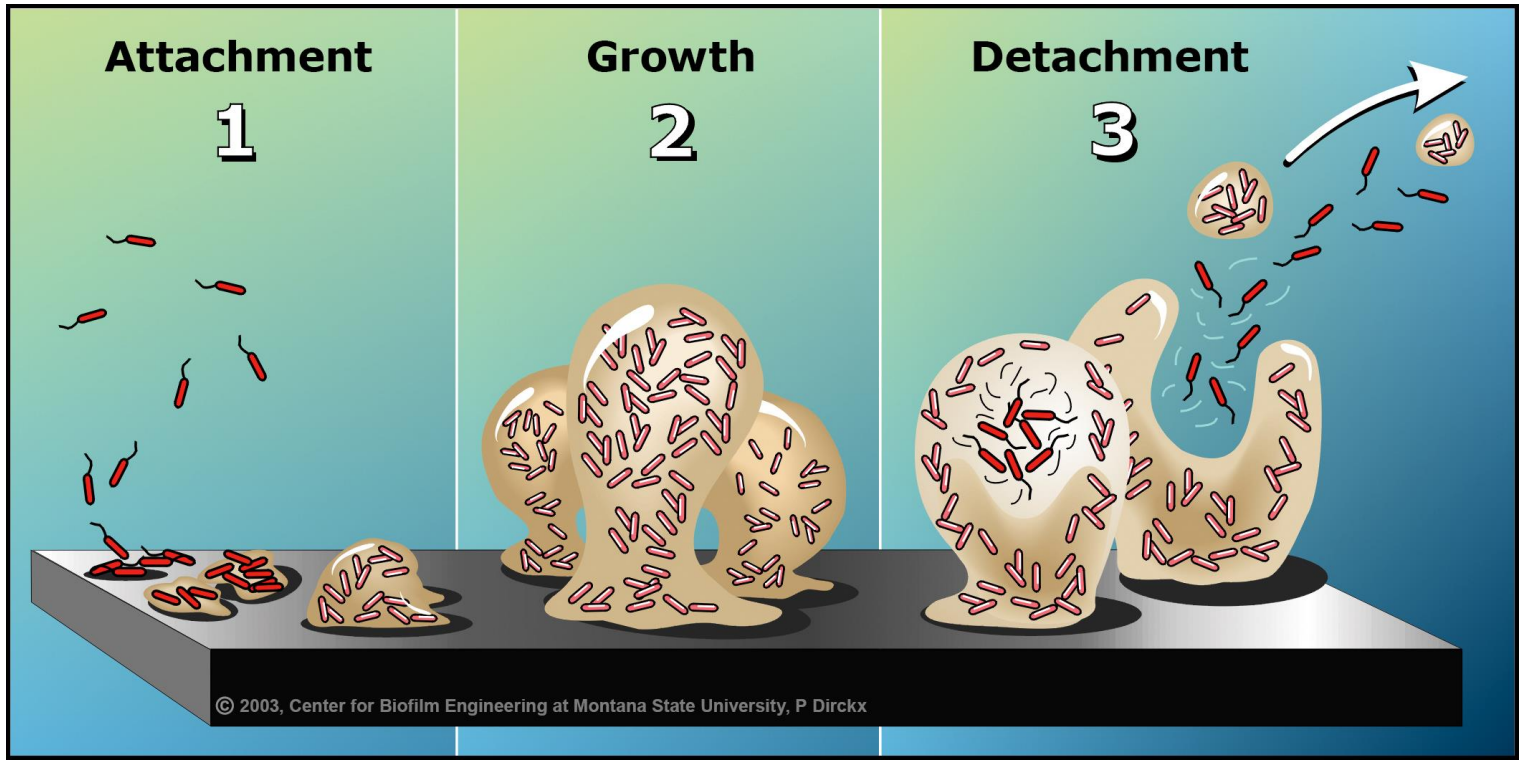


Fig. Biofilm life cycle (CBE Montana State Uni).

In natural systems

Fig. Jiuzhai Valley National Park

On engineered/ man-made structure

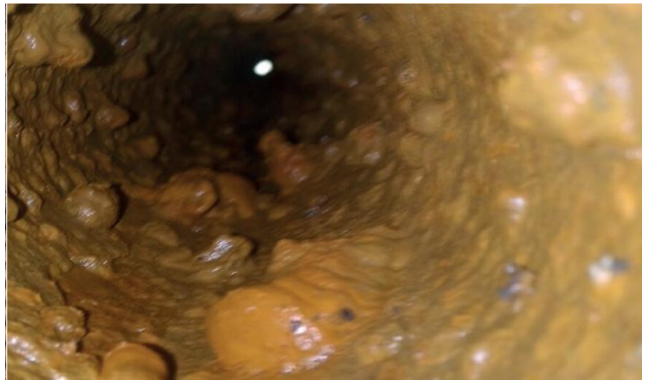
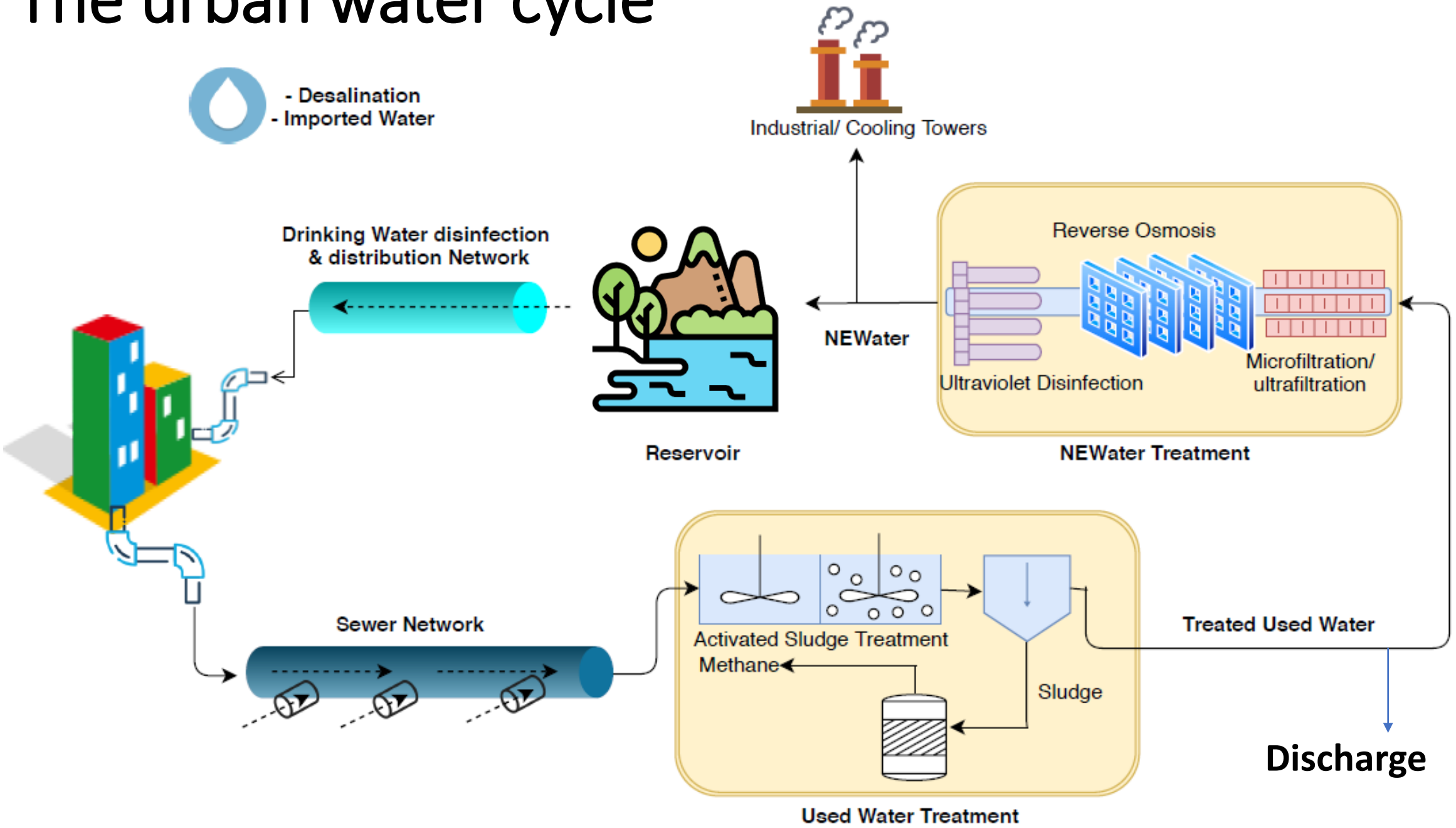


Fig. Metal Biocorrosion of a Water Well (Calbo et al., 2017)

Health & the human body

Fig. Dental plaque buildup on the surface of teeth. (Image: © Lighthunter | Shutterstock)

The urban water cycle



Biofilm causing odour and corrosion in concrete sewer systems

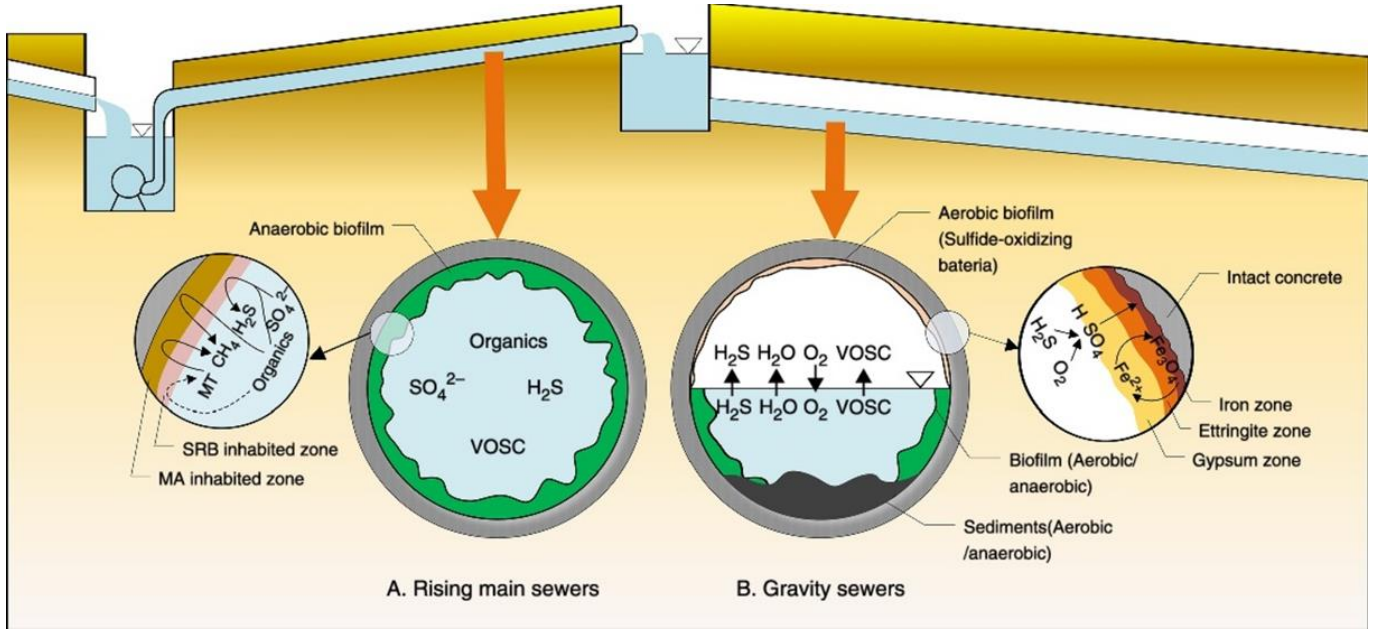


Fig. Sewer network corrosion mechanism. Jiang et al. 2019

Fig. Corroded sewer pipes.

