Effects of Denim and Polyester Fibres on Granular Sludge Reactors

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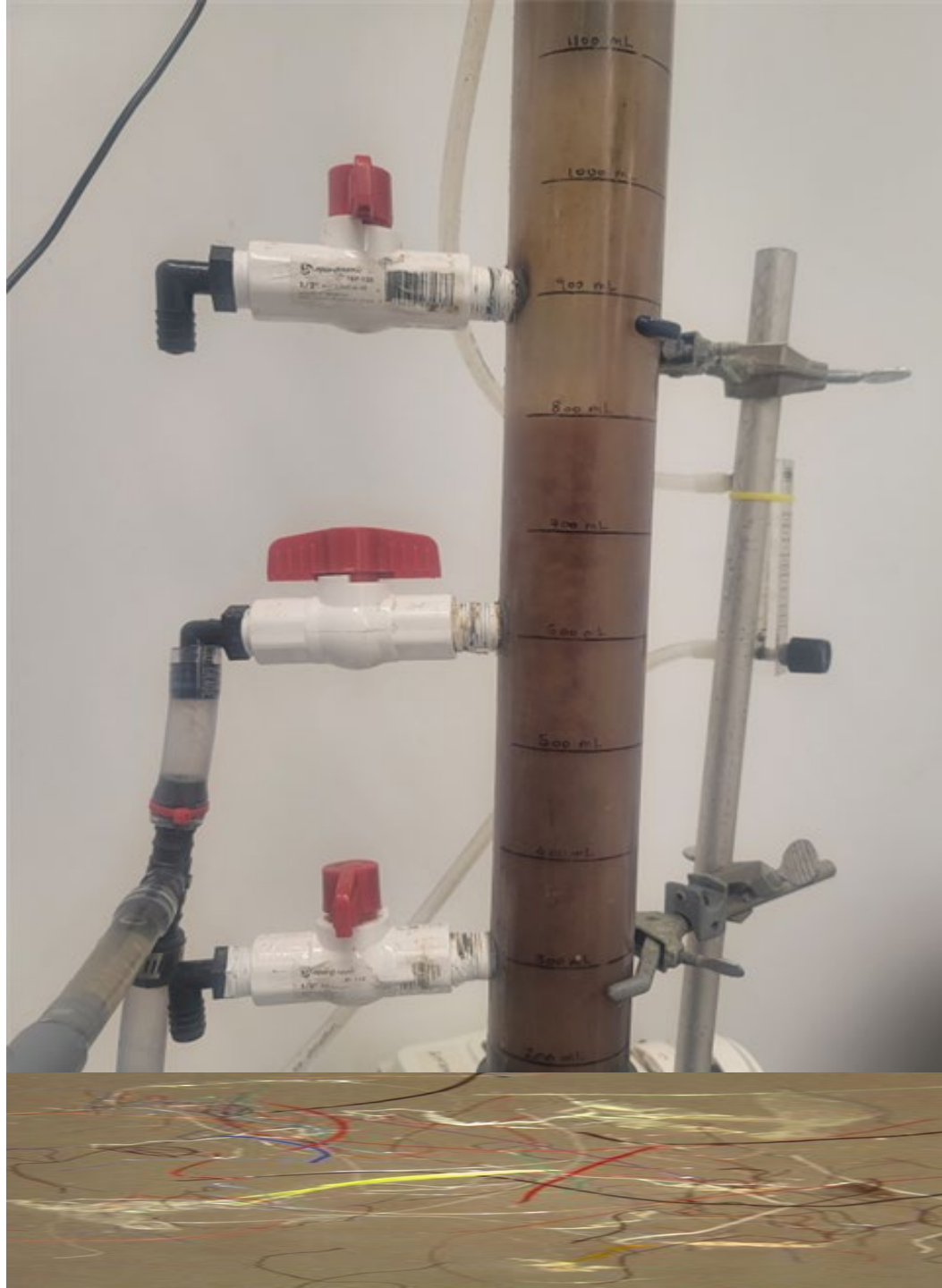
OUTLINE

- Introduction and problem statement
- Objectives
- Methodology
- Results
- Conclusions
- Q & A



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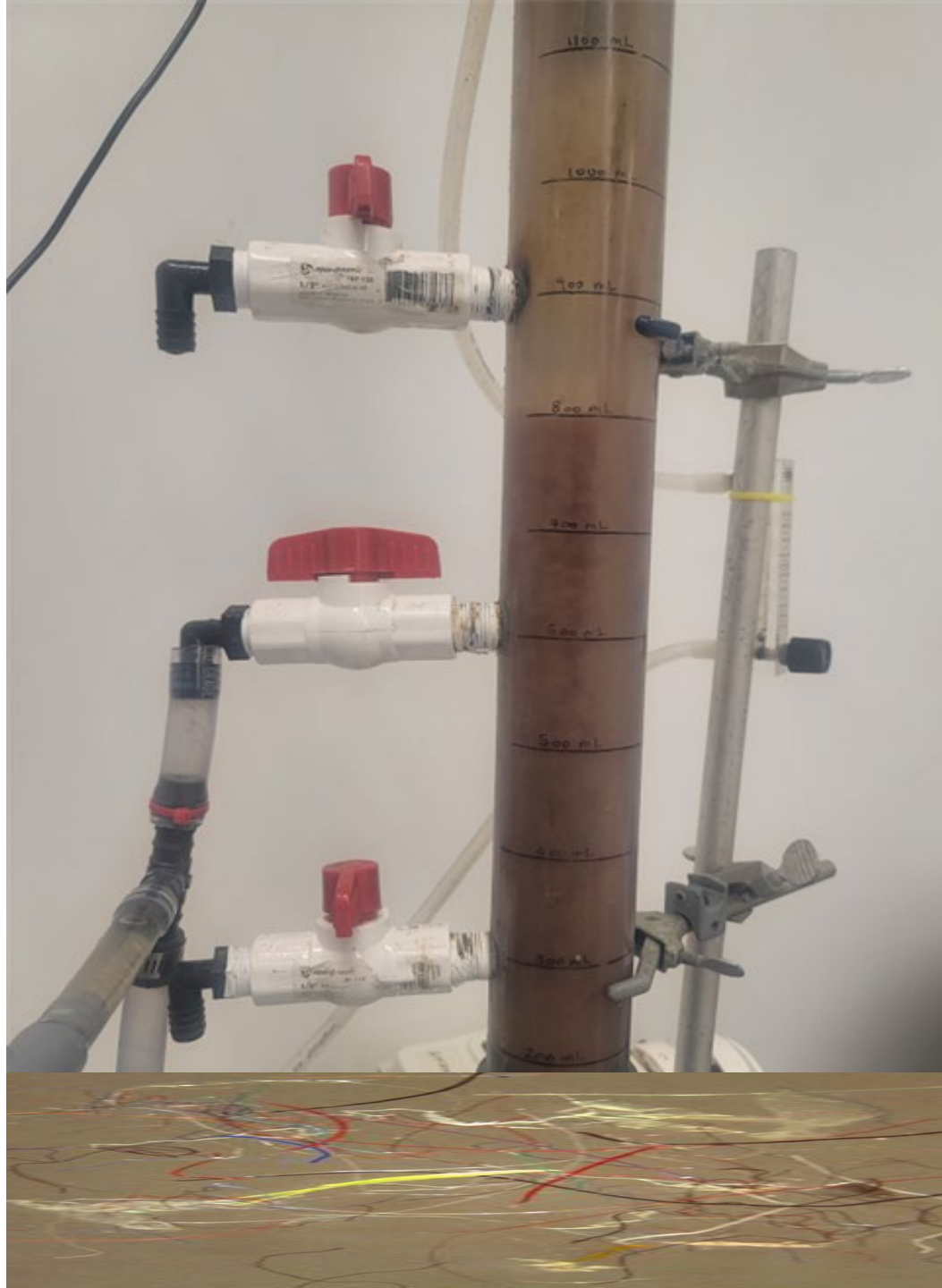
➢ Abbrevations

- MPs - Microplastics.
- MFs - Microfibres
- WWTPs - Wastewater treatment plants
- WW- Wastewater
- AGS- Aerobic granular sludge
- CAS- Conventional activated sludge



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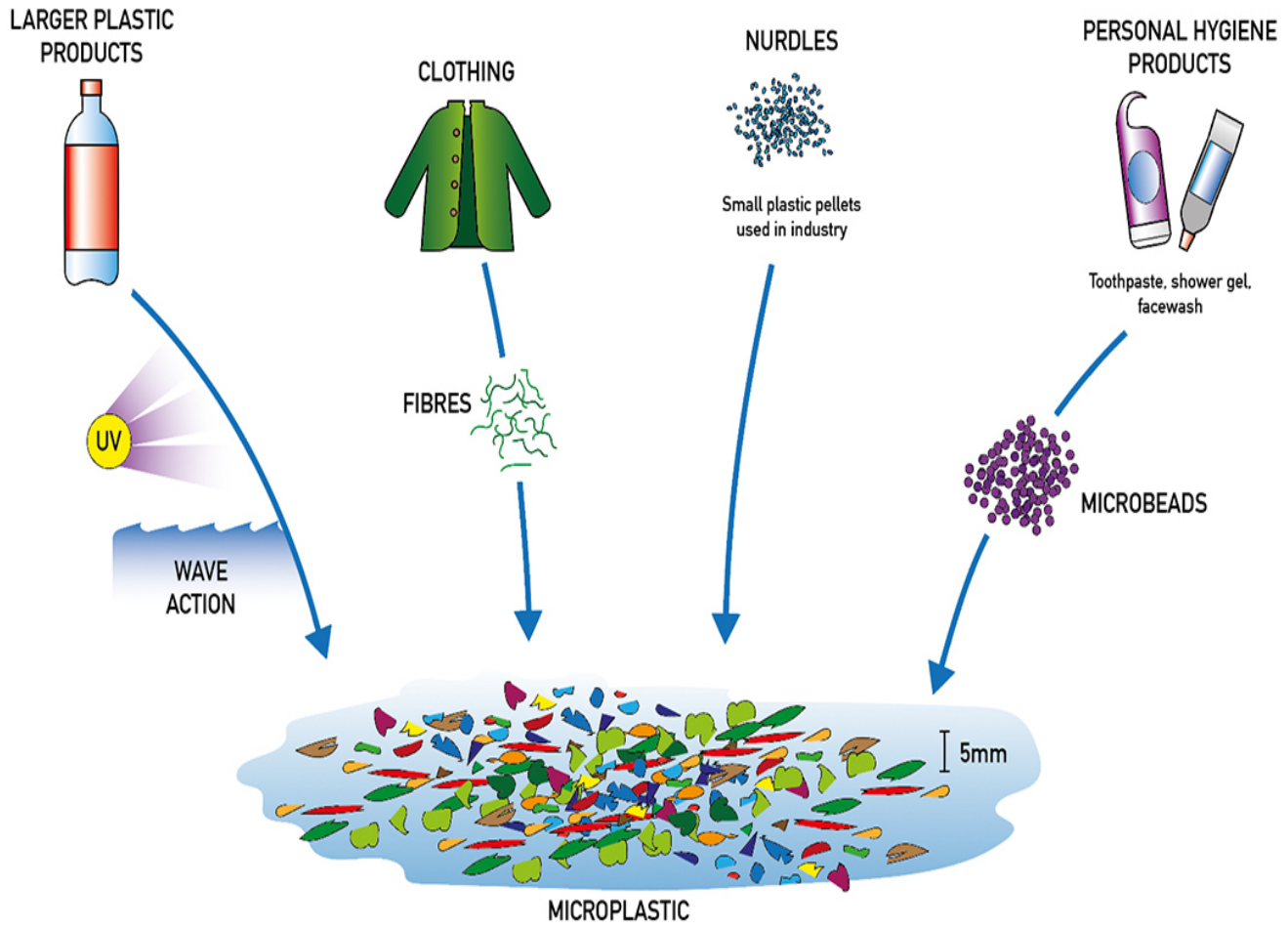
Introduction and problem statement.

