Optimization of combined UASB and continuous-flow SBR for sludge and gas production

Abdelsalam Elawwad, PhD

Cairo University, Egypt

the international water association

13th IWA Specialized Conference on Small Water and Wastewater Systems

5th IWA Specialized Conference on Resources-Oriented Sanitation

Introduction

- **UASB** is an attractive alternative for small wastewater systems
- **Advantages:** Low-cost, reliable, energy recovery, and low excess sludge production.
- **Disadvantages:** Low organic removal efficiency, and removal of ammonia is difficult.
- **Secondary treatment** of UASB's effluent is required to meet the effluent quality standards.
- A variety of post-treatment methods have been investigated in the literature.
- **Sequencing batch reactors (SBR)** is the most promising solution among these systems.

Introduction

- **SBR** has a great interest for wastewater treatment
- **Advantages:** Simple configuration, operational flexibility, high removal efficiency.
- **Disadvantages:** Complicated control, equalization, two reactors, unequal organic and hydraulic loading, ….ect.
- Some of these disadvantages can be overcome by using **continuous-flow Sequencing Batch Reactor (CSBR).**
- **CSBR** allows for continuous flow, less complicated control, simple configuration compared to a conventional SBR.
- This is an advantage in small and decentralized wastewater systems.

Objectives

First,

- **Assess** the capability of using an integrated UASB-CSBR system to meet standard effluent quality in Egypt.
- **Optimize** this system with regard to Hydraulic Retention time (HRT) and Cycle time.

Second,

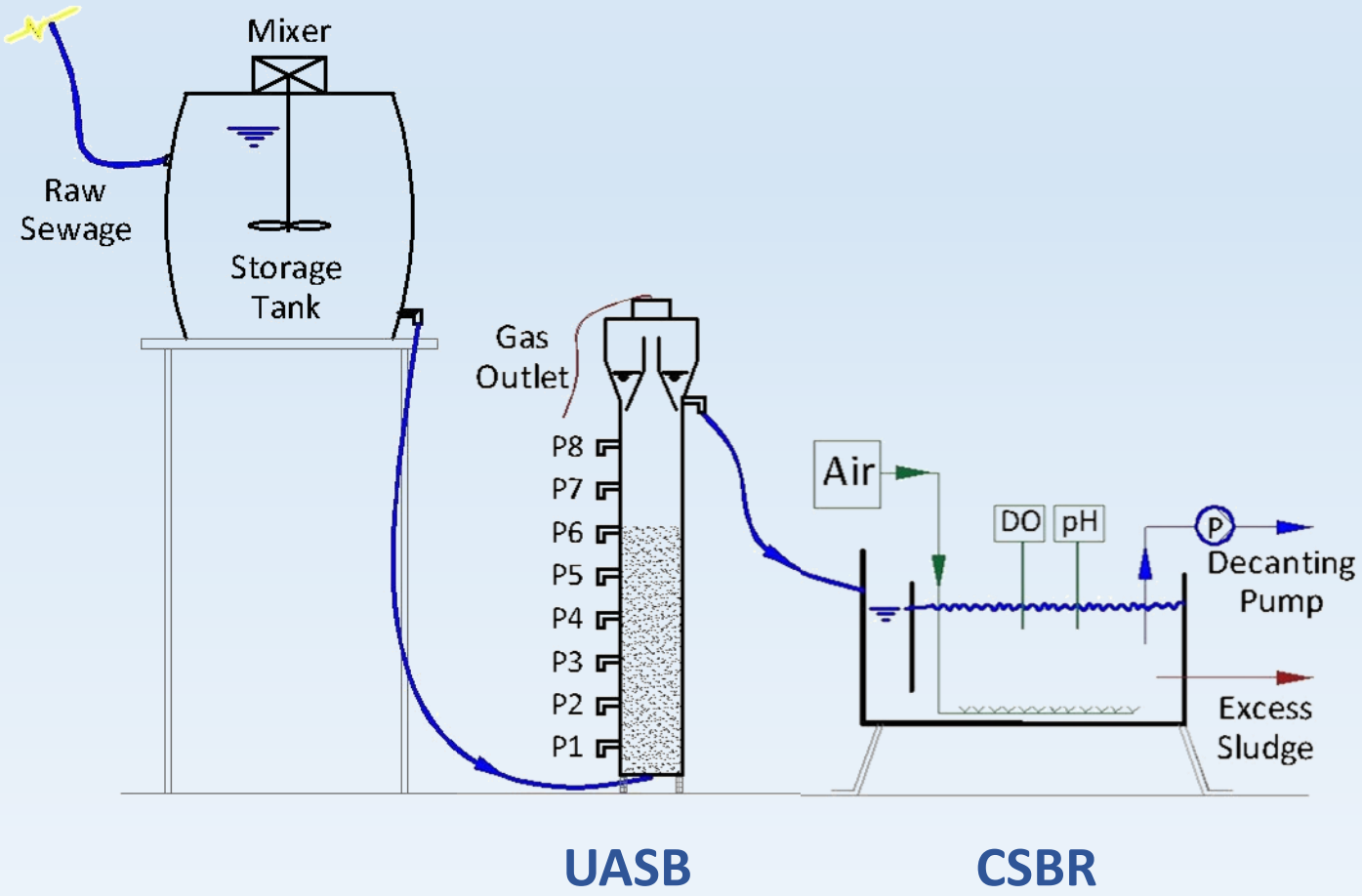
- Testing **waste sludge recycling** through the inlet of UASB.