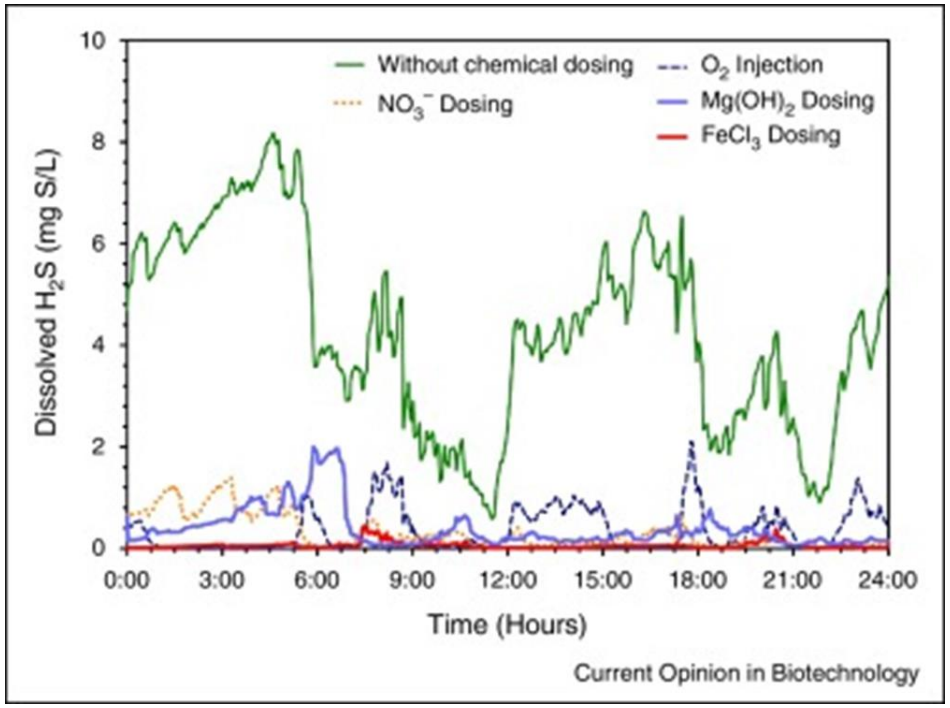


Fig. Chemical dosing for corrosion control.

Biofouling of membranes for water & used water treatment

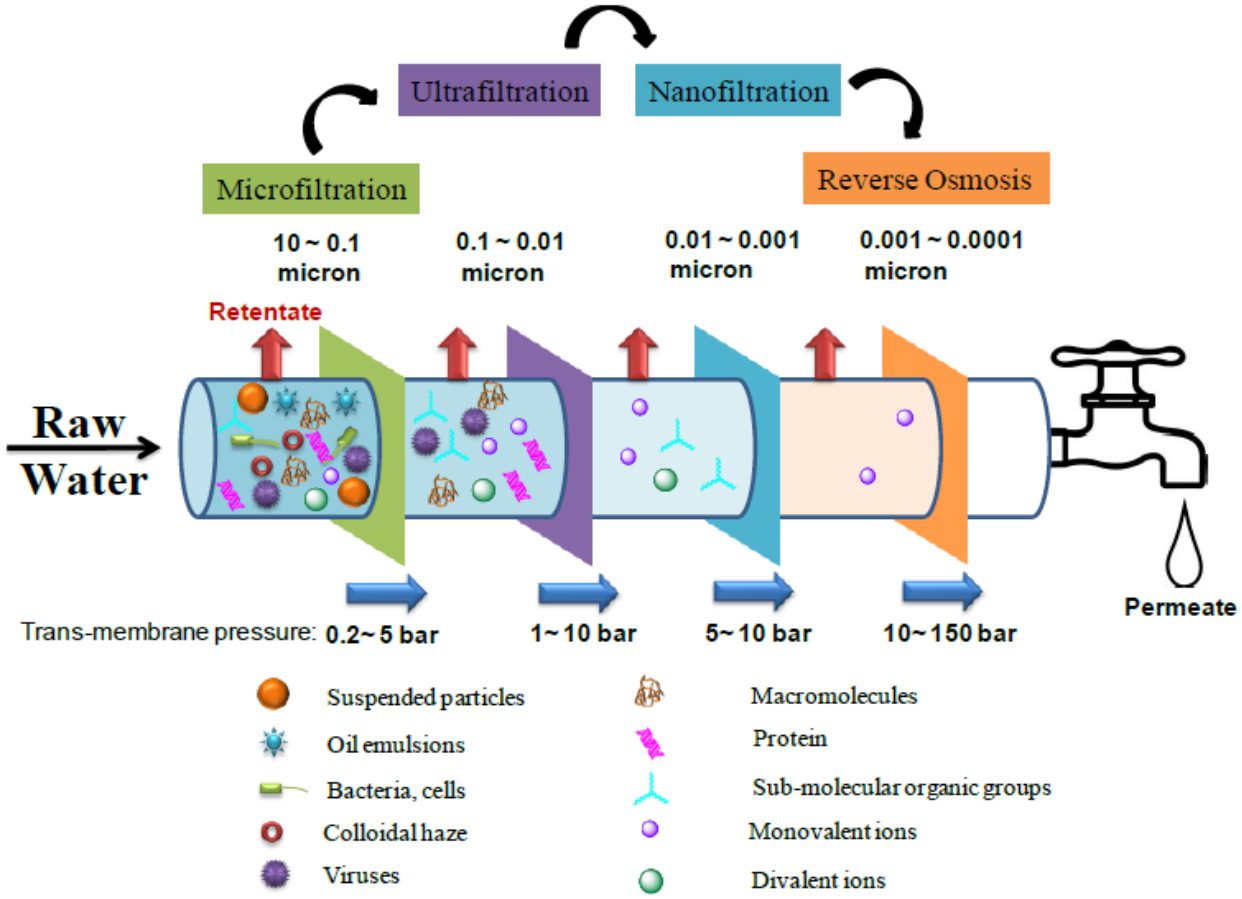


Fig. Pressure-driven membrane processes for water treatment (Liao et al., 2018).

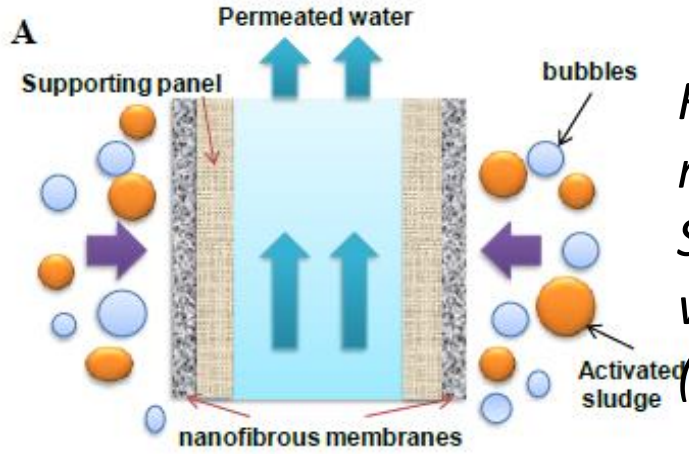
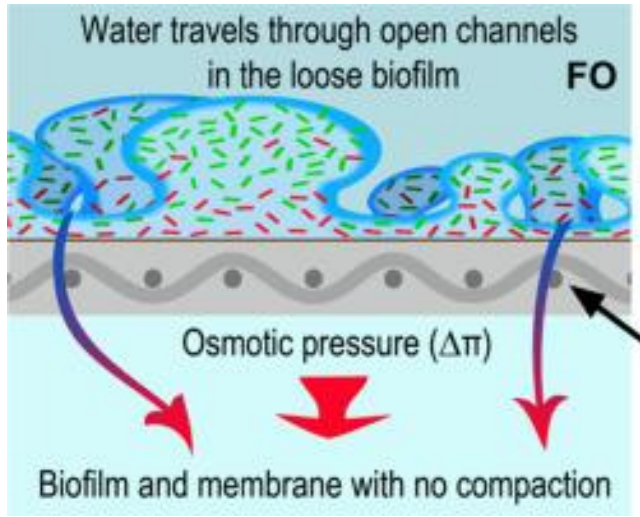
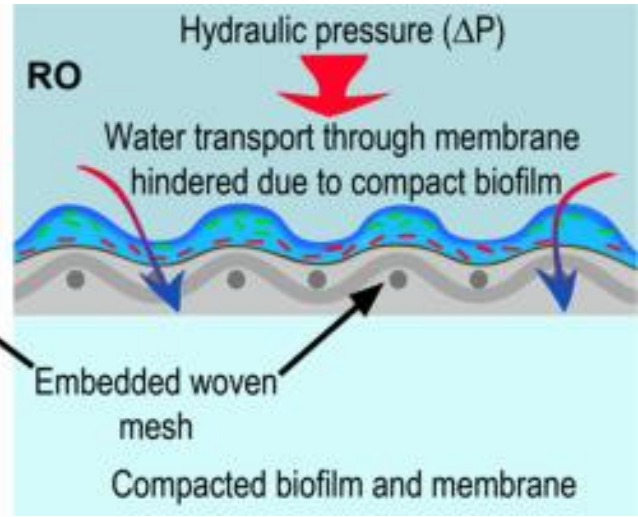
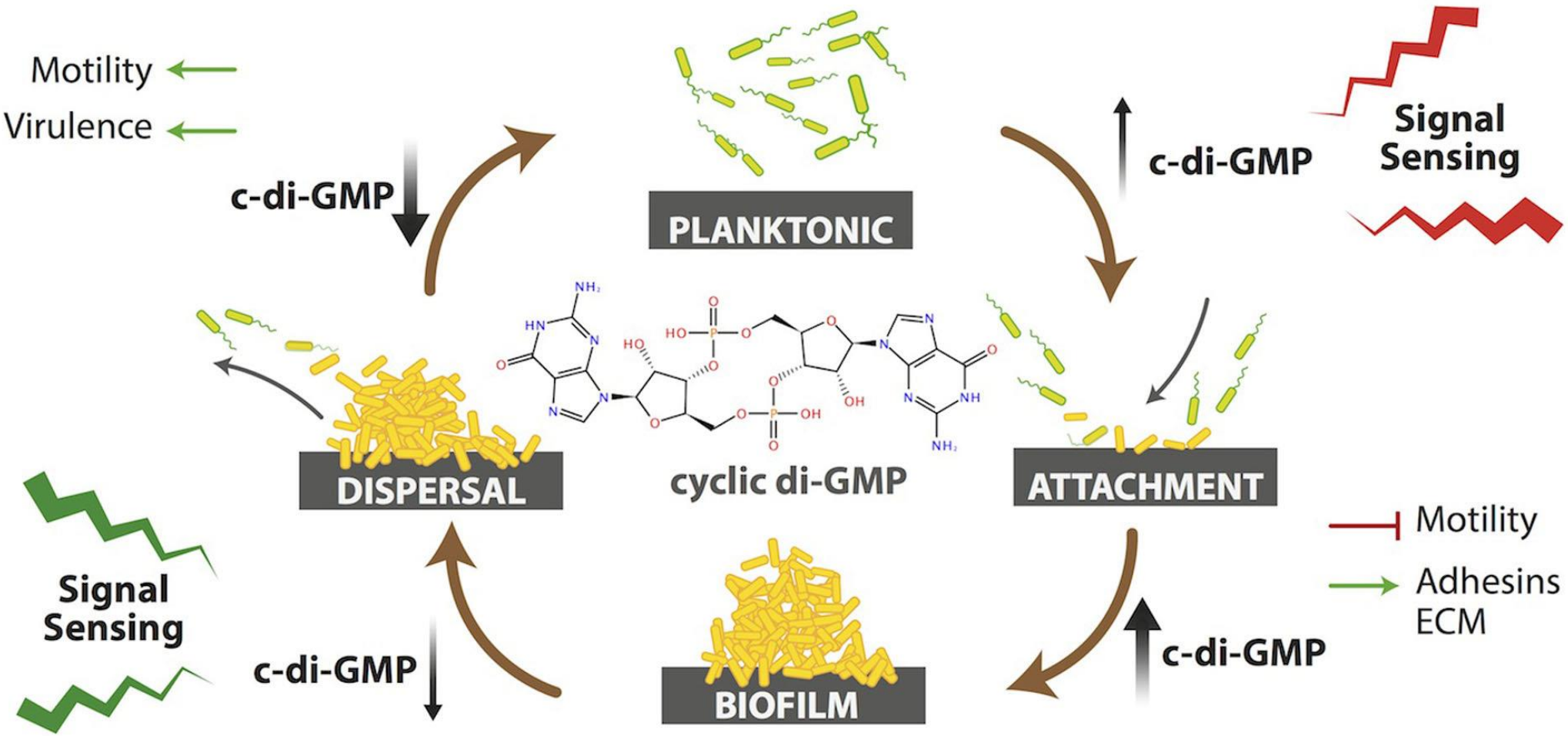