- Lately, microplastics (MPs) have received extensive attention due to their associated environmental risks.

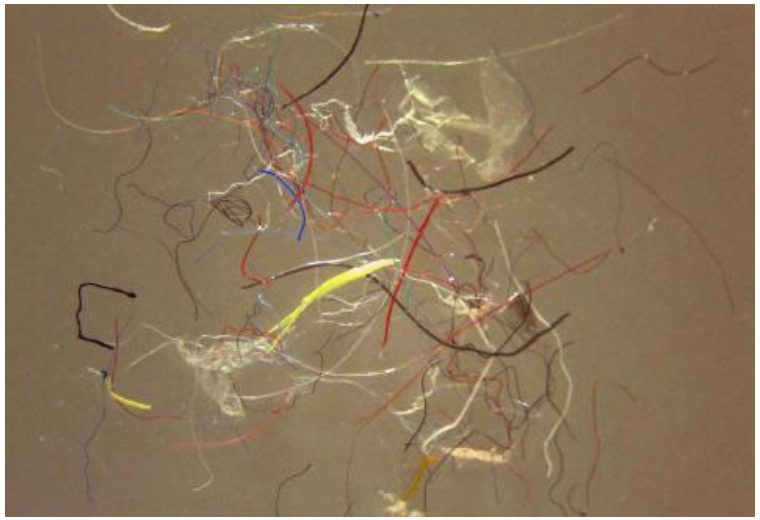
- If consumption trends continue by the year 2050, there will be more plastics than fishes in the ocean.

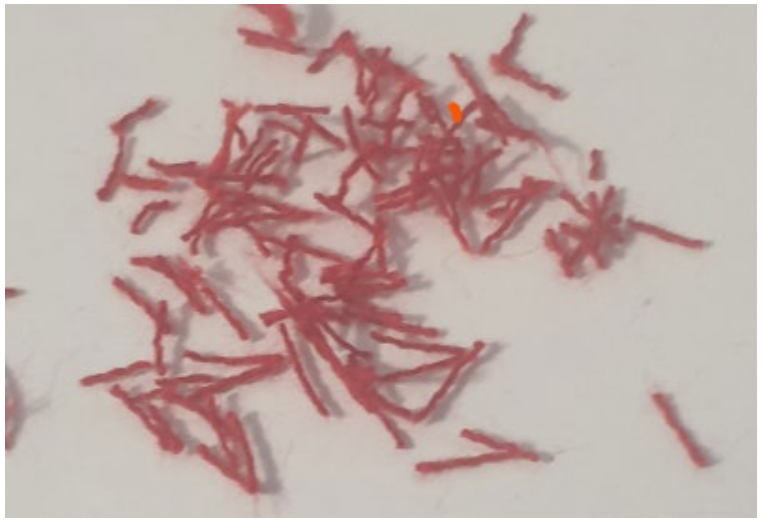


www.secondsguru.com

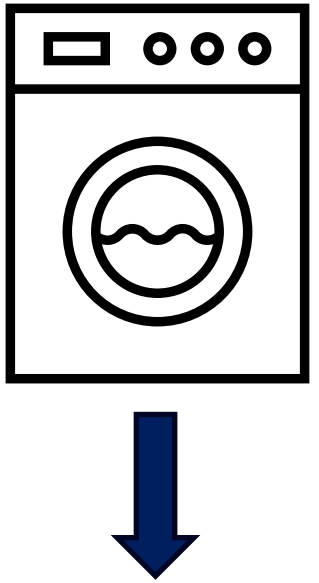
Introduction and problem statement.

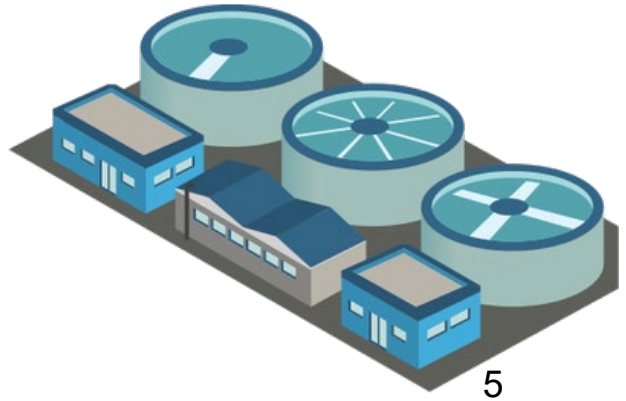
Microfibres (MFs), the dominant particles in the environment.





- MFs are pieces of tiny threadlike strands.
- Types: Natural, Synthetic, and Modified natural (denim).
- Main source: Laundry
- WWTPs are heavily impacted by MFs (concentrators).





WWTP

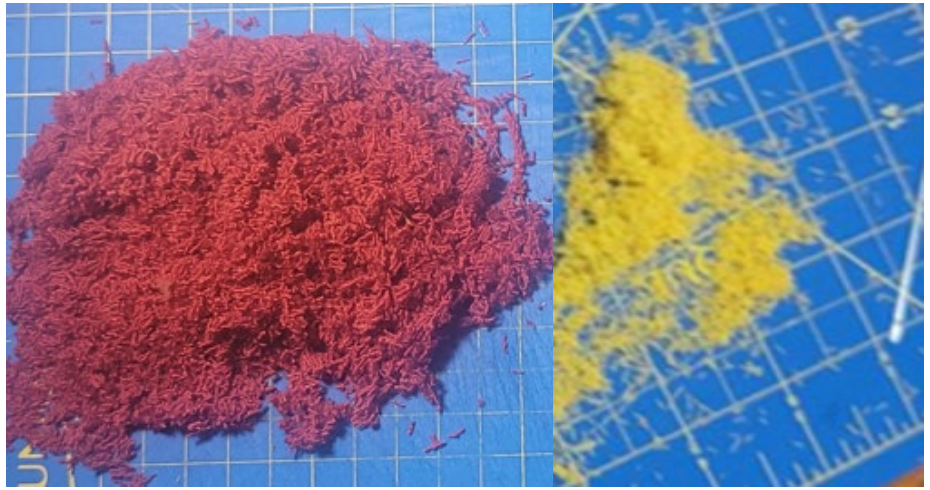
Introduction and problem statement.

- **The problem with Microfibres**

Absorb, contain

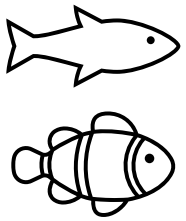
Endocrine disrupting compounds

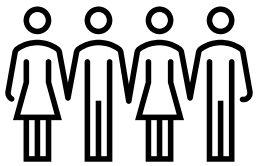
Pesticides Pharmacueticals



Endocrine disrupting compounds

Pesticides Pharmacueticals



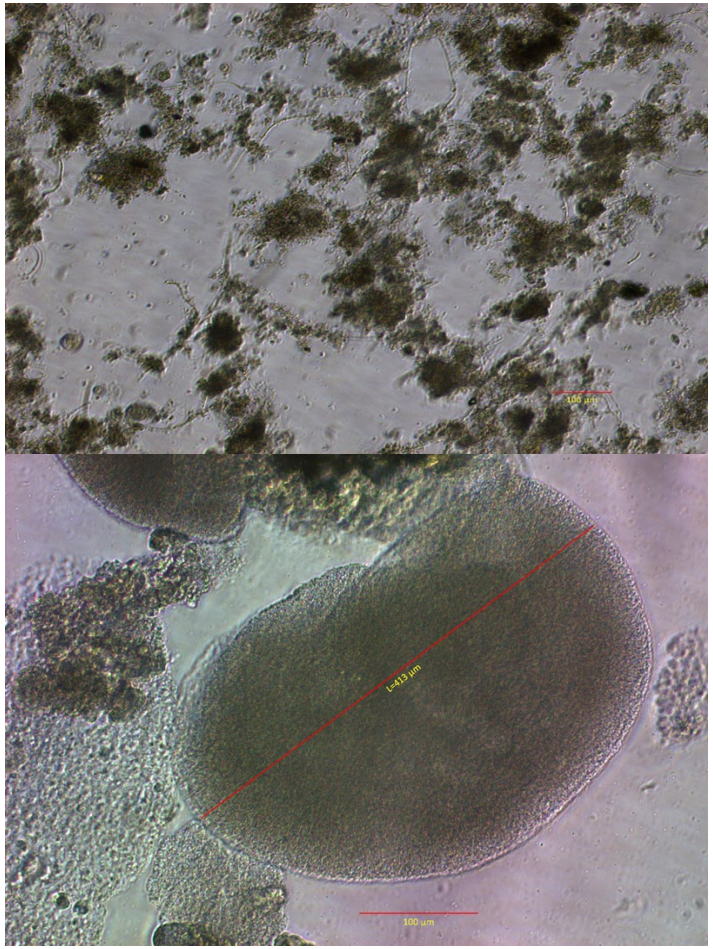


Objectives

1. Exploring the mechanisms of granulation, the formation of aerobic granules (AG) in bubble reactors with MFs.

2. Investigate the impact of different concentrations of denim and polyester MFs on AGS reactors.

Aerobic granular sludge (AGS)



- AGS a promising treatment technology.
- A rich consortium of tightly packed microorganisms that are formed when microbes self-immobilize and aggregate without a carrier media.
- AGS more resistant to shock loading.
- But the impact of MFs on AGS is currently unestablished