Hypothesis:

- Use of UASB as an anaerobic pretreatment and a waste sludge digestion step.
- Decrease sludge production and increase biogas production.

Experimental Work

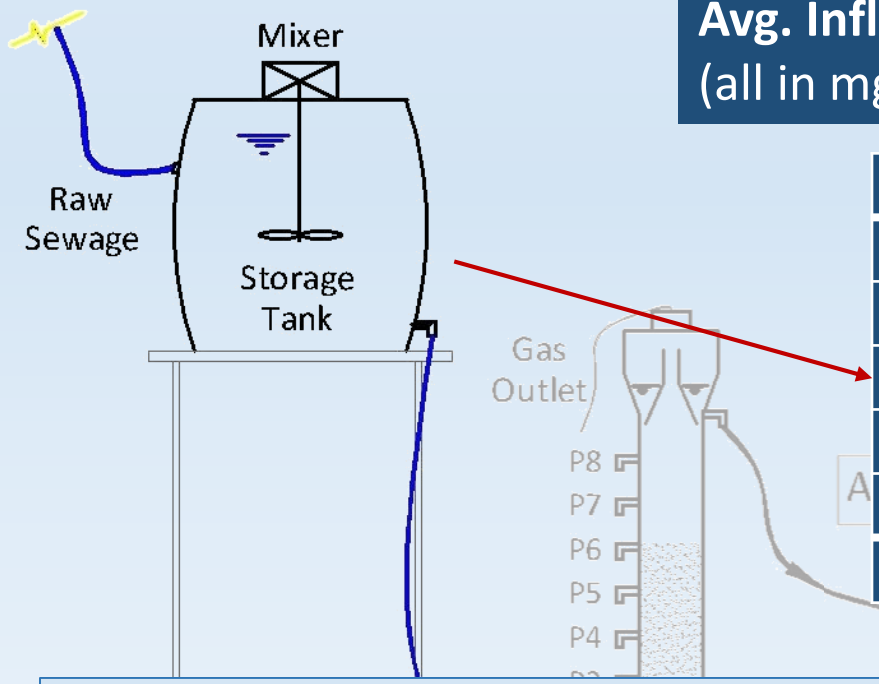
- Pilot plant at El-Berka WWTP, Cairo, Egypt.



Schematic diagram of the combined UASB and CSBR

Experimental Work

- Pilot plant at El-Berka WWTP, Cairo, Egypt.