Fig. Schematic of a membrane bioreactor for Sludge separation in used water treatment system (Liao et al., 2018)





Controlling biofouling through the understanding of cell signalling



Rinaldo et al. 2018

Biofouling control in reverse osmosis by nitric oxide treatment

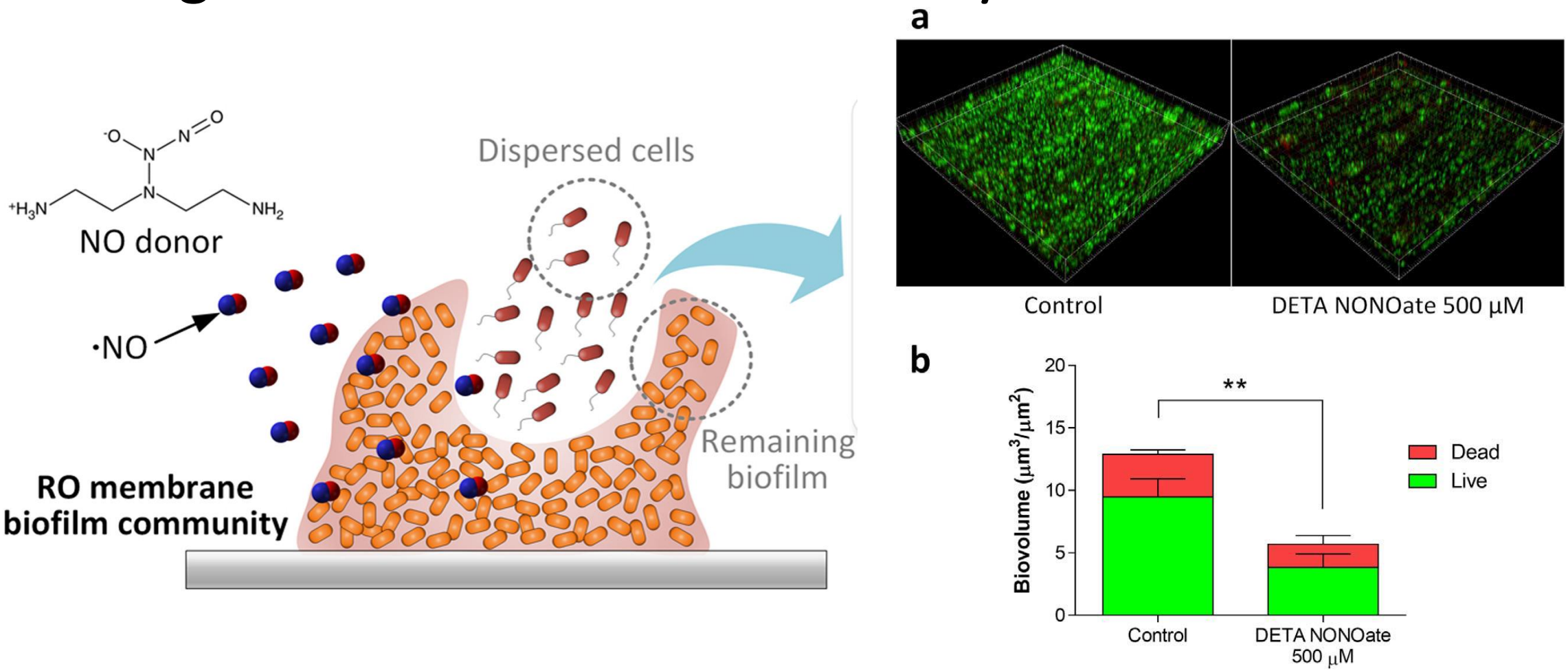
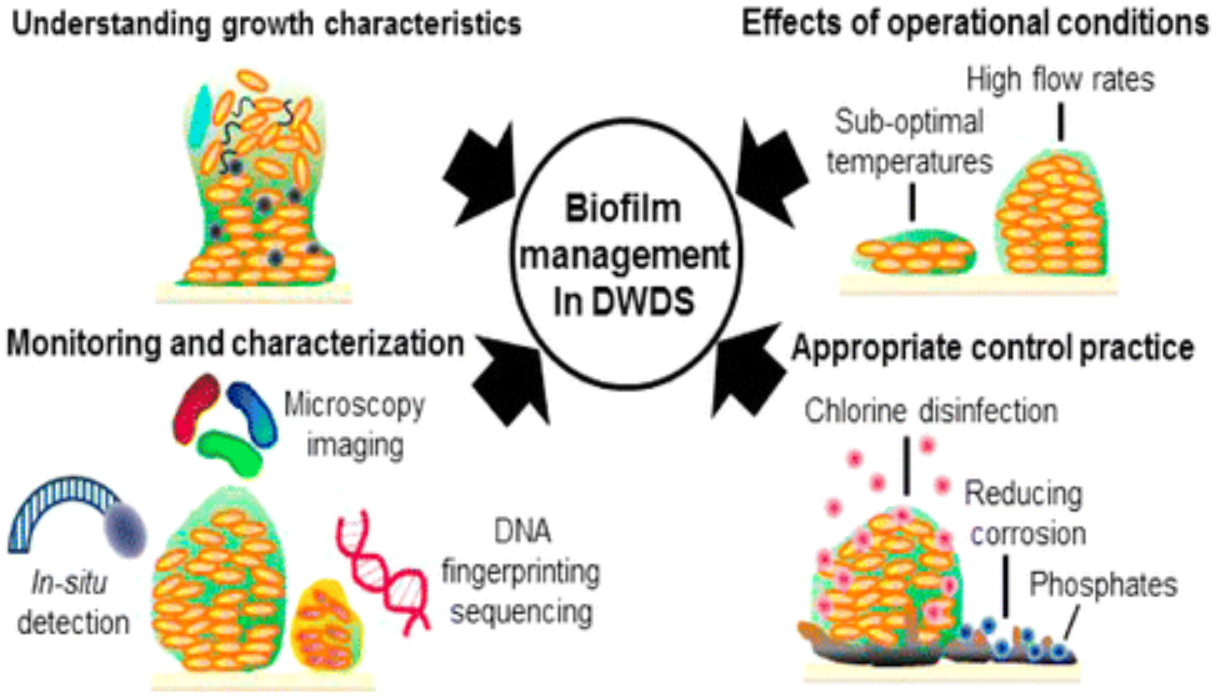


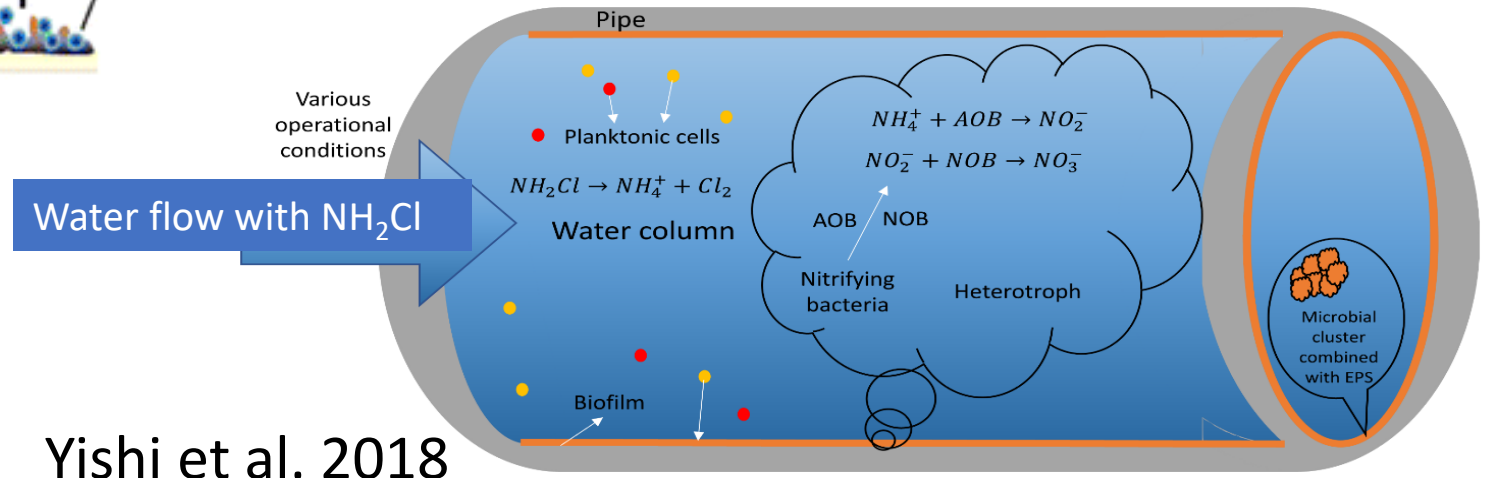
Fig. Autopsy of biofouled membranes. (a) CLSM images of the biofouled membranes. Image size: 424.27 × 424.27 µm. (b) Biovolume of live and dead cells on the biofouled membrane (Oh et al., 2018).