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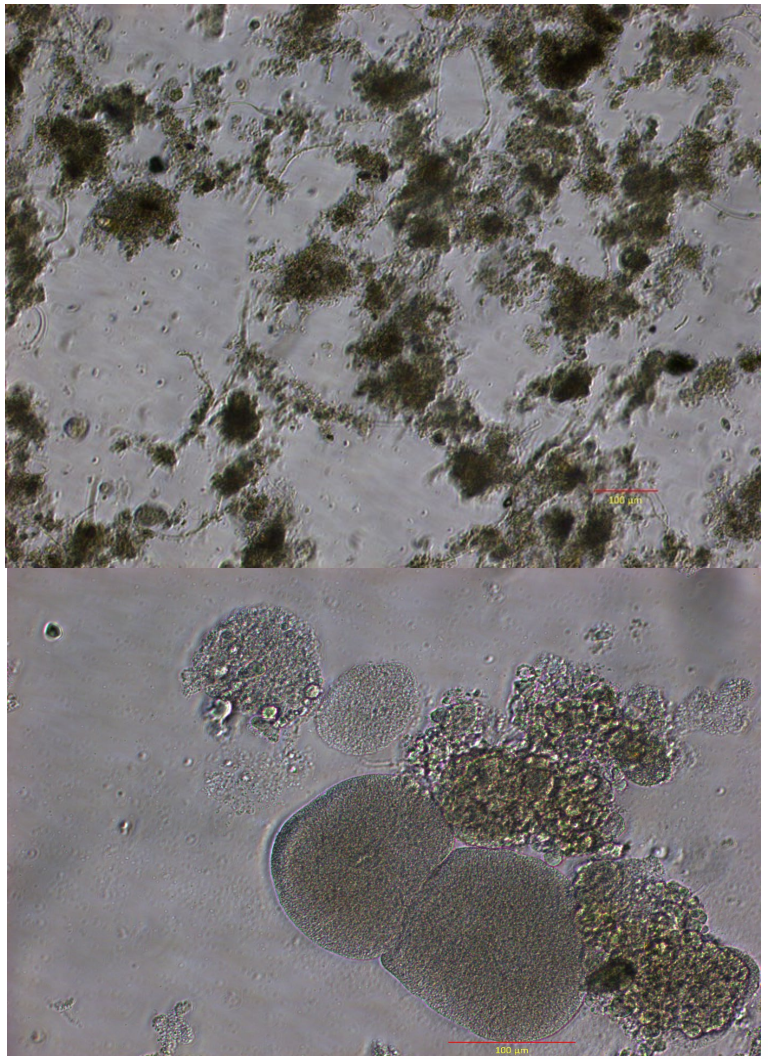
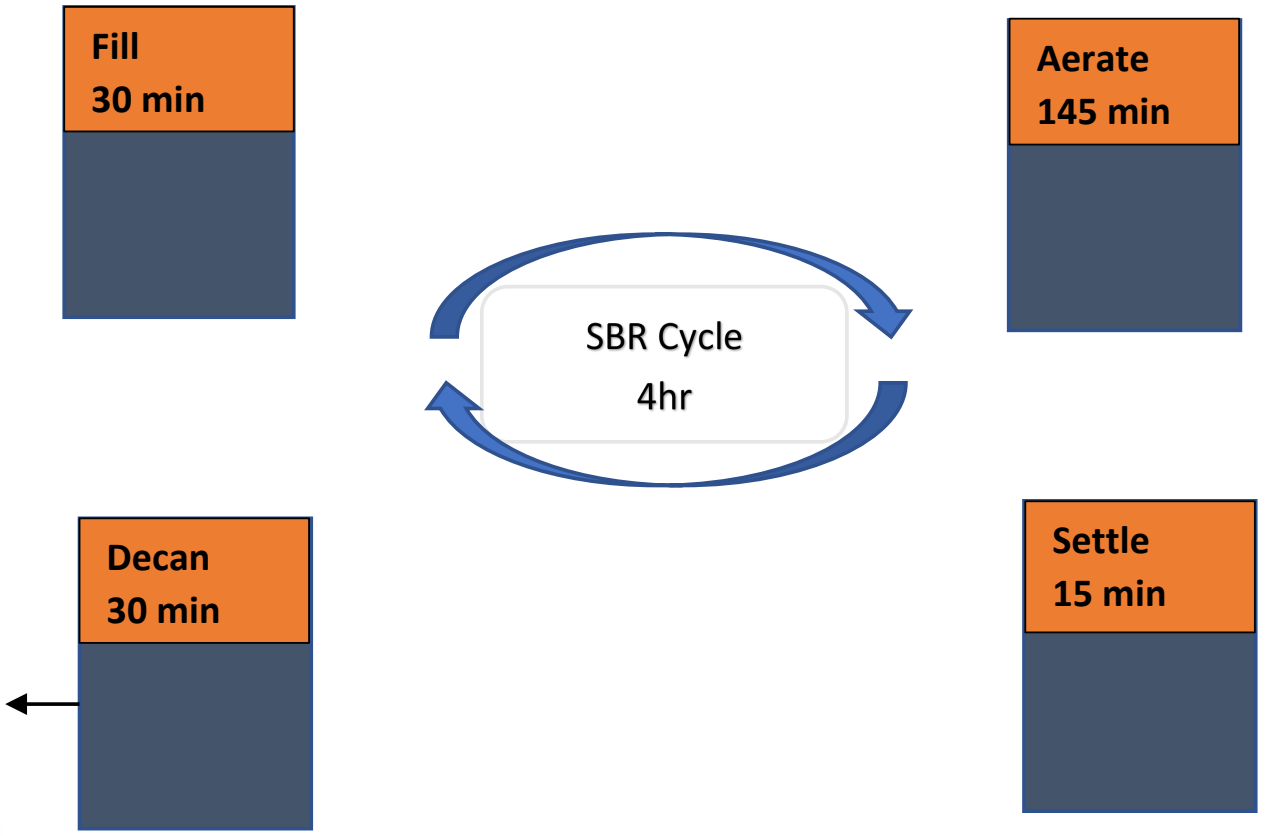
Advantages of AGS

- 3x higher settling velocity than CAS
- 20-25% reduction in operation costs than CAS
- 23-40% lower electricity consumption.
- 50-75% smaller footprint.
- Enhanced biological nutrient removal



Methodology



Methodology

MFs Preparation

4mm MFs dosed. Into the Influent

Concentrations

- 10 MFs/l
- 70 MFs/l,
- 210 MFs/l
- 1500 MFs/l

AGS Experiments

AG cultivated in 5 column-type SBR.

Synthetic WW

Std settings for optimizing granules

Tested weekly

Operated for 42 days

Analysis & Quality Control

Parameters tested: COD, TN, NH_3, P, MLSS, MLVSS, TSS

DNA extraction 16SRNA gene sequencing using Illumina

Influent concentrations of MPs

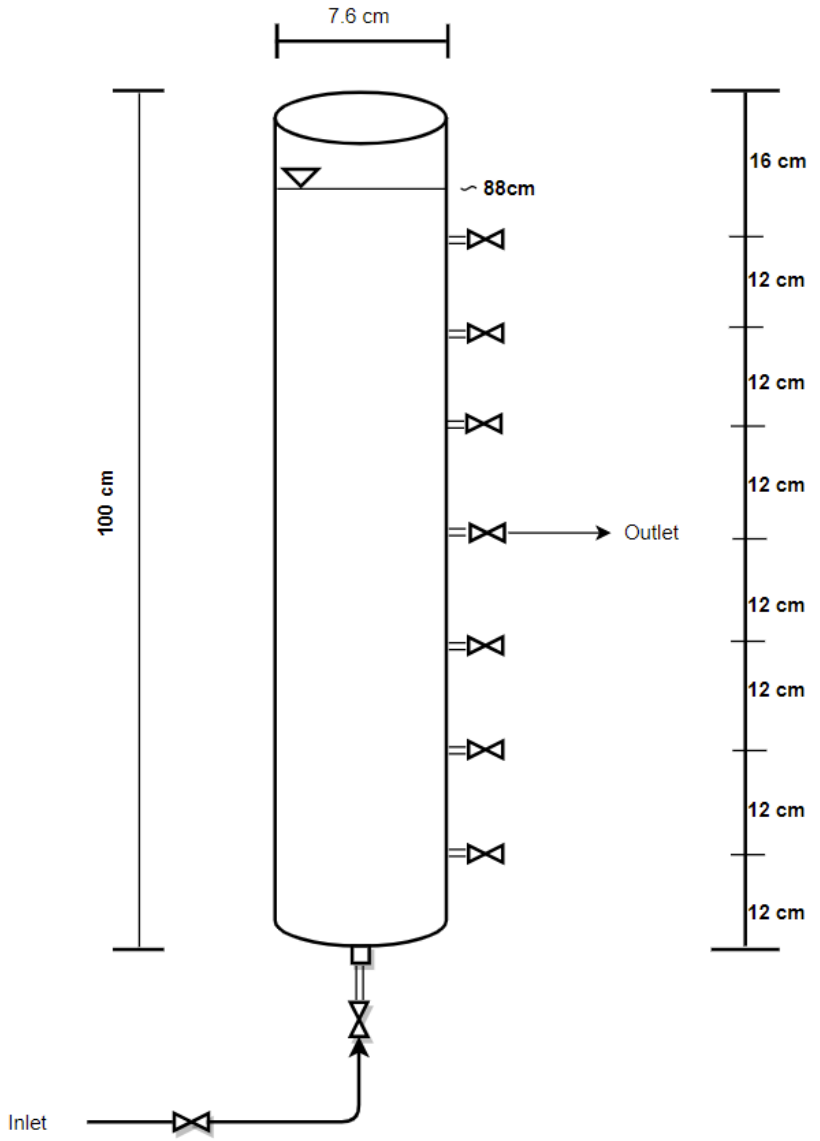
Influent concentration of MPs (mp/l)	Location	Source	Influent concentration of MPs (mp/l)	Location	source
0.5	Helsinki, Finland	(Talvitie et al. 2017)	57.6	Kenkaveroniemi, Finland	(Lares et al. 2018)
0.7	Helsinki, Finland	(Talvitie et al. 2017)	68	Netherlands and Germany	(Leslie et al. 2017)
0.79	South Carolina, USA	(Conley et al. 2019)	73	Netherlands and Germany	(Leslie et al. 2017)
0.8	South Carolina, USA	(Conley et al. 2019)	79	Changzhou, China	(Xu et al. 2019)
0.99	South Carolina, USA	(Conley et al. 2019)	79.9	Wuhan, China	(Liu et al. 2019)
1	California, USA	(Carr et al. 2016)	91	Netherlands and Germany	(Leslie et al. 2017)
1.5	Mersin, Turkey	(Akarsu et al. 2020)	92	Australia	(Ziajahromi et al. 2021)
2	Helsinki, Finland	(Talvitie et al. 2017)	95	Detroit, USA	(Michielssen et al. 2016)
2	Helsinki, Finland	(Talvitie et al. 2017)	95	Detroit, USA	(Michielssen et al. 2016)
2	Sydney, Australia	(Ziajahromi et al. 2017)	98	Australia	(Ziajahromi et al. 2021)
2.5	Northern, Italy	(Magni et al. 2019)	110	Changzhou, China	(Xu et al. 2019)
2.6	Mersin, Turkey	(Akarsu et al. 2020)	116	Changzhou, China	(Xu et al. 2019)
3.1	Mersin, Turkey	(Akarsu et al. 2020)	133	Detroit, USA	(Michielssen et al. 2016)
4	Jiangsu, China	(Lv et al. 2019)	143	Changzhou, China	(Xu et al. 2019)

Methodology.

