Advanced Nitrogen Removal Configuration with MBR Application for Water Reuse

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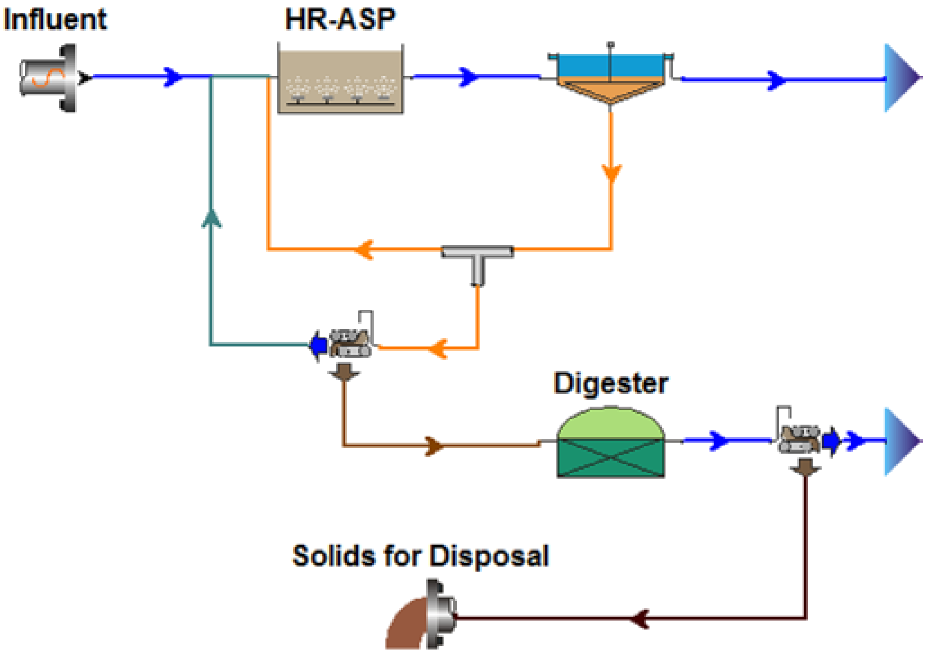
Outline

- **Seeking a sustainable N removal / water-reuse system**
  - COD removal – energy recovery
  - Efficient N removal (without C addition or depending on influent C)
- **Advanced nitrogen removal**
  - Nitrite shunt & Deammonification
  - NOB washout
- **High rate ASP ➔ Deammonification – MBR system**
  - Sidestream + mainstream nitritation-deammonification
  - Sidestream nitritation + mainstream deammonification

Emphasis on sustainability, energy neutrality



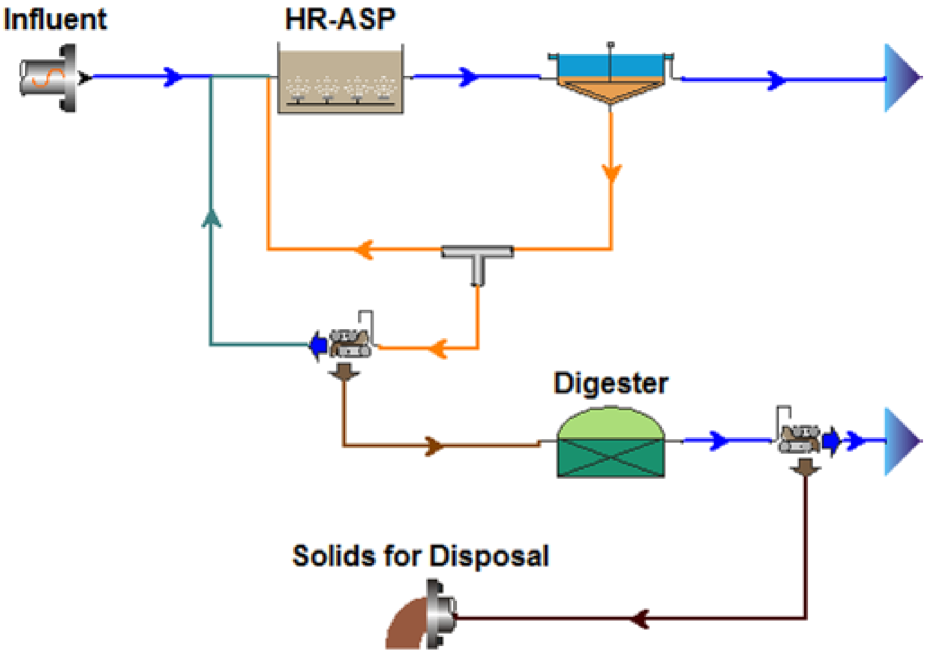
COD removal

- **HR-ASP system**
  - Impact of SRT

SRT (Day)	COD oxidized in HR-ASP (kg/d)	COD in overflow (kg/d)	COD sent to digester (kg/d)	Methane production (m^3/kg influent COD)	% (COD CH4/ influent COD)
0.50	1,215	2,087	8,699	0.192	49.4%
0.75	2,050	1,439	8,512	0.176	45.3%
1.00	3,030	1,186	7,783	0.143	36.9%

SRT (Day)	HR-ASP overflow (% of TN)	Stream to digester (% of TN)
0.50	67%	32%
0.75	62%	38%
1.00	57%	41%