Biofilm in drinking water distribution system



Liu et al. 2016

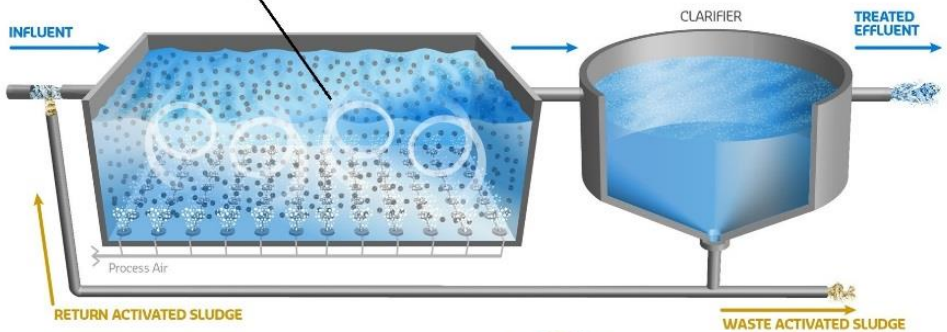
Fig. Biofilm growth in drinking water pipes



Yishi et al. 2018

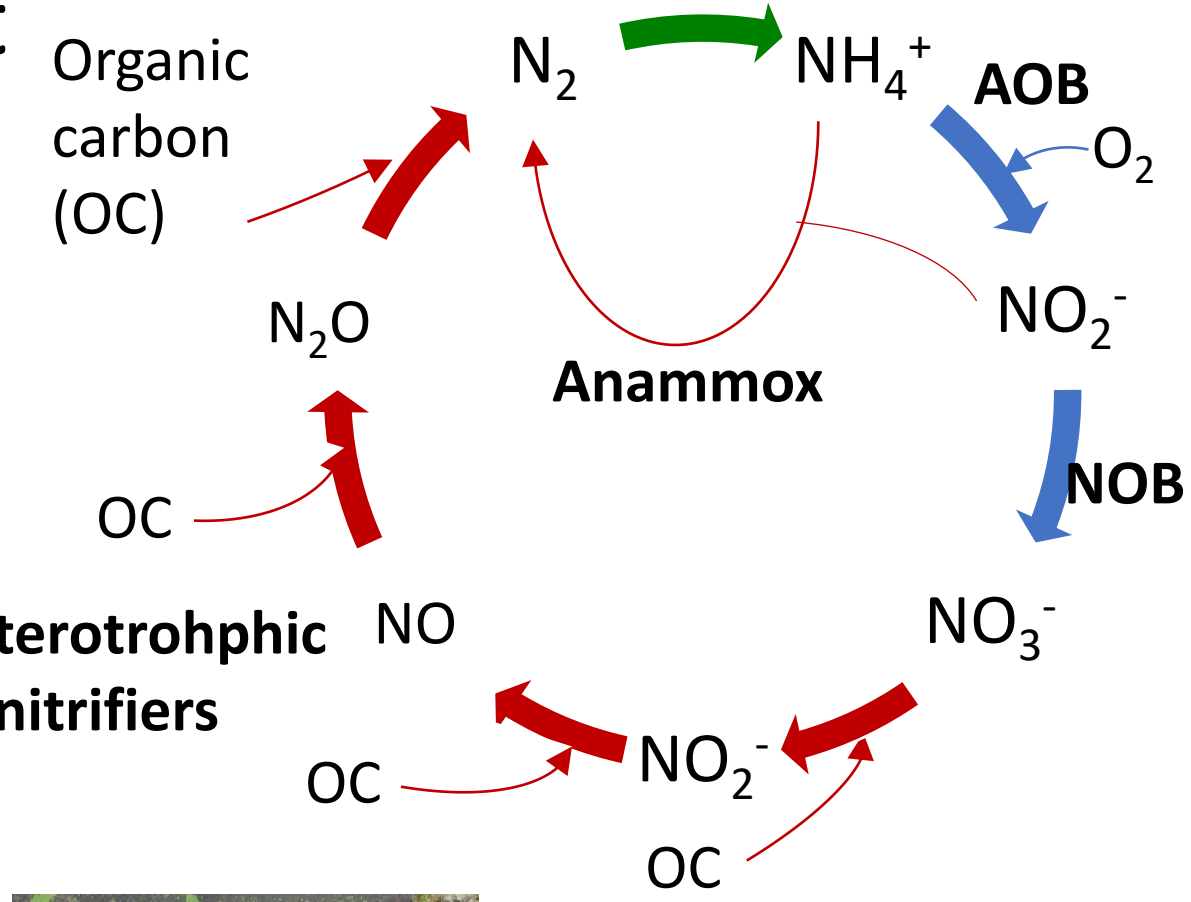
Biofilm for used water treatment

Moving Bed Bioreactors (MBBR)



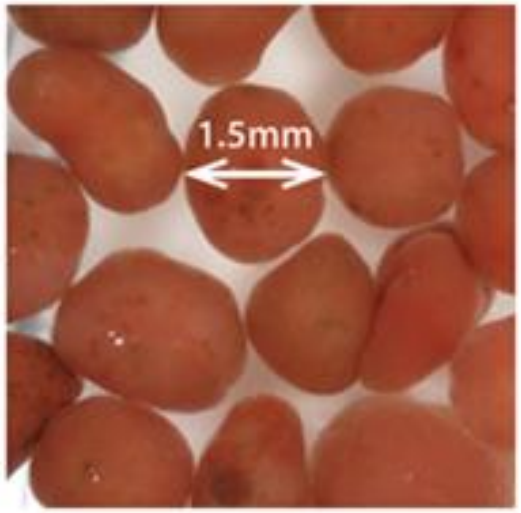
Discharge/ NEWater treatment

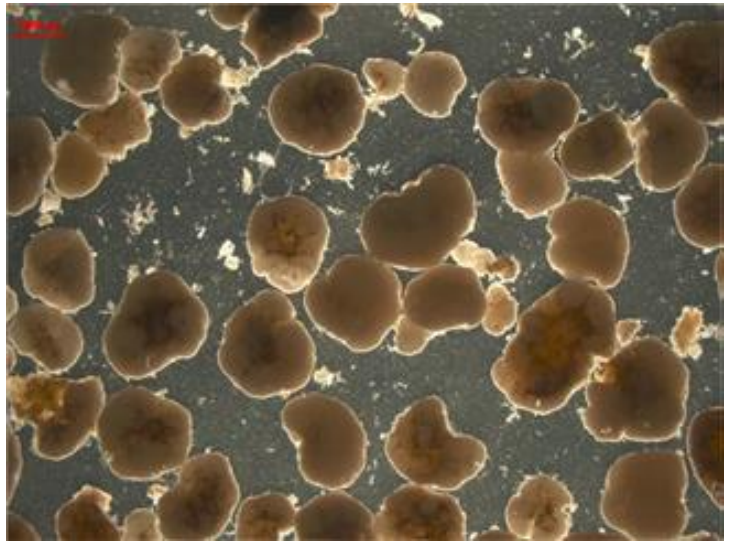
Different types of packing material

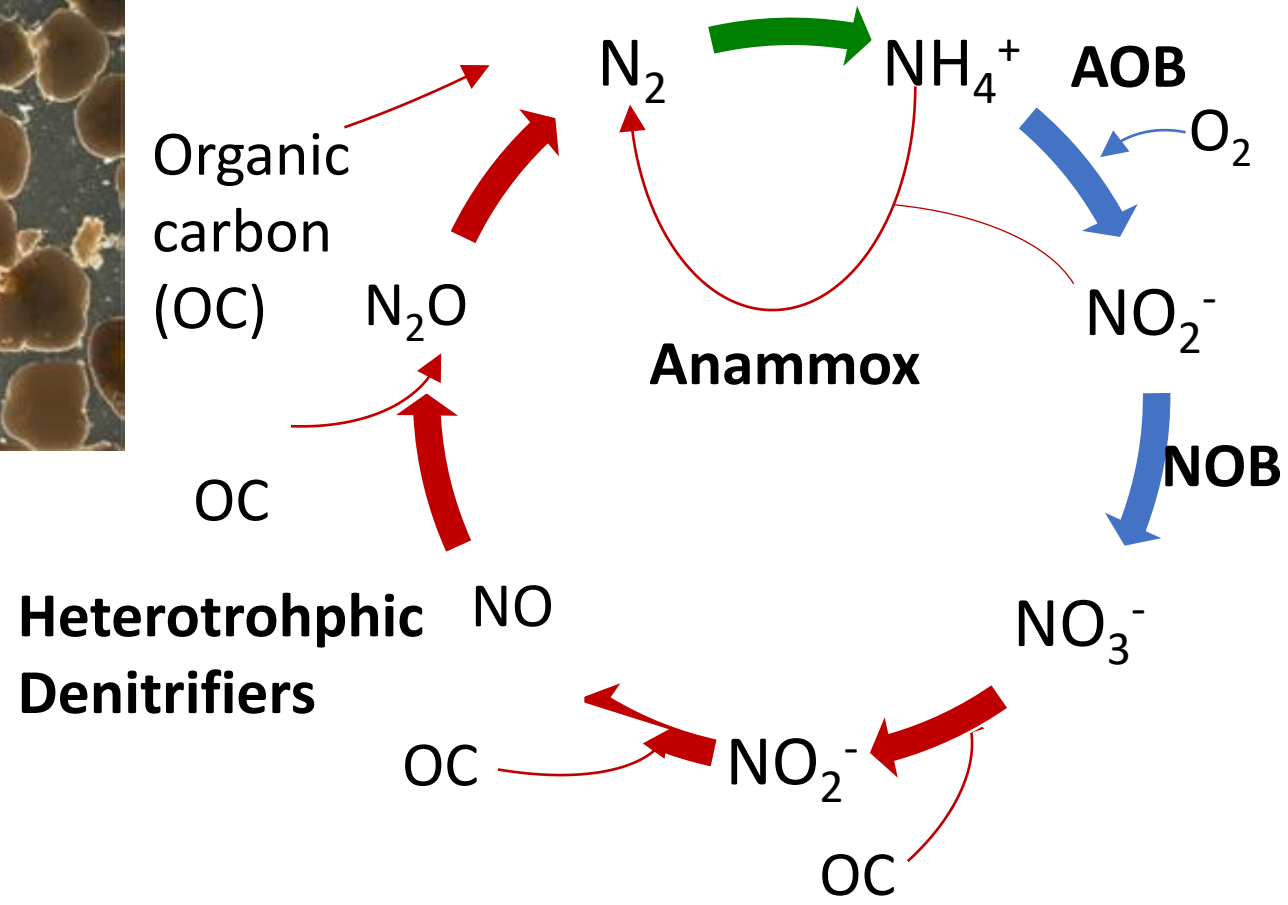


Eutrophication (Rinkesh, 2020)