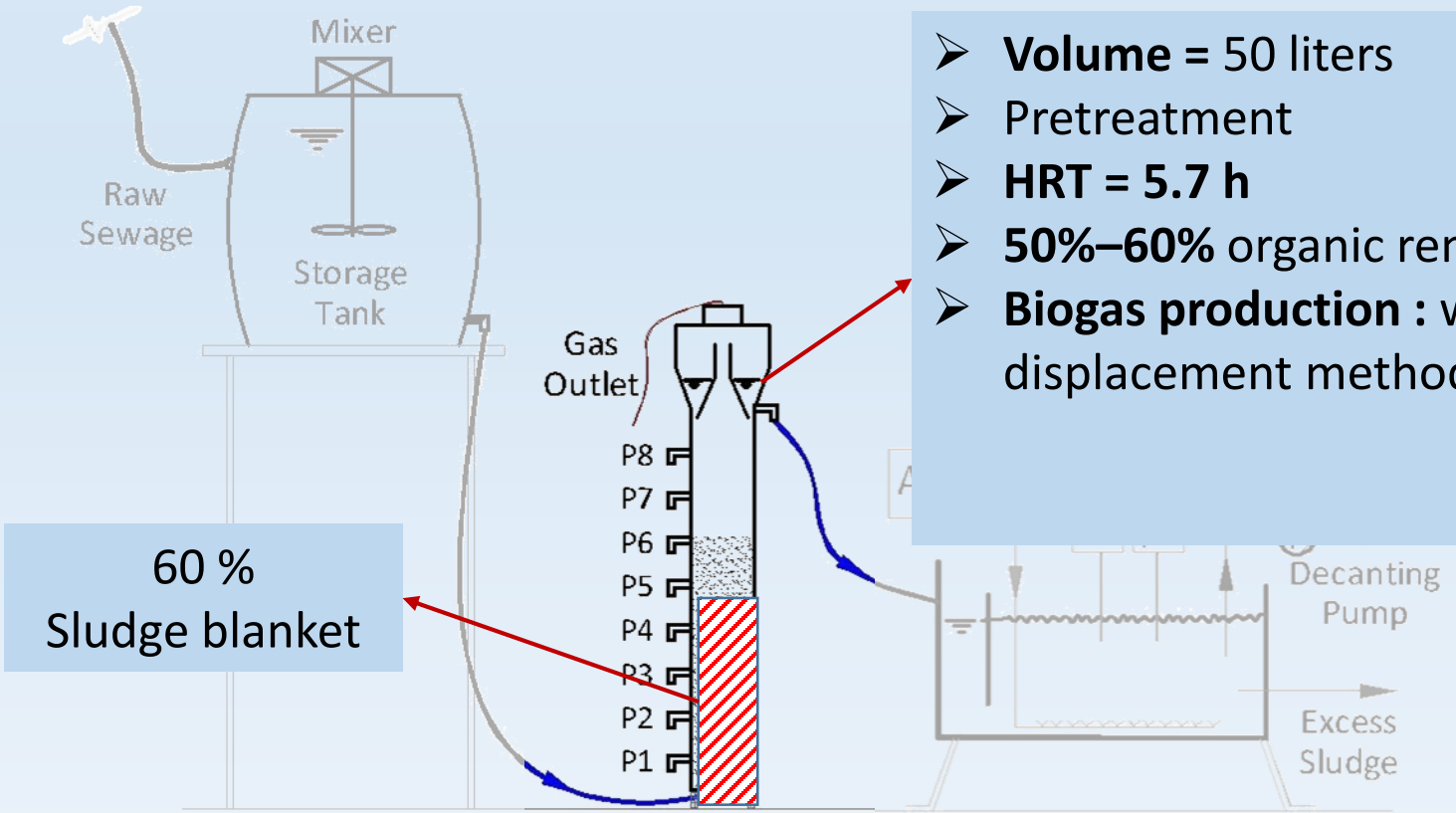
Avg. Influent wastewater characteristics (all in mg/l, except for pH)

Parameters	Avg.
pH	7.5
COD	452
BOD	288
TSS	233
TKN	49
NH_4–N	28

- Raw wastewater is coleclted after the grit removal chamber
- medium-strength wastewater from different rural areas.
- The storage tank is filled daily

Experimental Work

- Pilot plant at El-Berka WWTP, Cairo, Egypt.