- **SBR Operating conditions (AGS Reactors)**

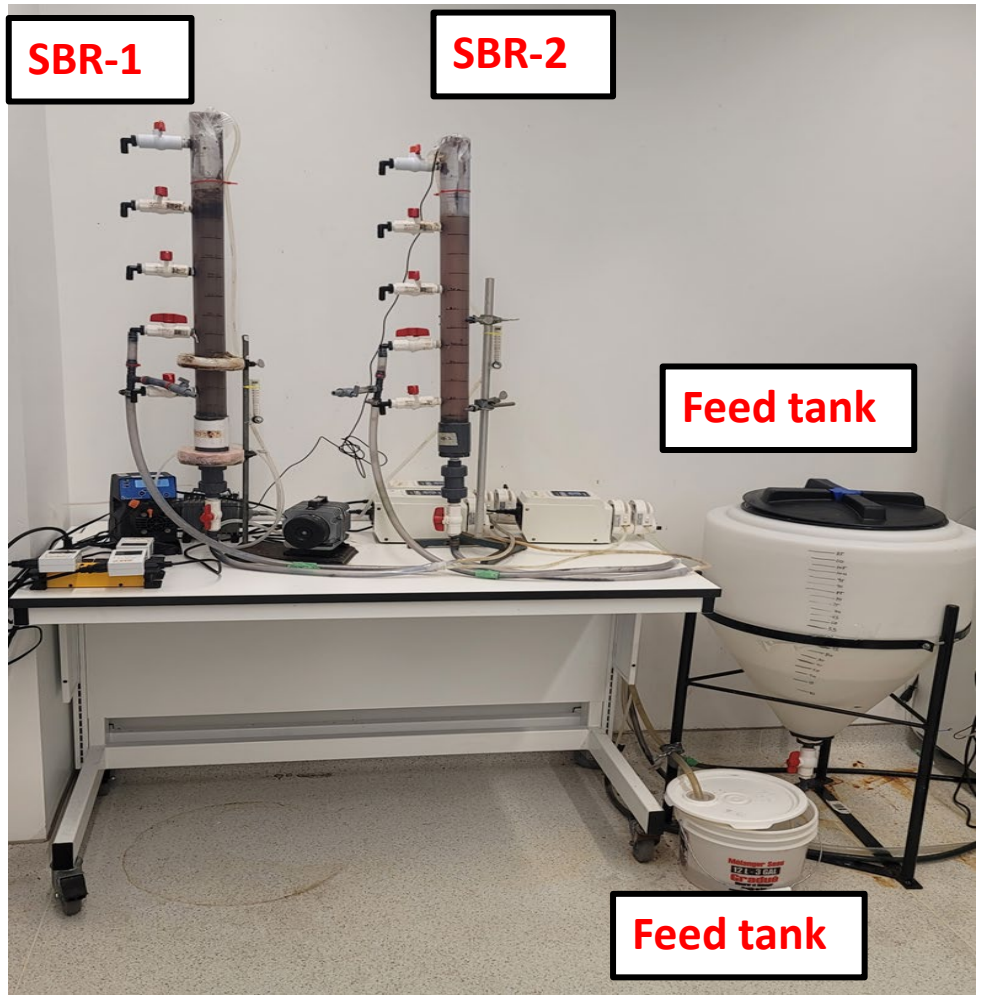
Parameters	Values
Influent COD concentration (mg/l)	1500
Anaerobic filling (min)	40
Aeration time (min)	145
Settling time (min)	30
Effluent discharge (min)	15
Idle (min)	10
VER (%)	50
Cycle time (hr)	4
HRT (hr)	8
Duration of operation (days)	42
Temperature °C & pH	22-25 & 7.5±0.5

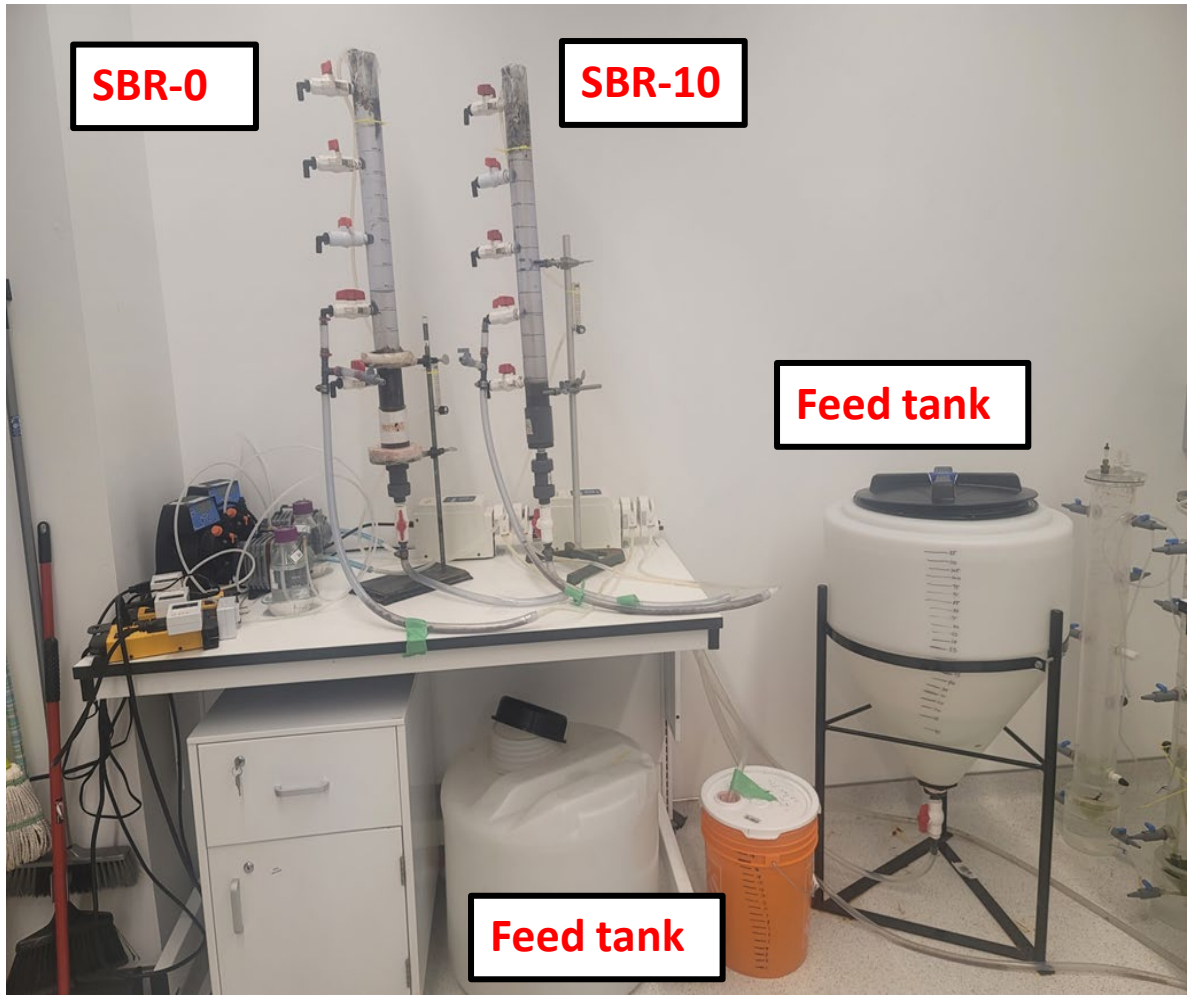
AGS Reactor Configuration



Methodology.