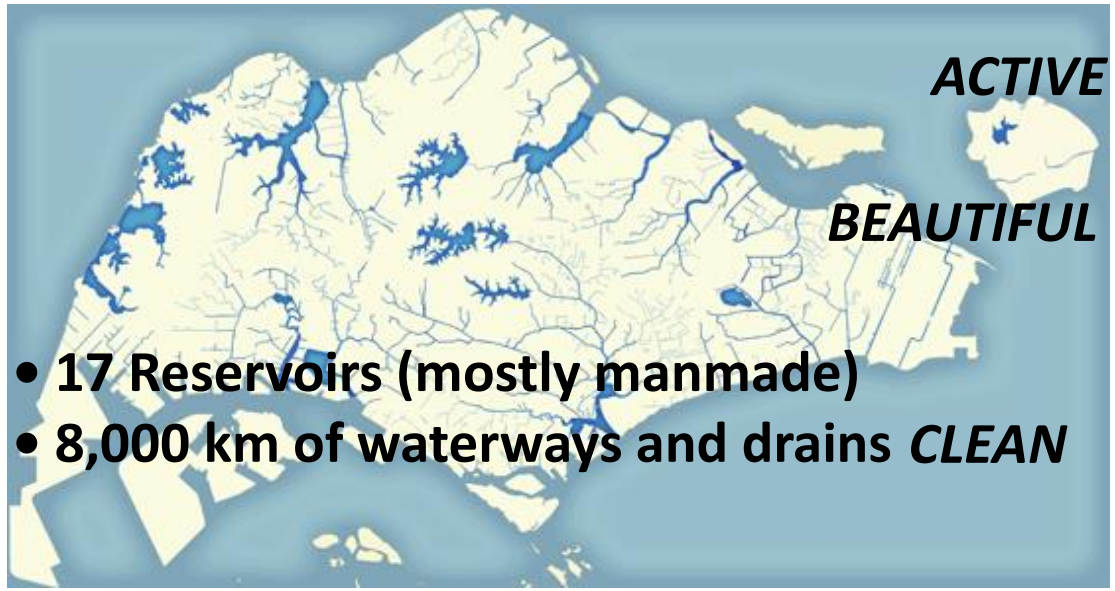
Biofilm for used water treatment



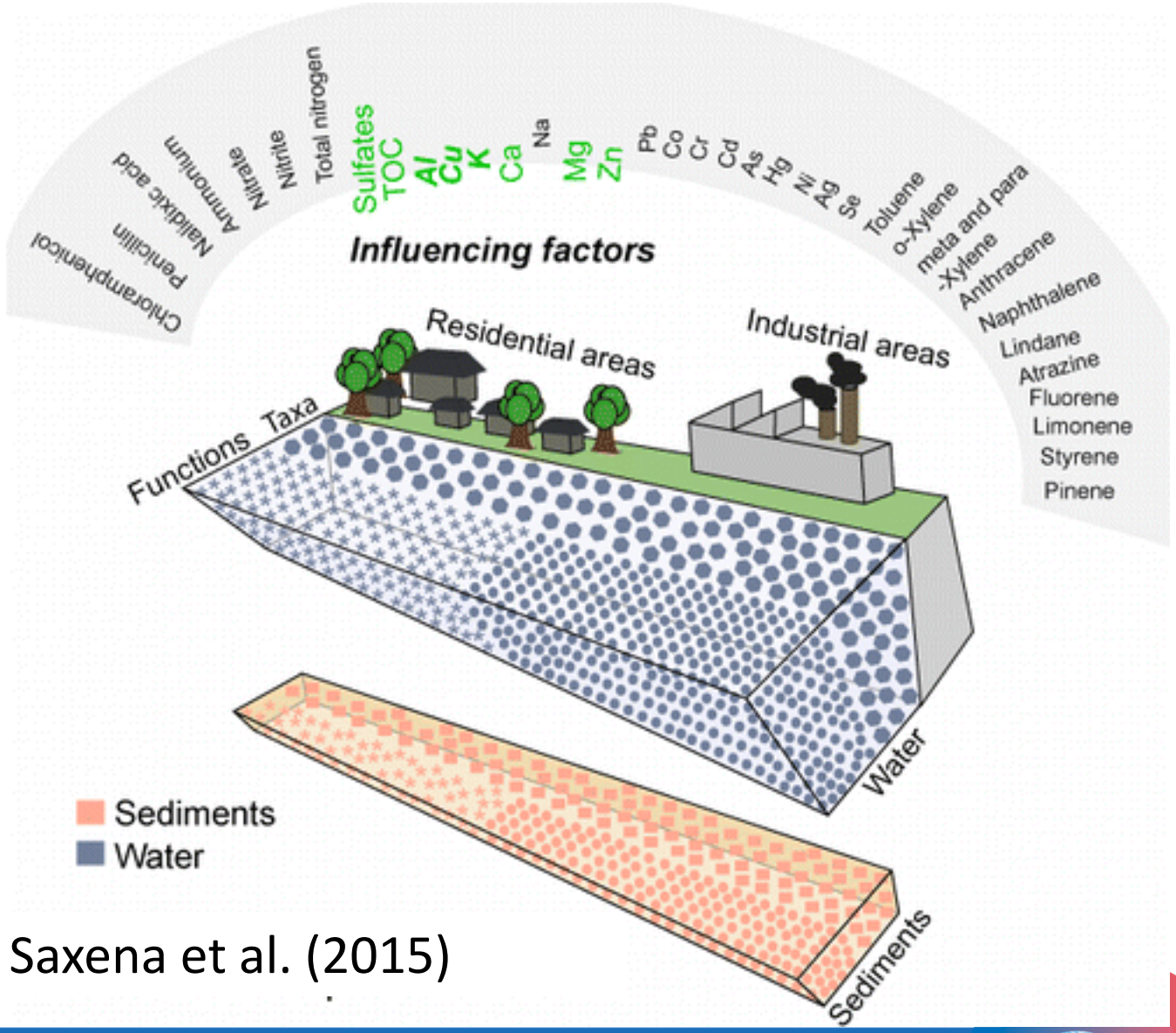




Understanding Microbial Communities in the Waterways



- 17 Reservoirs (mostly manmade)
- 8,000 km of waterways and drains *CLEAN*



Saxena et al. (2015)

Conclusion

Biofilms can be detrimental to some processes but can also be manipulated or optimized for biotechnological applications.

Contact us:

yylaw@ntu.edu.sg

Michel.birnbaum@ntu.edu.sg

Rapid and Gold-standard Pathogen Detection

Dr Amit Kumar
Cofounder & CEO, Biopsin Pte Ltd

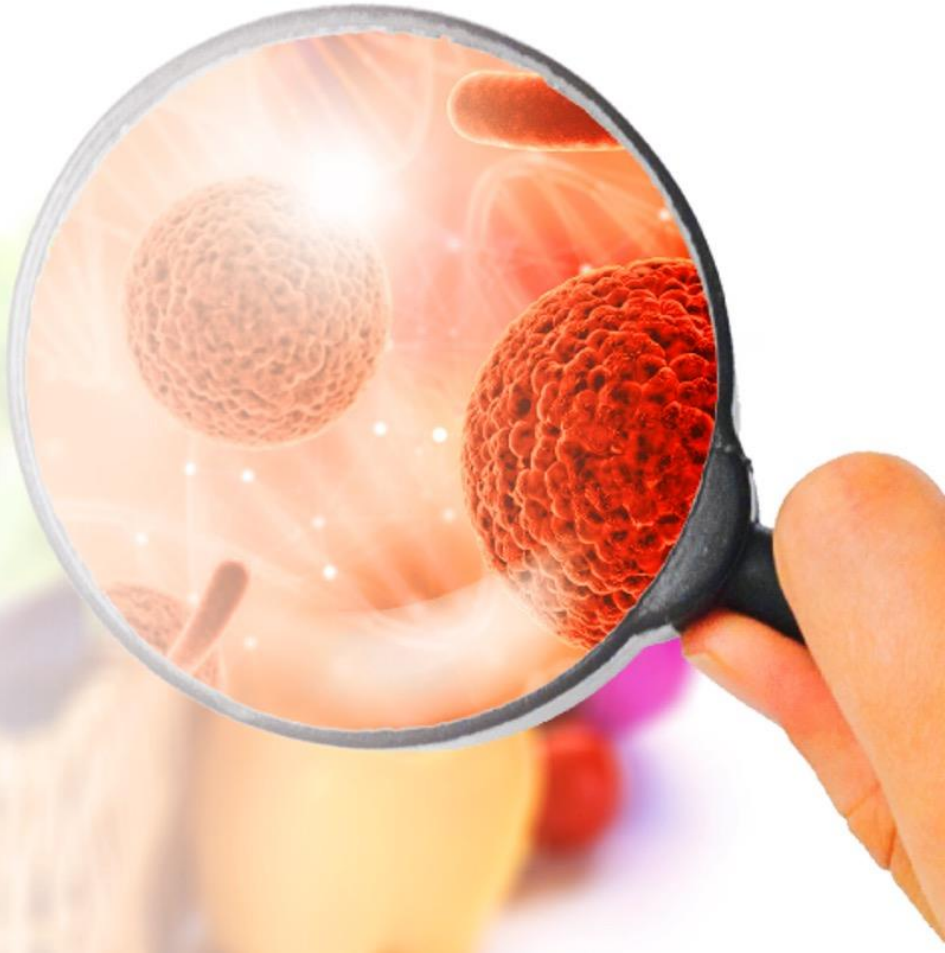
SWA
SINGAPORE WATER ASSOCIATION

SCELSE
Singapore Centre for Environmental Life Sciences Engineering

Singapore National
BIOFILM
Consortium

Biopsin

Rapid & Gold-standard Microbial Detection



One in 10 people fall ill every year because of exposure to pathogens

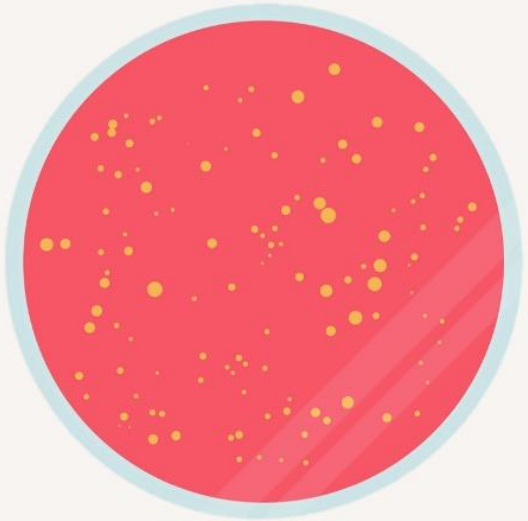
ECONOMIC BURDEN OVER

$100 BILLION

Conventional Method of Pathogen Detection is Over a Century Old

Labor-intensive & Unportable

Tedious and necessitates **trained professionals** and a **dedicated lab.**



Dangerously Time Consuming

Considering all factors, takes **1-2 weeks** to get the result.