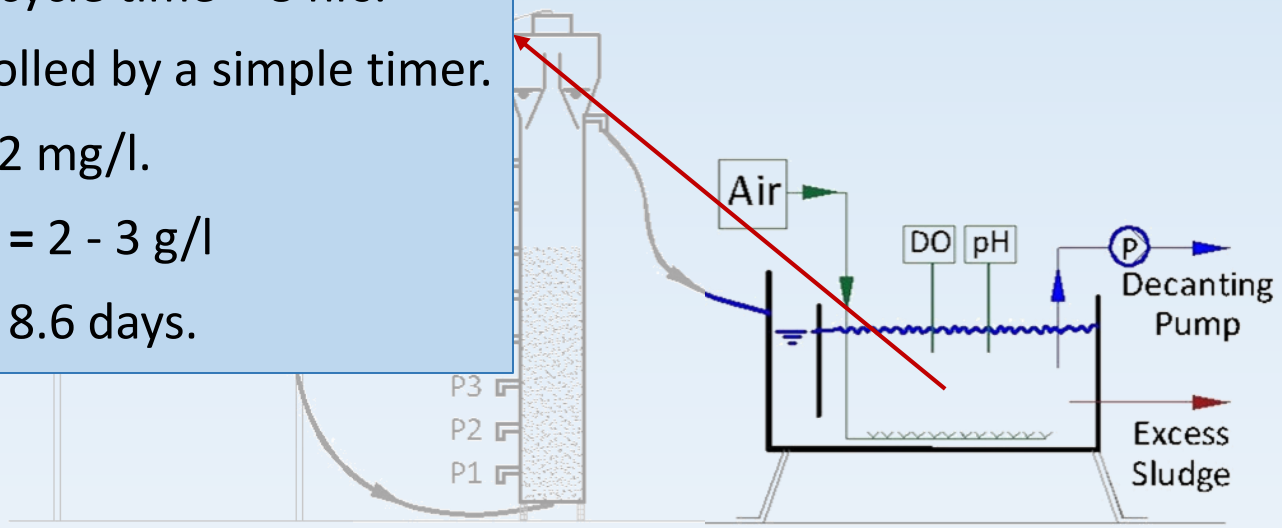
- **Volume =** 50 liters
- Pretreatment
- **HRT = 5.7 h**
- **50%–60%** organic removal
- **Biogas production :** water displacement method