- Experimental Set-up

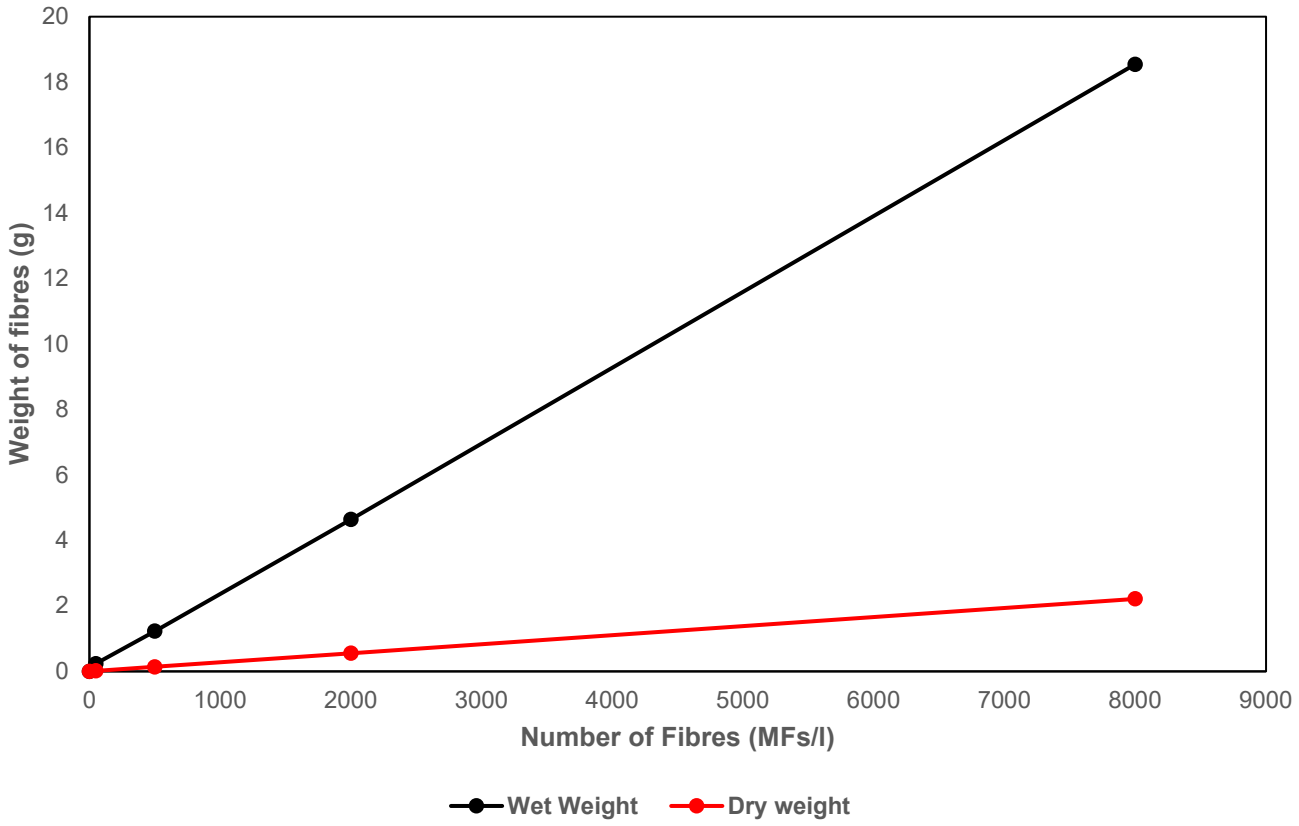




AGS Reactors and feed tank

Mixed liquor suspended solids 4000mg/l, COD:N:P 100:4.5:0.5

Methodology



5-point calibration curve for dosing

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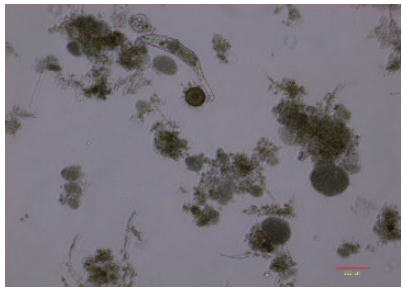
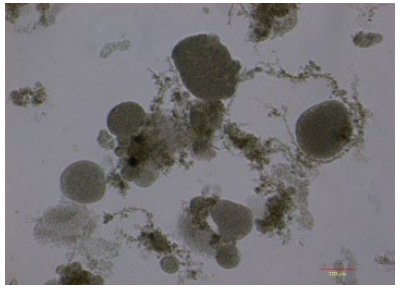
❖ Results and Discussion

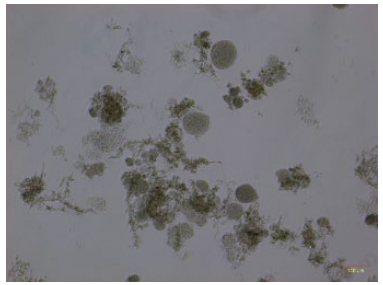
Fibres enhance granulation



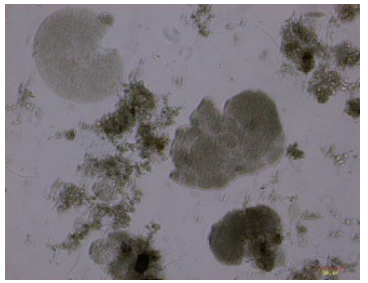
a.Day 9



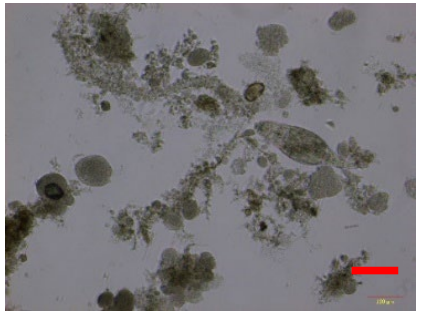
b.Day 14 Control



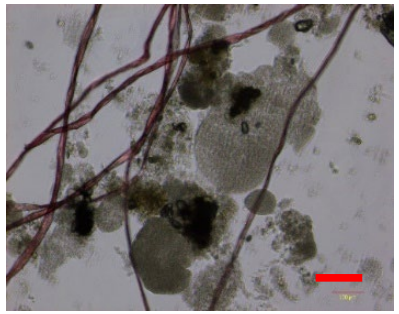
c.Day 9



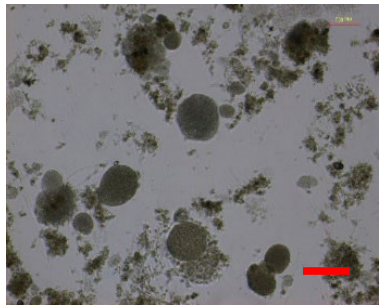
d.Day 14 SBR-10



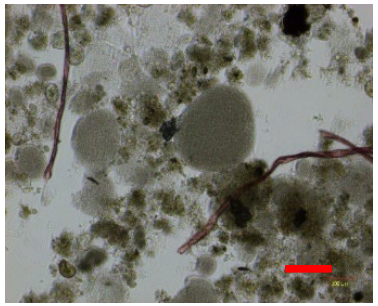
e. Day 9



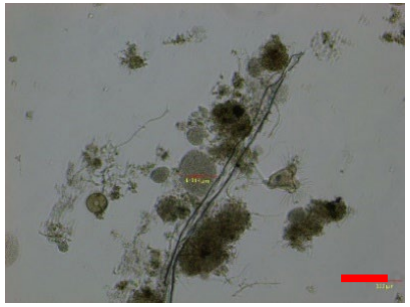
f. Day 14 SBR-70



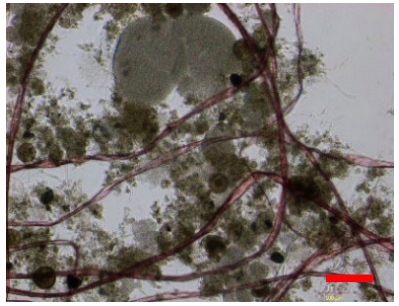
g. Day 9



h.Day 14 SBR-70



i. Day 9



j. Day 14 SBR-1500

Granulation process on days 9 and 14 in SBR-0, SBR-10, SBR-70, SBR-210 and SBR-1500 Bar = 100µm

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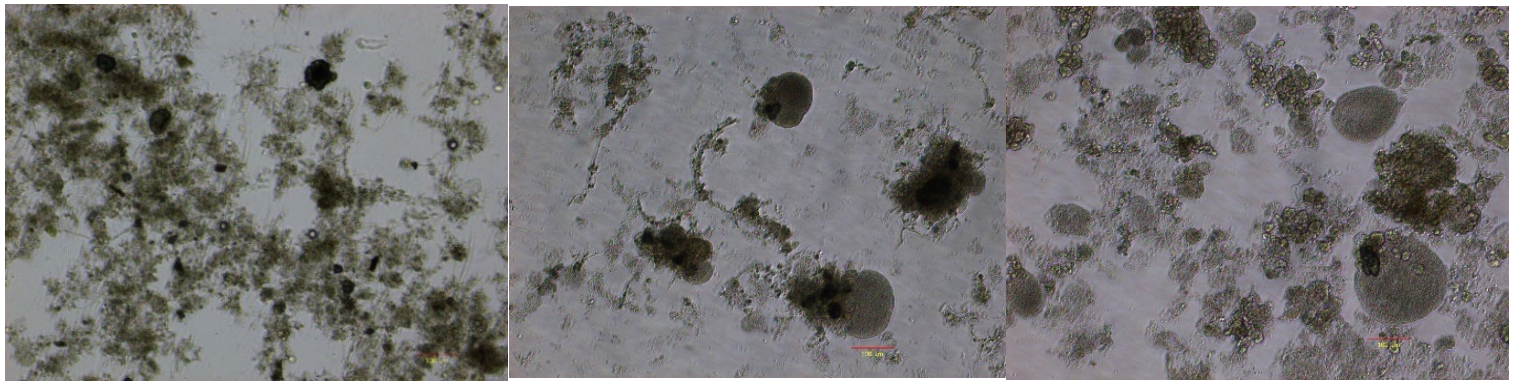
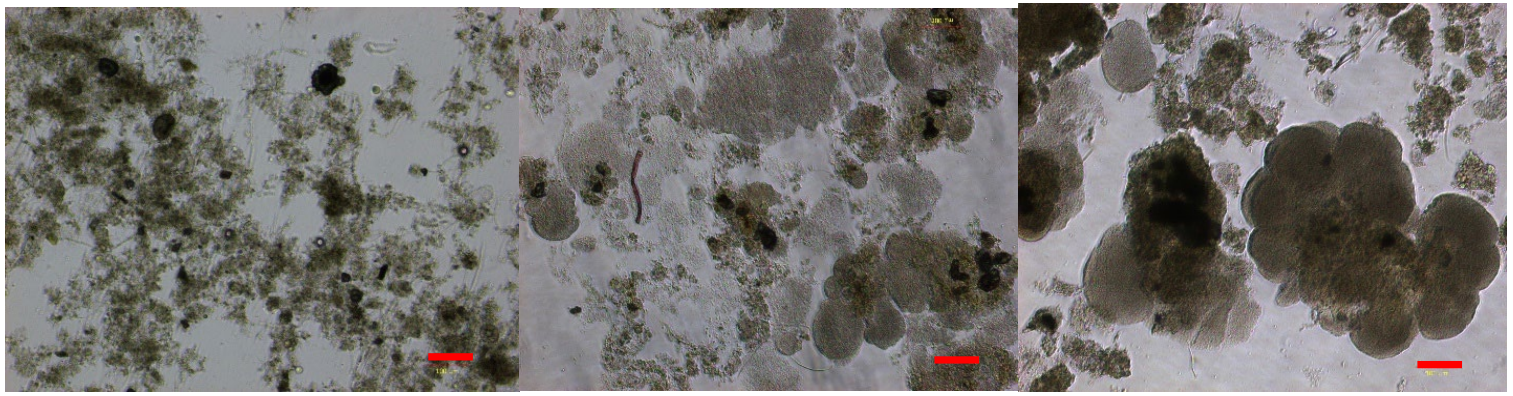
Fibres enhance granulation (SBR-1 & SBR-2).