GOAL

To Build World's First Solution

for

GOLD-STANDARD

MICROBIAL DETECTION

IN MINUTES

SOLUTION

Cartridge

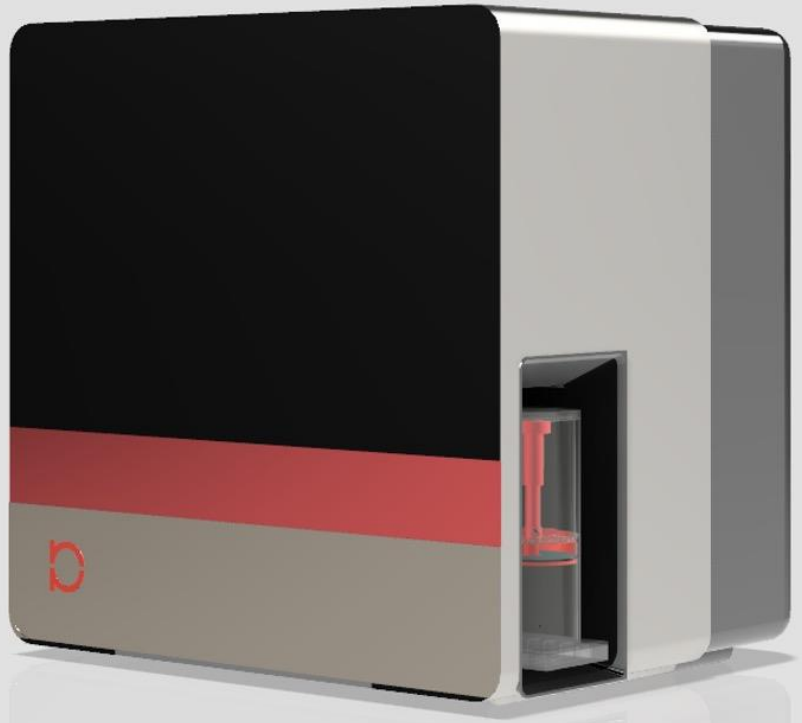
-- pre-processing

-- pathogen trapping slide

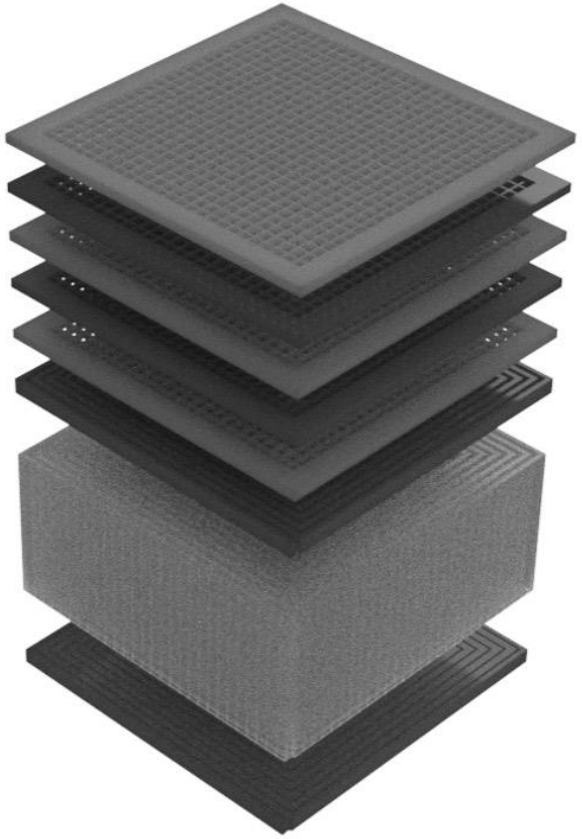
Device

-- detector

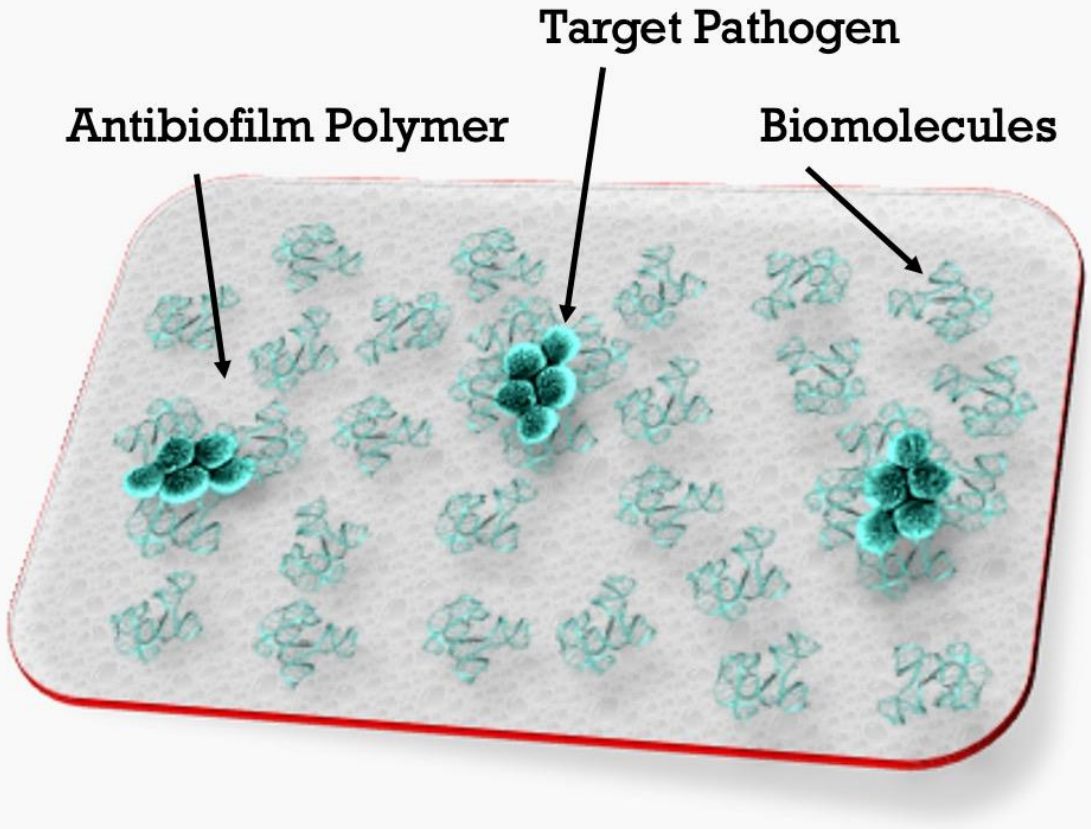
-- software



TECHNOLOGY



Filtration Module

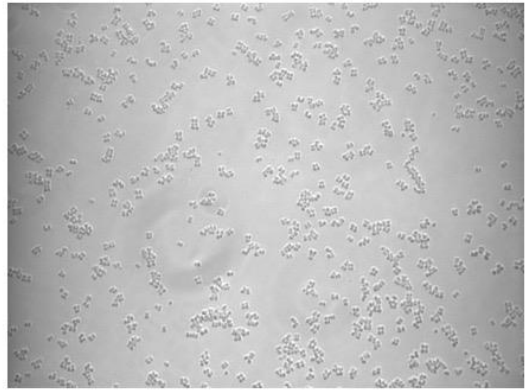


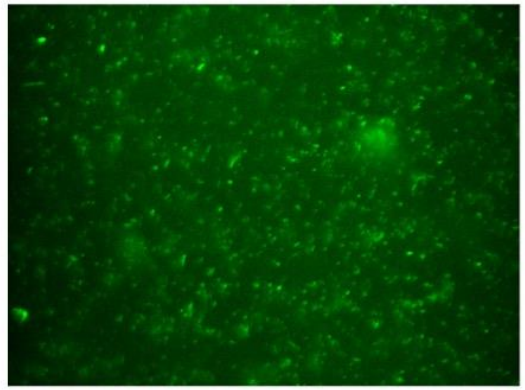
Target Pathogen Trapping Slide

Result: Target Bacteria Attachment on Pathogen Trapping Slides

Sample without Target Bacteria

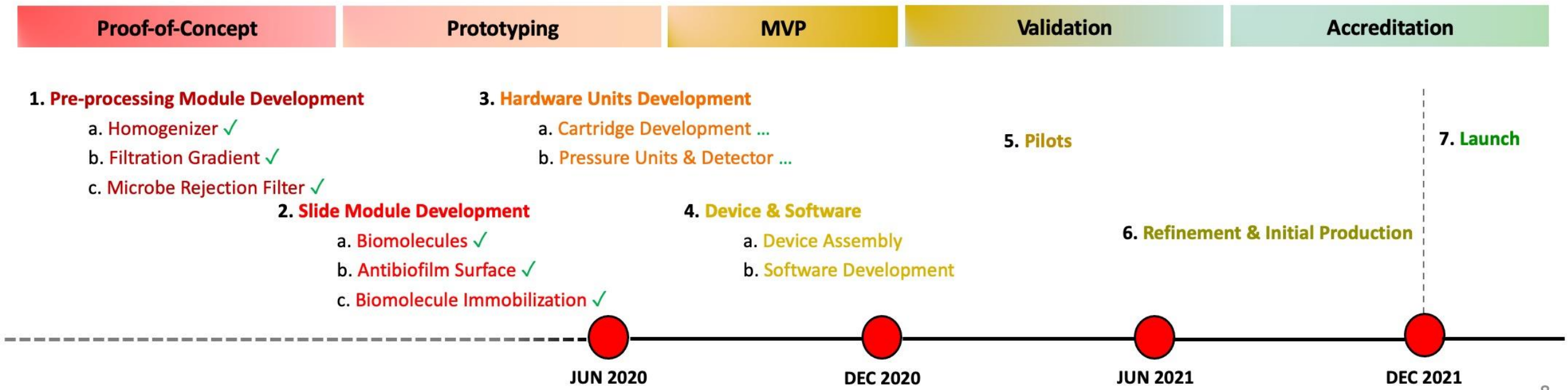
Sample with Target Bacteria





MILESTONES

- **Achieved proof-of-concept for *Staphylococcus aureus***
- **Currently prototyping to develop the commercial solution**
- **Work in Progress on *Escherichia coli*, *Vibrio* and *Legionella***