UASB

Experimental Work

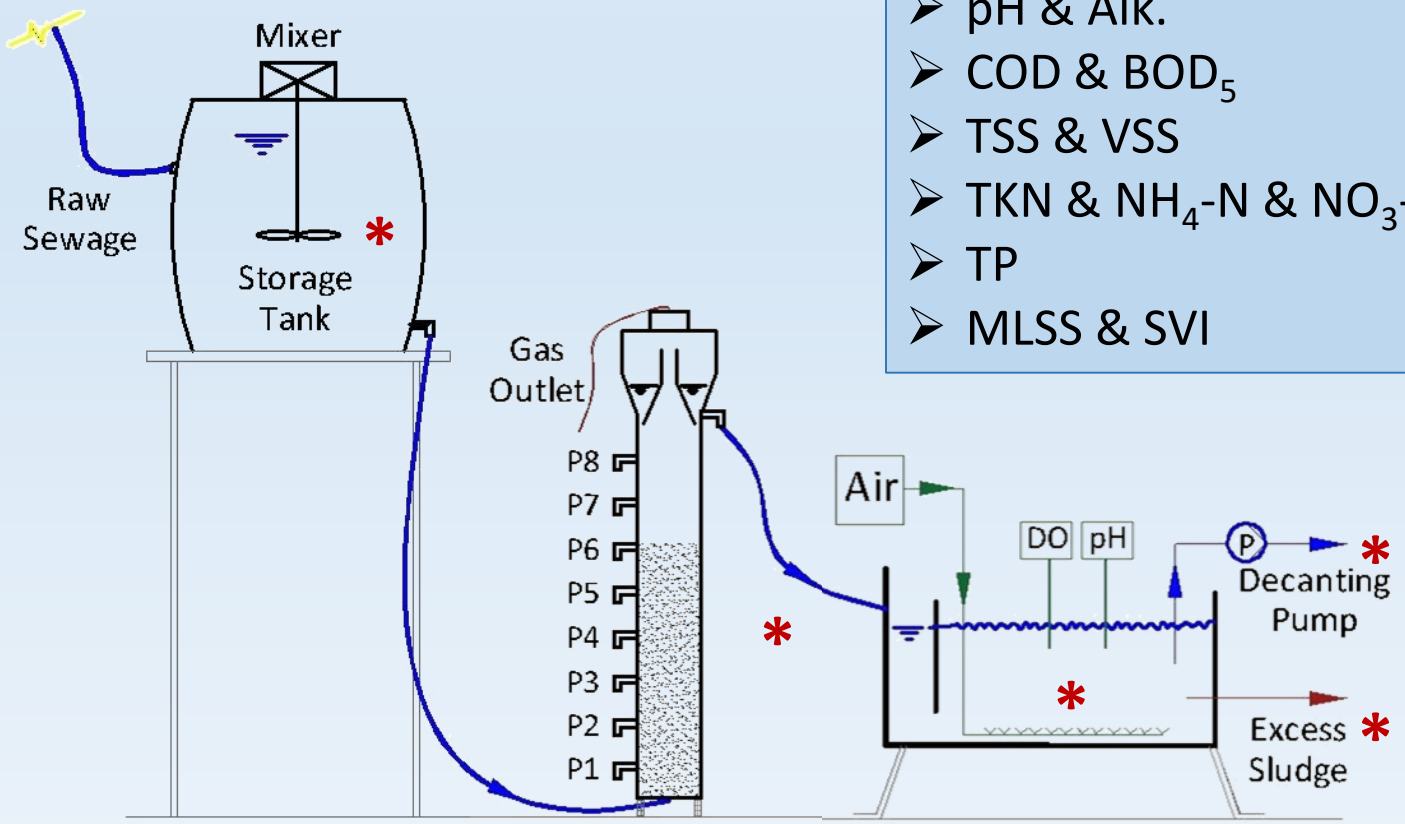
- Pilot plant at El-Berka WWTP, Cairo, Egypt.

- **Volume =** 180 Liters
- **15 %** pre-react
- **40 %** Fill percentage
- **T**otal cycle time = 8 hrs.
- controlled by a simple timer.
- **DO** > 2 mg/l.
- **MLSS =** 2 - 3 g/l
- **SRT =** 8.6 days.



CSBR

Experimental Work



Measured parameters:

- pH & Alk.
- COD & BOD_5
- TSS & VSS
- TKN & NH_4-N & NO_3-N & NO_2-N
- TP
- MLSS & SVI

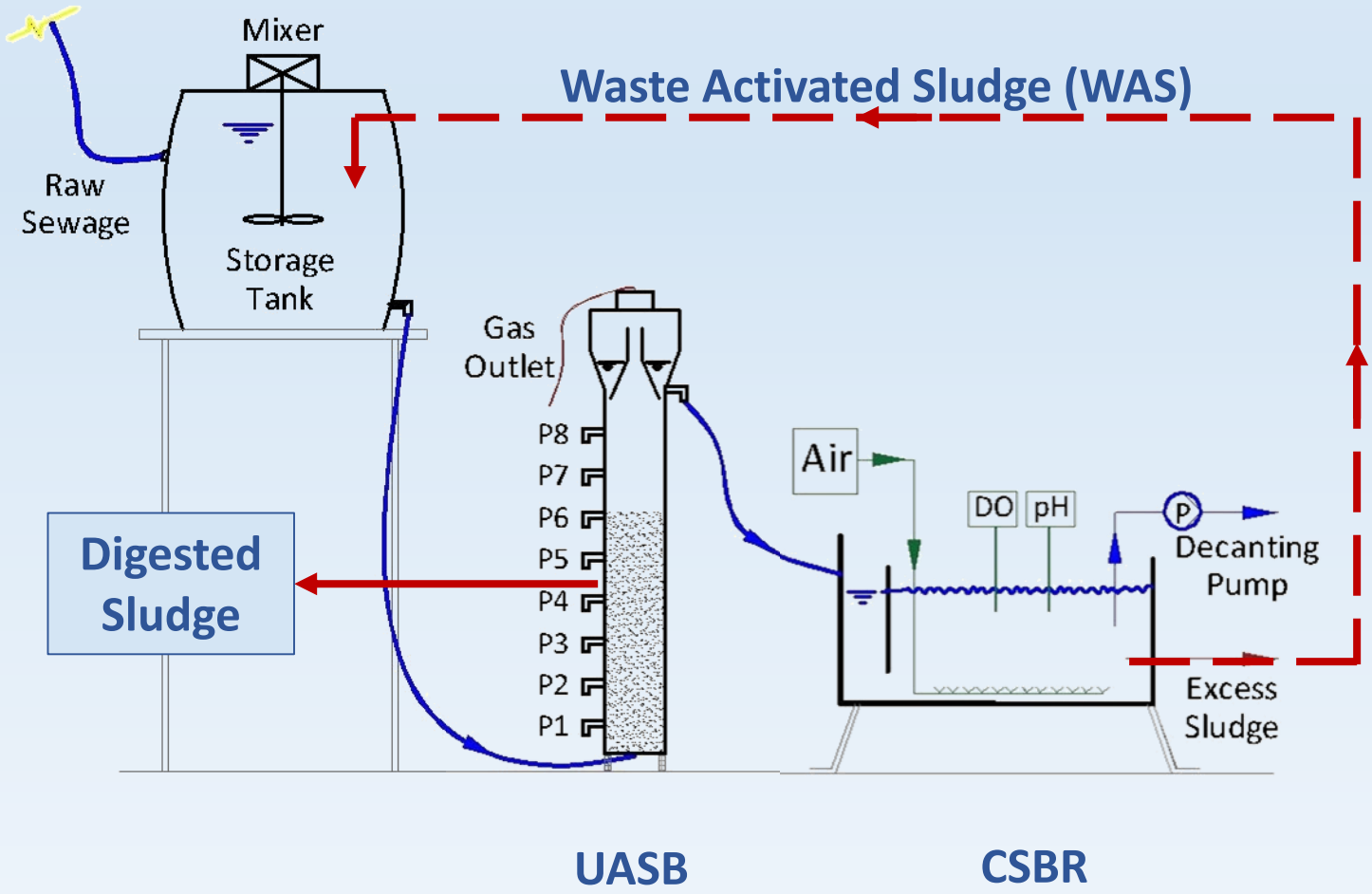
* Sampling Points

Experimental Work

Photos for the combined UASB and CSBR

Experimental Work

➢ Waste Sludge Recycling



Experimental Work

- Operating conditions throughout the study

Parameters	without Sludge Recycling ~ 4 months		with Sludge Recycling ~ 4 months	
	Range	Avg.	Range	Avg.
Temp °C	19 - 28	22.7	20 - 29	24.3
Flow rate (l/d)	187 - 223	212	191 - 218	204
HRT in UASB (hr)	5.4-6.4	5.7	5.5-6.3	5.9
OLR (kg COD/m^3/d)	1.3-2.9	2.1	1.2-2.4	1.7
DO in SBR	1.9 – 2.8	2.2	2.1 – 2.7	2.4