a)DAY 0 b)Day 18 c)Day 40 Bar=100µm

SBR-1

Control reactor



d)Day 0 e)Day 18 f)Day 40 Bar=100µm

SBR-2

Reactor with fibres

SBR-1 (control) 40 Days
SBR-2 (fibres) 18 Days

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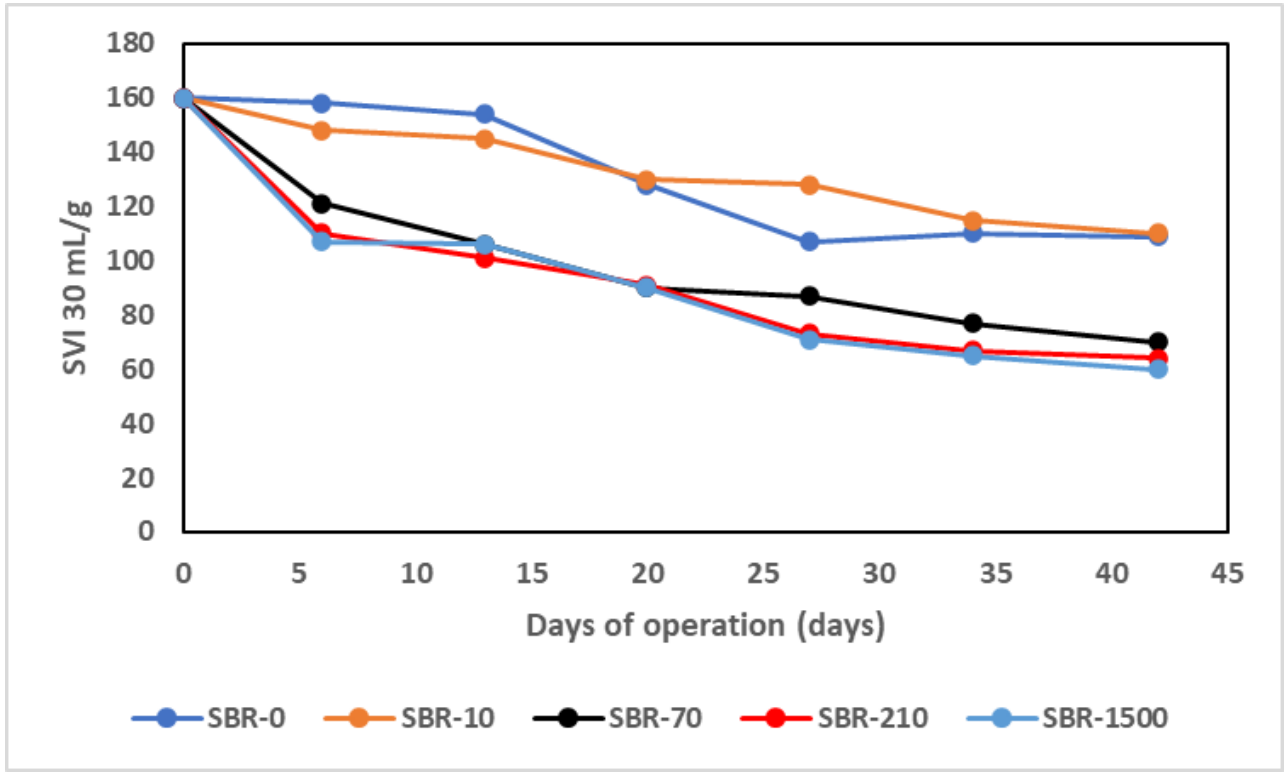
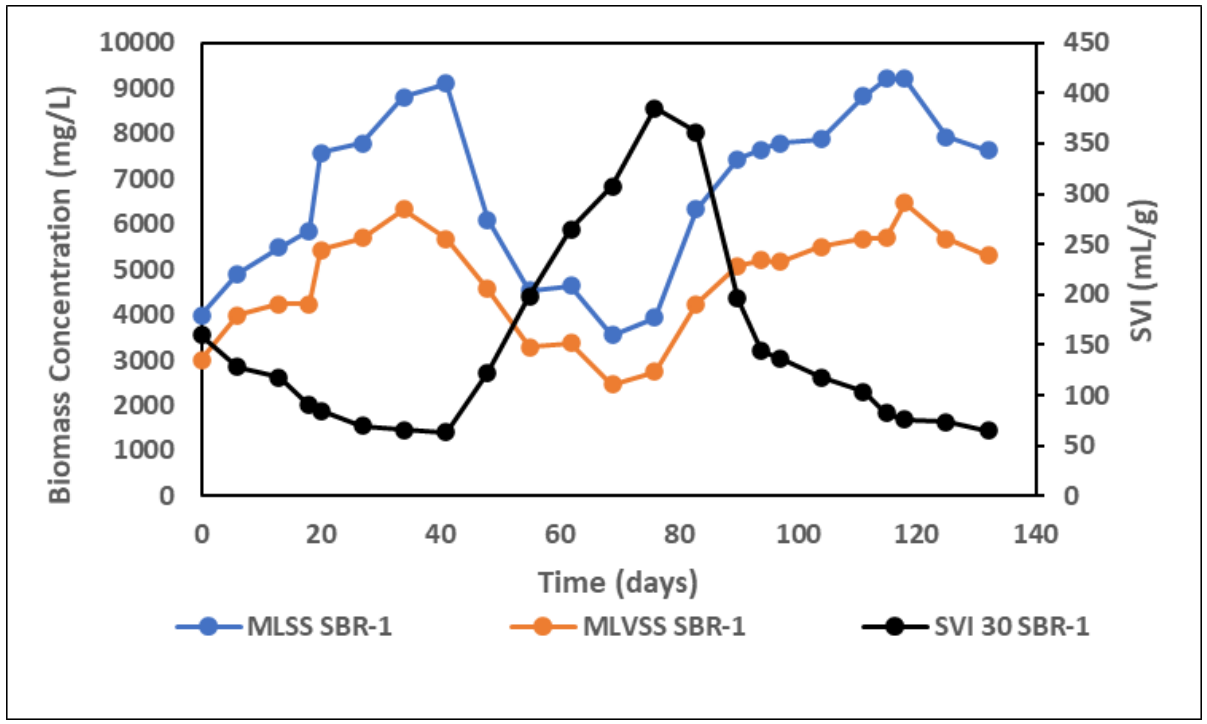
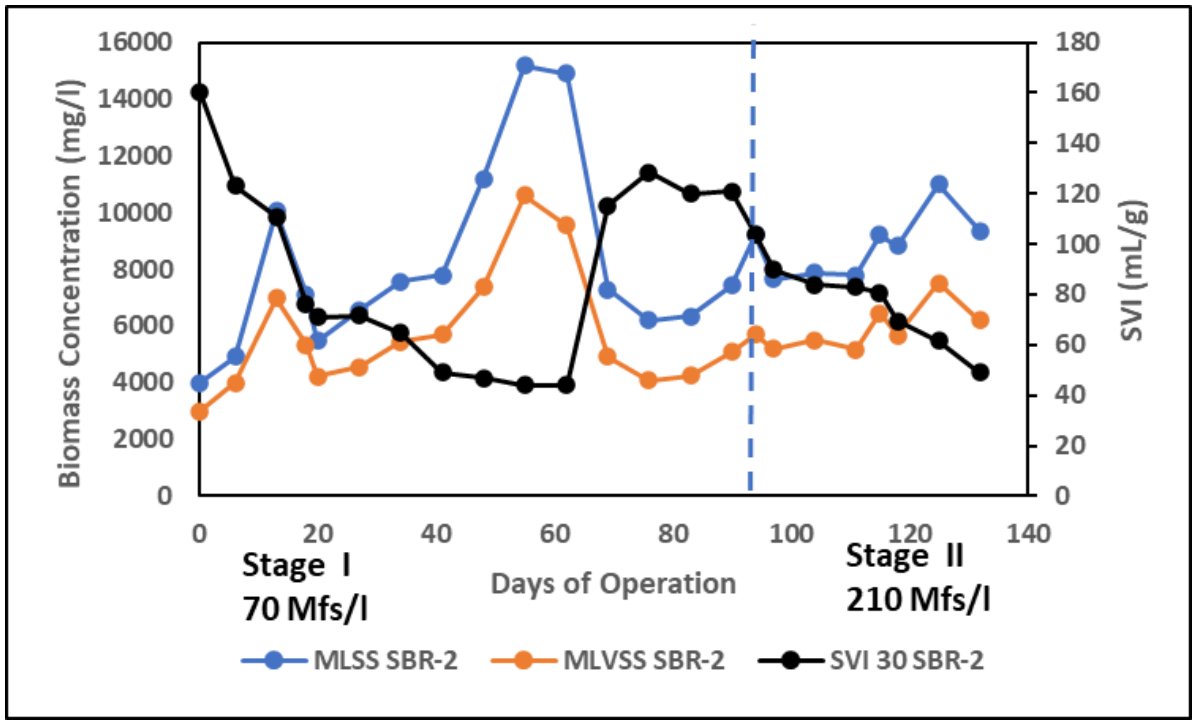
Fibres enhanced settleability



SVI_{30} PROFILES FOR SBR-0,SBR-10, SBR-70, SBR-210 & SBR-1500

❖ Effects of fibres on AGS SBR-1 & SBR-2.





BIOMASS CONCENTRATION AND SETTLEABILITY SBR-1 AND SBR-2

SBR-1 Day 1 (160 mL/g), Day 18 (90 mL/g), Day 40 (64 mL/g), Day 100 (118 mL/g), Day 132 (65 mL/g)
SBR-2 Day 1 (160 mL/g), Day 18 (76 mL/g), Day 40 (48 mL/g), Day 100 (90 mL/g), Day 132 (48 mL/g)