Microbial Testing Spans Across Many Industries

- Food and Beverage
- Healthcare
- Water
- Pharma
- Agriculture
- Biotech
- Consumer Goods
- Others

Water

Routine Microbial Tests

- Heterotrophic Plate Count
- *Escherichia coli*
- *Legionella* (ISO 11731)

Capability:

Microbial Testing in Food & Water

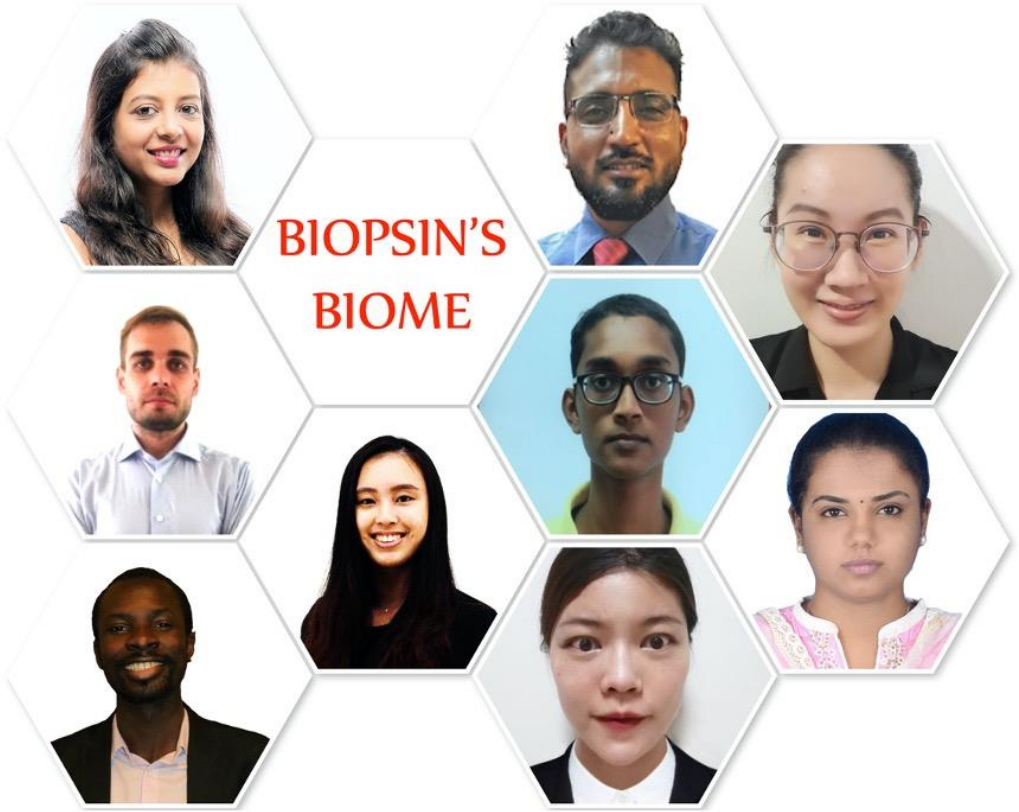
by Traditional & Advanced Methods

BSL-2 facility

2000 sq. ft. lab-space

In process to get accredited

ACKNOWLEDGEMENT



Pre-Seed

$ 250,000

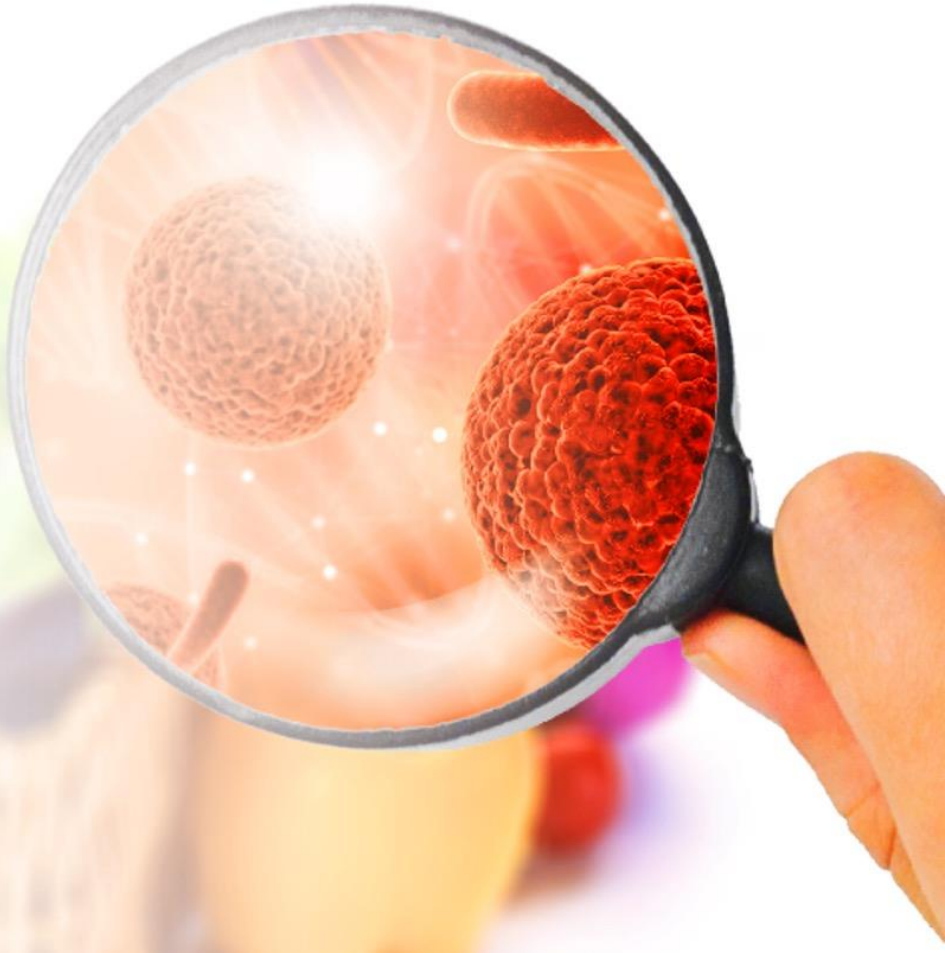
SOSV THE ACCELERATOR VC HAX

Grant (Equity Free)

$ 650,000

TEMASEK FOUNDATION ecosperity

Biopsin



Rapid & Gold-standard Microbial Detection

www.biopsin.com

amit@biopsin.com

Biofilm sensors and real-time application & benefits for water treatment.

Mr Andy Wirjawan
Director, United Water Technologies Pte Ltd

SINGAPORE WATER ASSOCIATION

SCELSE
Singapore Centre for Environmental Life Sciences Engineering

Singapore National BIOFILM Consortium

NexGen
Water Technologies

ALVIM BIOFILM SENSOR

Biofilm in Urban Water Cycle

20th August 2020

Agenda

- Introduction
- How does it work ?
- Case study - the impact of biofilms to HVAC Chiller & RO biofouling.
- Collaboration opportunities

Introduction

NexGen Water Technologies' focus is to bring the next generation of 'break-through' technologies to water & wastewater industries.

NexGen Water Technologies

- ALVIM Biofilm Sensor
- ULE Aeration System
- Nano-bubble Generator

How does it work ?

- ALVIM Biofilm sensor is a real-time biofilm sensor.
- Developed by Italian Institute of Marine Science (www.ismar.cnr.it).
- Measuring electrochemical signal of biofilm activity.
- Representing biofilm's thickness & coverage on the surface of the equipment.
- Only measuring biofilm growth & presence.

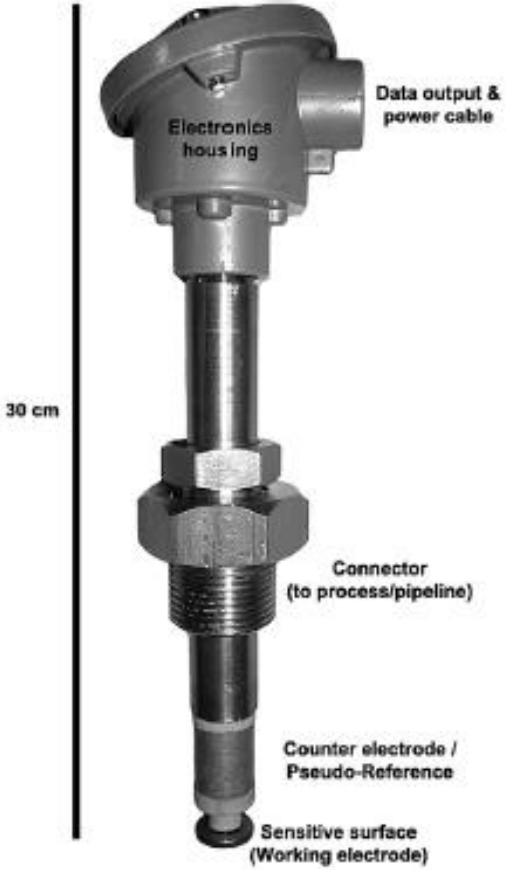


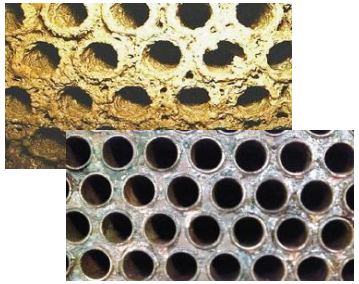
Fig. 2 – ALVIM biosensor.