Results

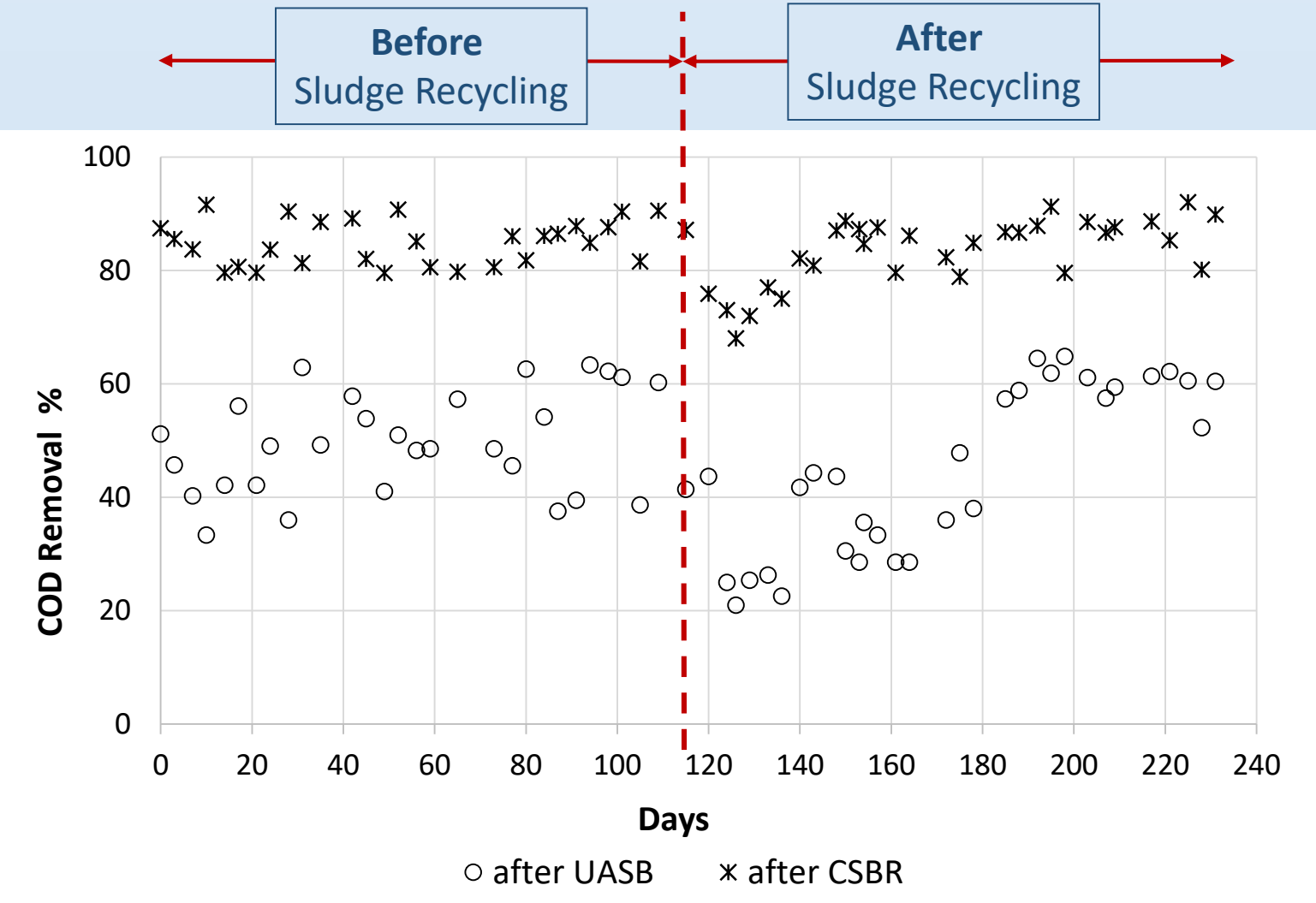


Figure: COD Removal Efficiency % after UASB and SBR treatment

Results

- Overall **COD & TSS & ammonia** removal efficiencies were **85%, 87%,** and **82%,** respectively.
- System was **stable** under variable organic and nitrogen loads.
- Removal efficiencies was comparable to literature.
- **No significant impact** on the treatment efficiency due to sludge recycling.
- Based on SS measurements, **50 - 60% reduction in sludge** can be achieved and about **35 % increase in biogas production** using sludge recycling approach.
- Sludge from UASB, VSS/TSS ratio was 0.6 in average which indicates well stabilized sludge.

Conclusion

- Removal efficiencies about **85% for COD, TSS and ammonia** can be achieved .
- The proposed UASB-CSBR system could be a promising and cost-effective option for treating wastewater in small and decentralized wastewater systems.
- The sludge recycling approach proposed in this study was helpful in **reducing sludge production and increasing gas production** with no significant impact on removal efficiency.
- **Further investigations** on the effect of sludge recycling approach on sludge characteristics and dewaterability is required.
- Longer period of investigation with detailed sampling program could be required.

Thank You

for your attention