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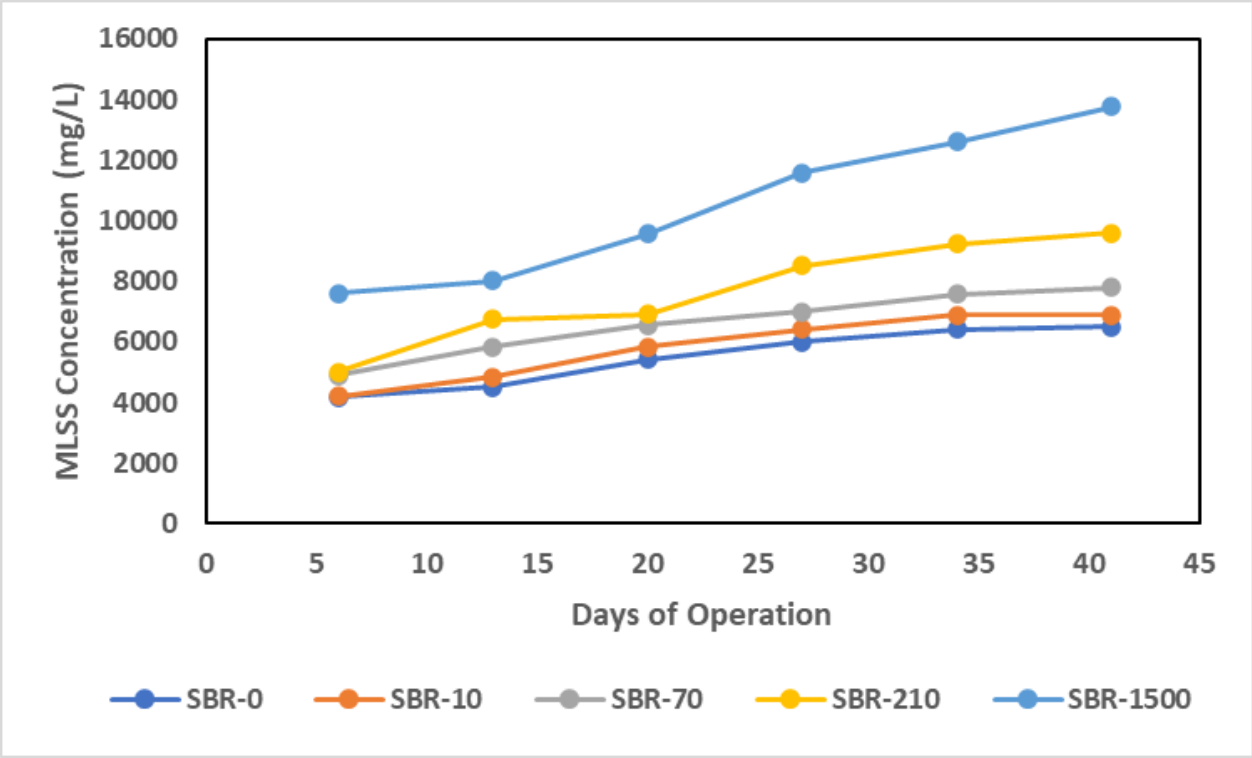
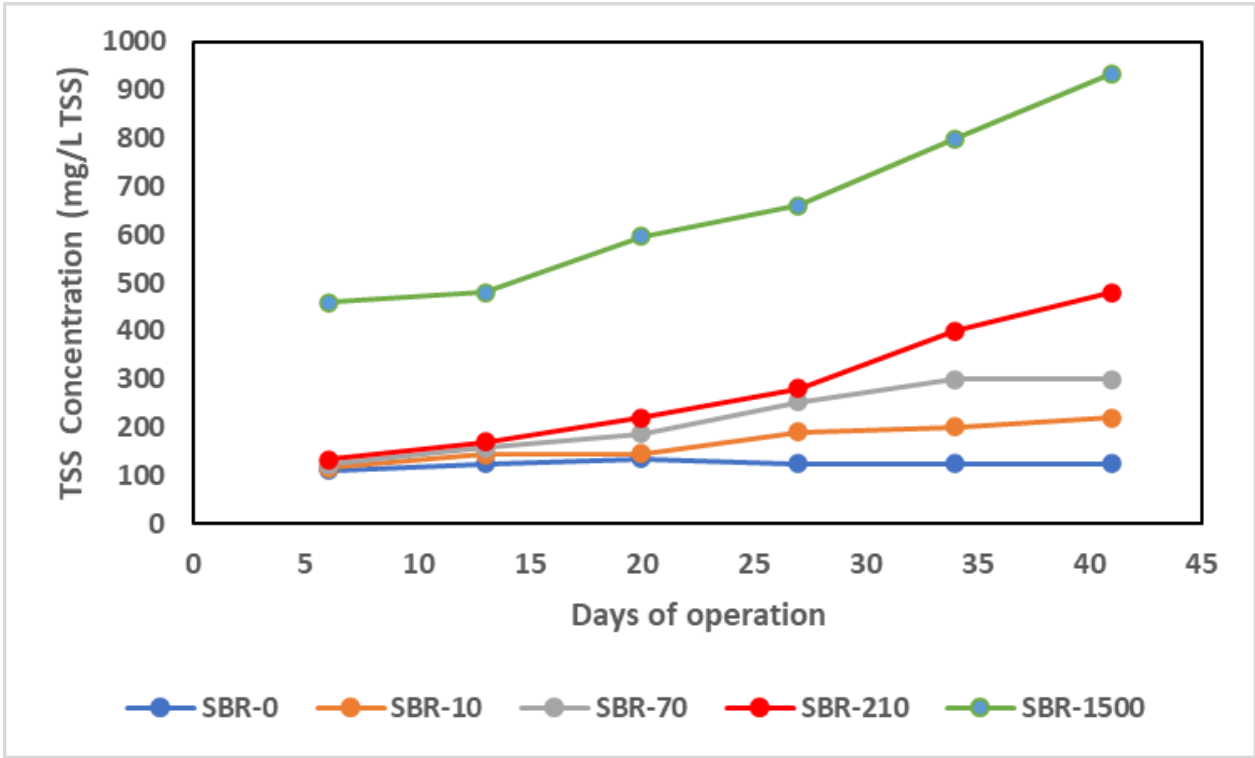
MLSS & TSS values increased with increasing fibre conc



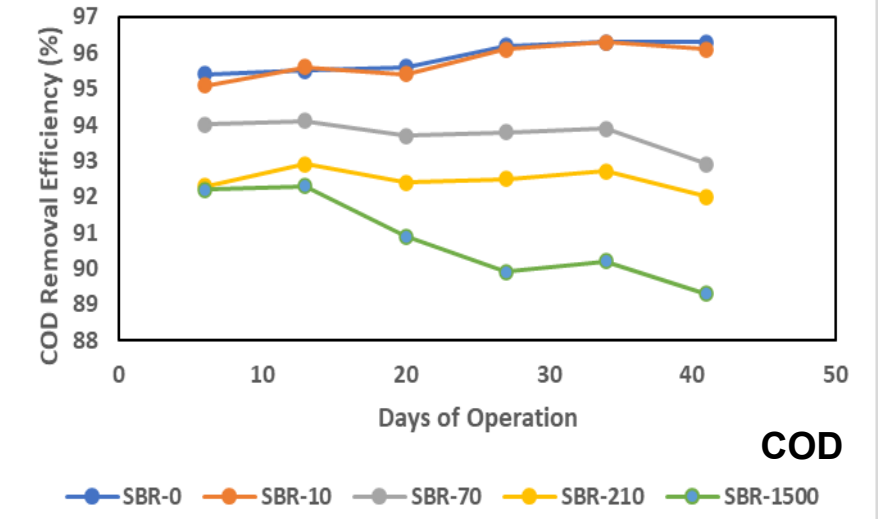


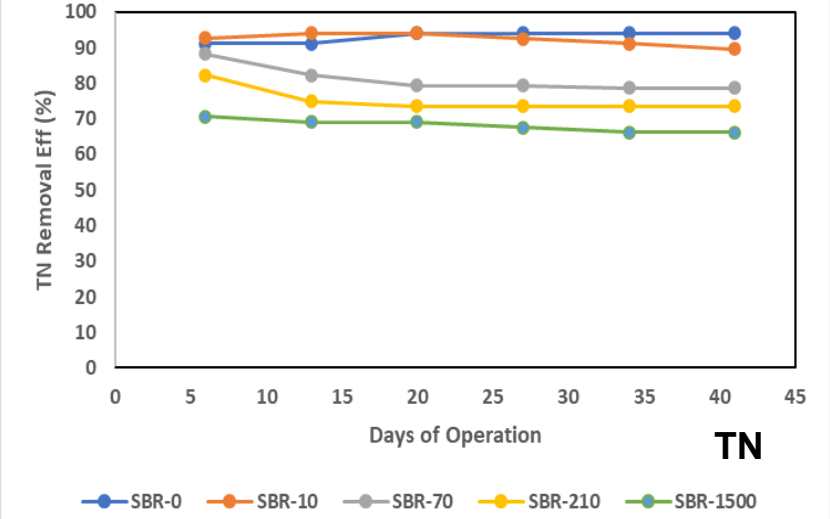
MLSS AND TSS PROFILES FOR SBR-0, SBR-10, SBR-70, SBR-210 AND SBR-1500

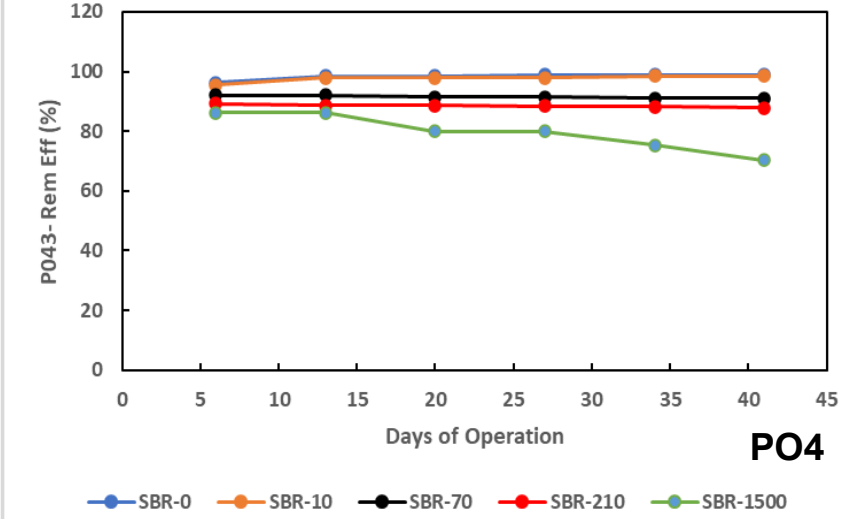
- **Are the effects of fibres on AGS concentration dependent?**

At high concentrations fibres affect COD, TN & PO_4^{3-}.