Case Study 1 – Chiller HVAC system

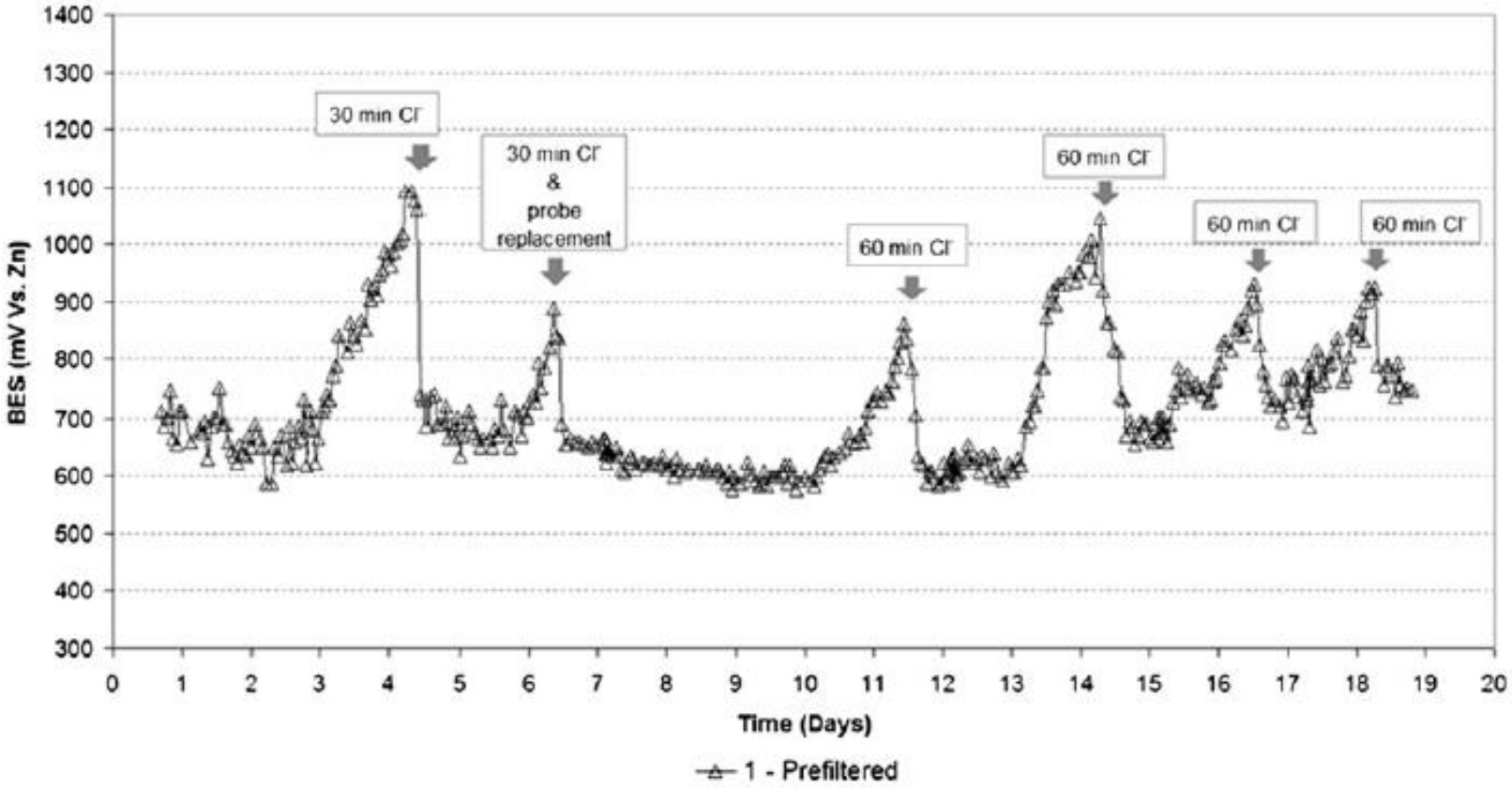
Deposit Material	Thermal Conductivity (W/m-K)
Calcium Carbonate ($CaCO_3$)	2.9
Iron Oxide (Fe_2O_3)	2.9
Calcium Sulfate ($CaSO_4$)	2.3
Biofilm	0.6

Biofouling is 4.8X more insulating than common "hardness" scales.

Additonal Energy Costs Per Year Due to Scale Deposition				
Tons of Chiller Capacity	Scale Deposit Thickness (mm) 0.2	0.3	0.6	0.9
300	$ 1,976	$ 3,953	$ 8,894	$ 13,341
500	$ 3,294	$ 6,588	$ 14,823	$ 22,235
900	$ 5,929	$ 11,858	$ 26,681	$ 40,022
1200	$ 7,906	$ 15,811	$ 35,575	$ 53,363
2000	$ 13,176	$ 26,352	$ 59,292	$ 88,938



Case Study 1 – Chiller HVAC system



Case Study 2 – Seawater RO system

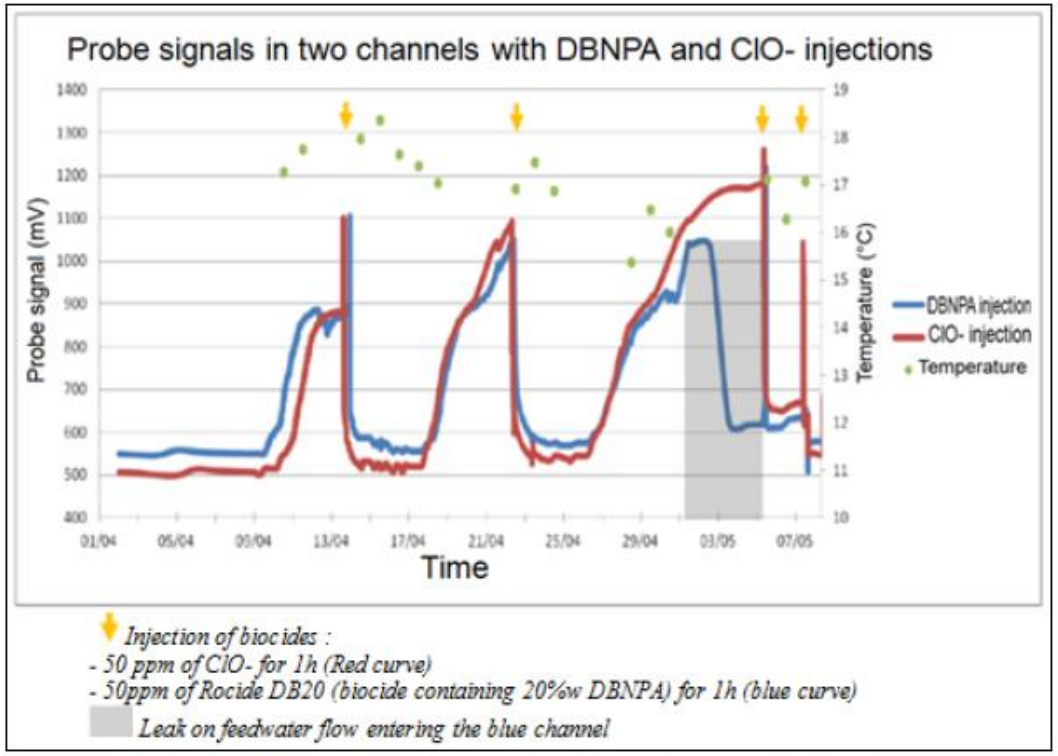


Figure 10 : Detection and removal of biofilm by batch injections of biocides

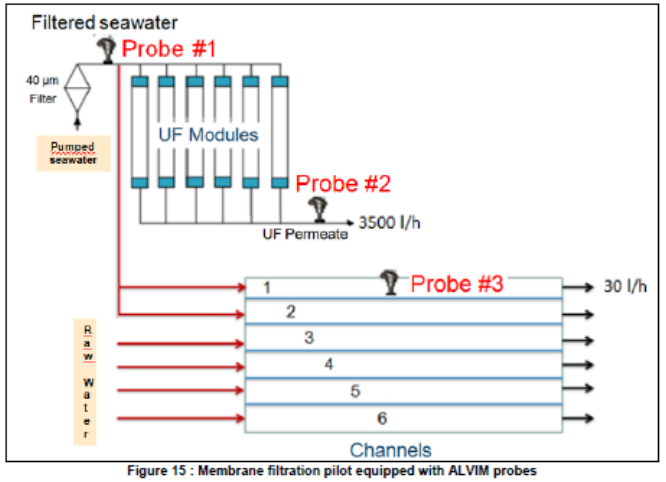


Figure 15 : Membrane filtration pilot equipped with ALVIM probes

Monitoring and control of biofilm in SWRO system →

Collaboration Opportunites

- 2 nos of ALVIM Biofilm Sensor available for TRIAL.

andy@nexgenwater.co

daryl@nexgenwater.co

Thank you
&
Let us collaborate !

NexGen
Water Technologies

❖ *What is the role of biofilms in the urban water cycle ?*
❖ *What is the impact of biofilms ?*
❖ *What can be done to improve detection & water treatment quality ?*

Q & A

Biofilms in the Urban Water Cycle

20 August 2020, Thursday, 10:00am – 11:00am

SWA
SINGAPORE WATER ASSOCIATION

SCELSE
Singapore Centre for Environmental Life Sciences Engineering

Singapore National BIOFILM Consortium

Complimentary Webinar

Fostering WATER Technology Partnership

27th August 2020

Thursday

4:00pm – 5:00pm

Register Now

Should you have any questions regarding this webinar, contact SWA
T: 6515 0812 or enquiry@swa.org.sg

EWTCOI
NGEE ANN POLYTECHNIC

SWA
SINGAPORE WATER ASSOCIATION

This webinar seeks to provide a better understanding of how R&D supports water technology deployment when partnering EWTCOI

Time	Agenda
4.00 - 4.02 pm	**Opening & Housekeeping**
4.02 - 4.10 pm	**Welcome Address** by Dr Chen Chia Lung, SWA/EWTCOI
4.10 - 4.35 pm	**Multiple Supports from EWTCOI** by Dr Jason Tang, EWTCOI
4.35 - 4.50 pm	**Developing Super Hydrophilic Water Filtration Membrane with EWTCOI** by Mr Pung CT, Firmbase
4.50 - 4.55 pm	**Q & A**
4.55 - 5.00 pm	**Closing**

Dr Jason Tang, has been with EWTCOI for more than 10 years supporting technology development in the area of environment and water technology. Trained as a molecular biologist under ASTAR's Institute of Molecular and Cell biology, he has moved on to develop a unique 20 year background in multiple forms of research (basic, clinical & translational) as well as business development and strategic planning providing EWTCOI's clients with unique advantages.

Mr Choong Theng (CT) is the founder of Firmbase Pte Ltd which was started in 2011. Firmbase focuses on development opportunities in advanced polymeric materials to meet the growing needs on water, energy, and infrastructure and has been advancing on new generation of hydrophilic additives for polymeric water filtration membranes. Prior to his venture, CT has worked for a Global Fortune 500 Company in the Specialty Chemical industry for over 20 years with extensive senior management experiences in Asia Pacific Business Leadership and Operations Management.

❖ *What is the role of biofilms in the urban water cycle ?*
❖ *What is the impact of biofilms ?*
❖ *What can be done to improve detection & water treatment quality ?*

Thank You

Singapore Water Association
T: 65150812
E: enquiry@swa.org.sg
W: www.swa.org.sg

Biofilms in the Urban Water Cycle

20 August 2020, Thursday, 10:00am – 11:00am

SINGAPORE WATER ASSOCIATION

SCELSE
Singapore Centre for Environmental Life Sciences Engineering

Singapore National BIOFILM Consortium