Parameters	SBR-0	SBR-10	SBR-70	SBR-210	SBR-1500
COD (%)	96	96	94	93	89
TN (%)	93	93	81	75	68
NH_3 (%)	99	99	98	98	97
PO_4^{3-} (%)	98	98	92	89	80
Rem Eff %	-	100	98	99	98

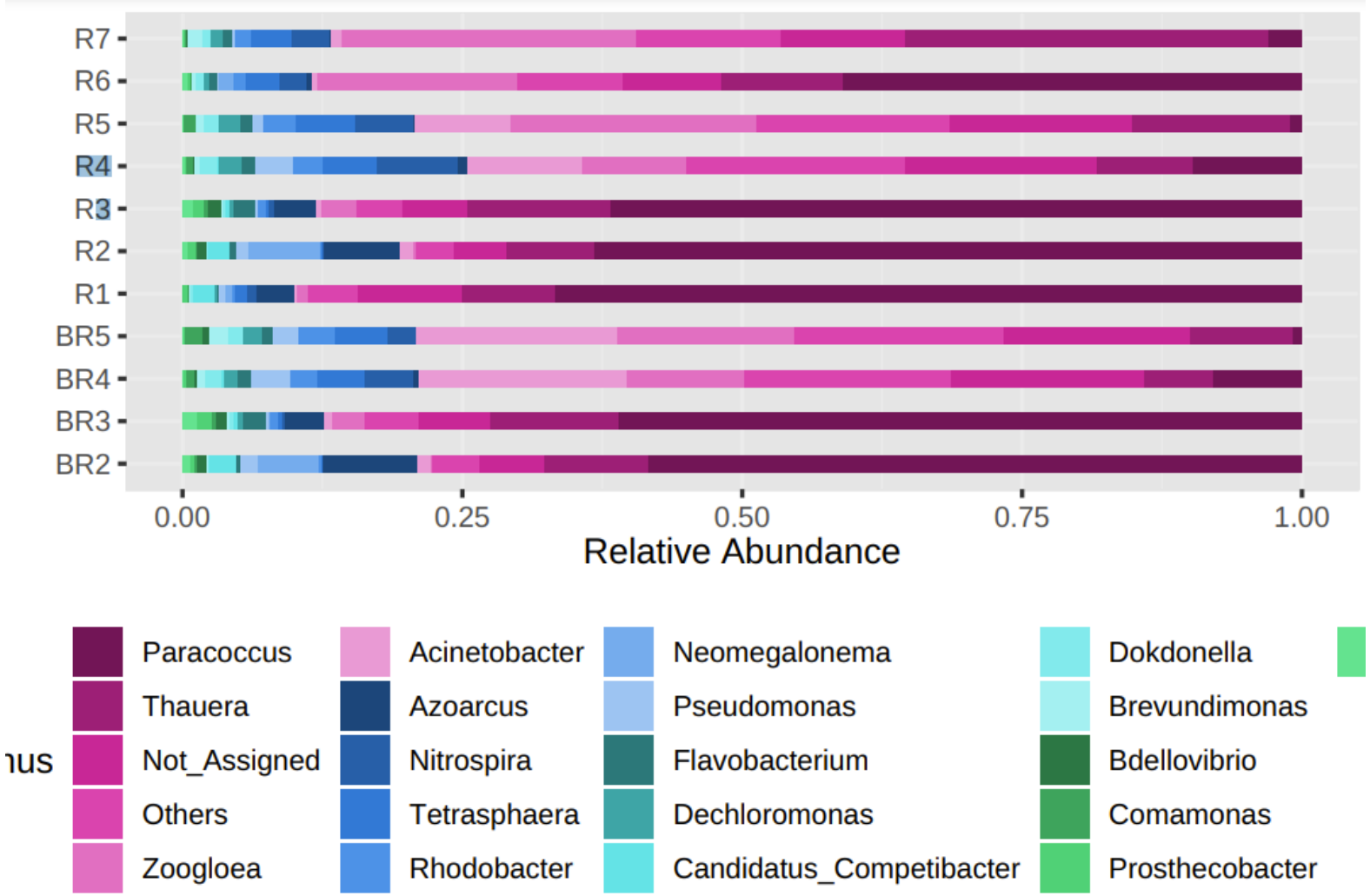






❖ So, what is the cause of this decline?

Effects of different fibre concentrations on AGS.

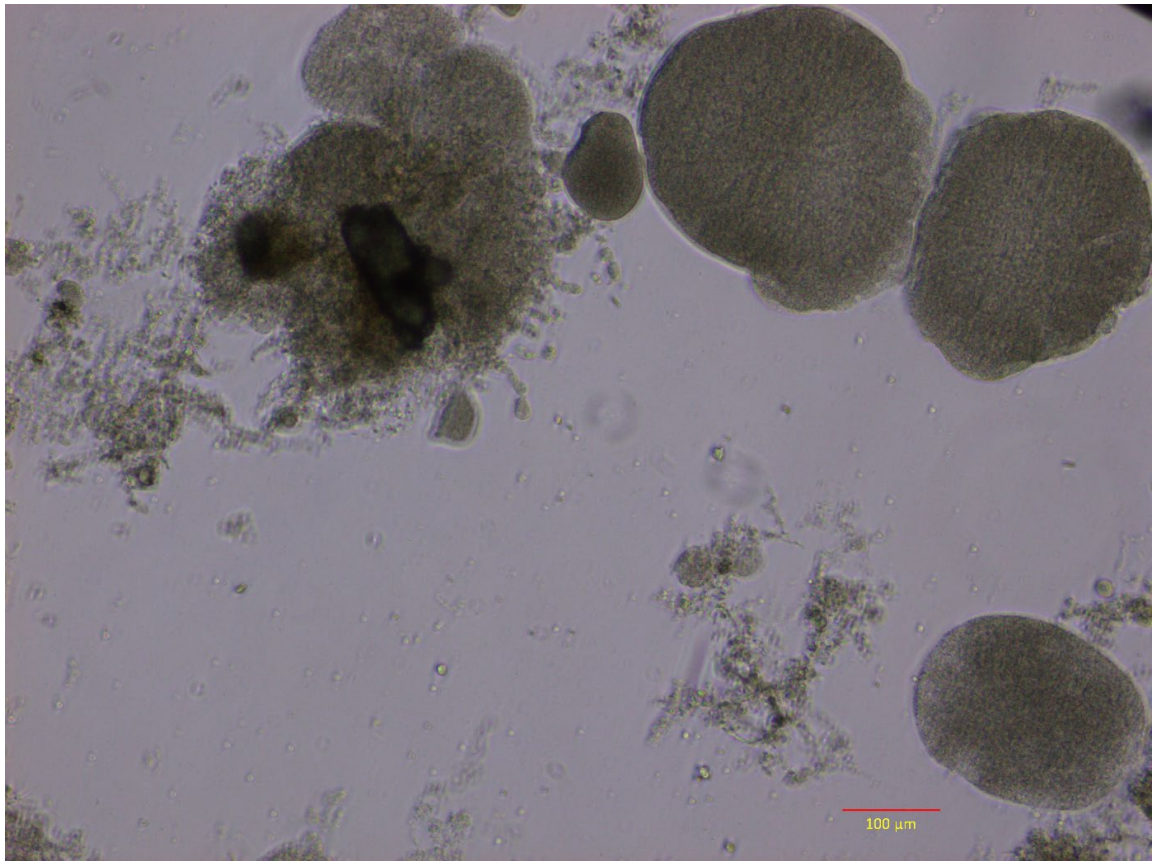


High diversity associated with granulation

Abundances of the microbial community at the genus level (R7 = SBR-0, R6 = SBR-10, R3 = SBR-70, R5 = SBR-210, R4 = SBR-1500, BR3= biofilm from SBR-70, BR4 = biofilm from SBR-1500 & BR5 = biofilm from SBR-210)

Paracoccus, Thauera and Zoogloea (580,606,615,600,657)

MF Removal Efficiency: AGS



AGS 98-99%

SBR - 70 99%

SBR - 210 99%

SBR - 1500 98%

MF Removal efficiencies for SBR-70, SBR-210 and SBR-1500

Removal of microplastics in different treatment stages of various WWTPs in chosen Studies.

Preliminary/ Primary Treatment/ % Removal	Secondary Treatment/ % Removal	Advanced Treatment/ % Removal	Primary & Secondary Treatment/ % Removal	Primary / Secondary & Tertiary/ % Retention	Location	Source
SGGRS	AS	NA	99.9%	NA	Lysekil, Sweden	(Magnusson and Norén 2014)
SGGRS **78%**	AS 20%	NA	98.41%	NA	Glasgow, UK	(Murphy et al. 2016)
SGGRSS **NS**	NS	GF	NS	96%	Saxony, Germany	(Mintenig et al. 2017)
SGGRS **NS**	AS NS	MBR,DAF,RSF,DF >95%	NS	86.1%	Finland	(Julia Talvitie, Mikola, Koistinen, et al. 2017)
SGGRS	AS	GF 20%	64%	84%	Northern Italy	(Magni et al. 2019)
SGGRS **40.7%**	AS 23.7%	NA	64.4%	NA	Wuhan, China	(Liu et al. 2019)
SGGRS **NS**	Oxidation ditch(AS) NS	MBR NS	53.6%	82.1%	Wuxi, China	(Lv et al. 2019)

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Conclusion.

- High fibre concentrations impact WW treatment.
- AGS exhibited high removal efficiencies.
- Increased alpha diversity
- Fibre-degrading microorganisms were observed
- It provides better treatment and nutrient removal inspite of high fibre loads
- Source control and more research with the aim of developing more effective ions are crucial.

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Funding

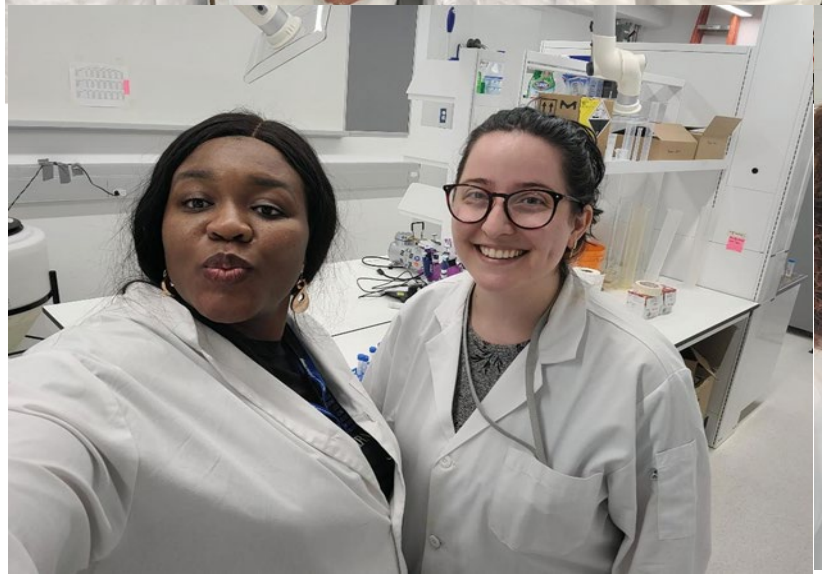
- Queen Elizabeth II – Graduate Scholarship in Science and Technology (QEII-GSST) 2021-2022, 2022-2023.
- George Vari friendship award in honor of President Lachemi 2021/2022 (Diversity).

Real AGS Plants in the USA

www.Aqua-aerobic.com

Appreciation



Appreciation








Thank you for listening

Questions ?