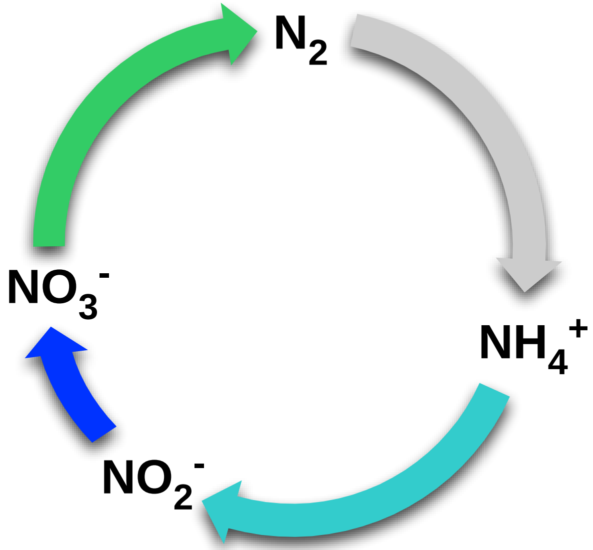
Emphasis on sustainability, energy neutrality



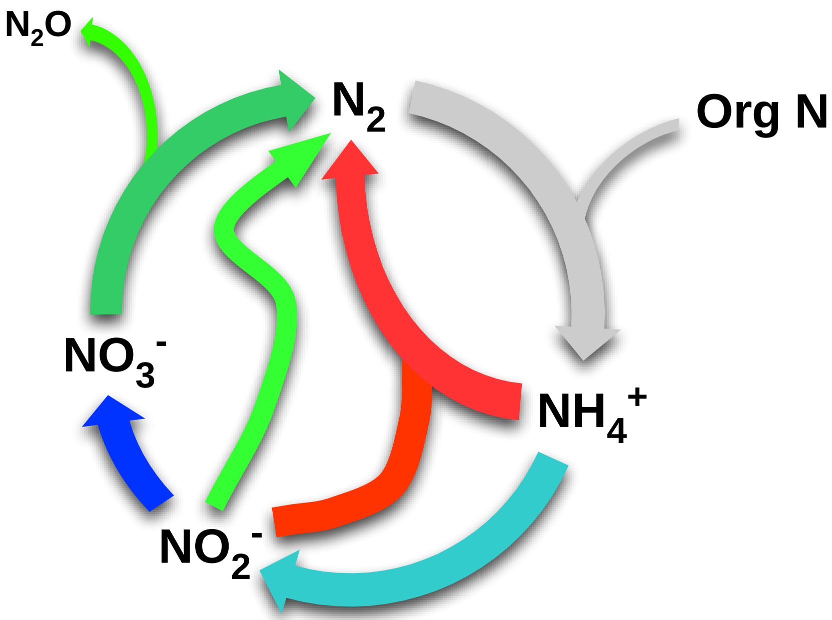
NH_3
Low bCOD

High NH_3
No bCOD

N Removal



N Removal

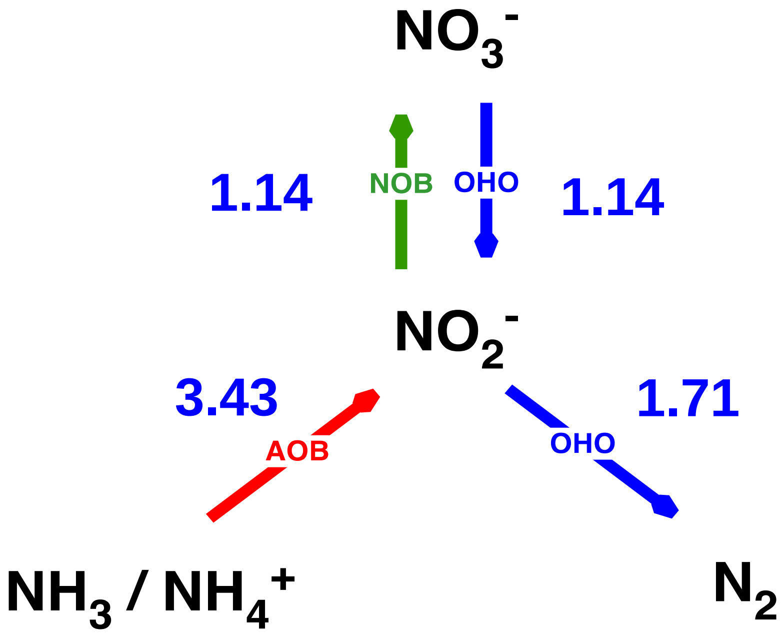


Nitrogen Removal

- **Shortcut N removal (Nitrite shunt)**
  - Reduce oxygen demand
  - Reduce C requirements
- **Deammonification**
  - Small oxygen demand
  - No C requirement

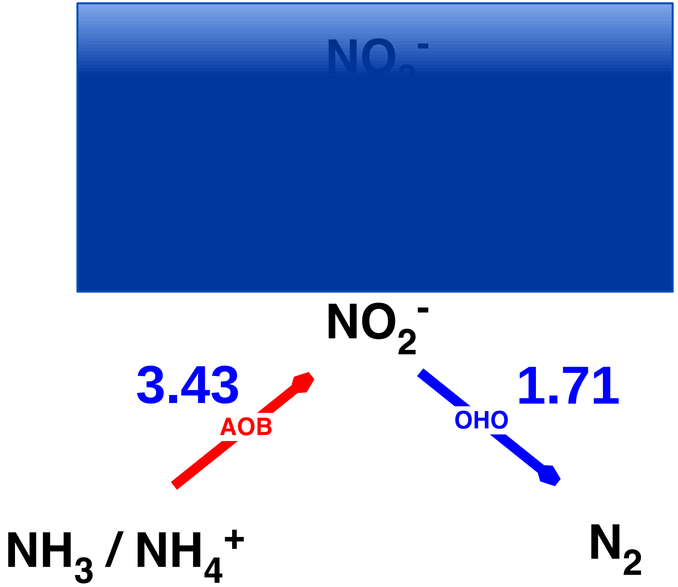
Nitrification and Denitrification

- Oxygen requirements



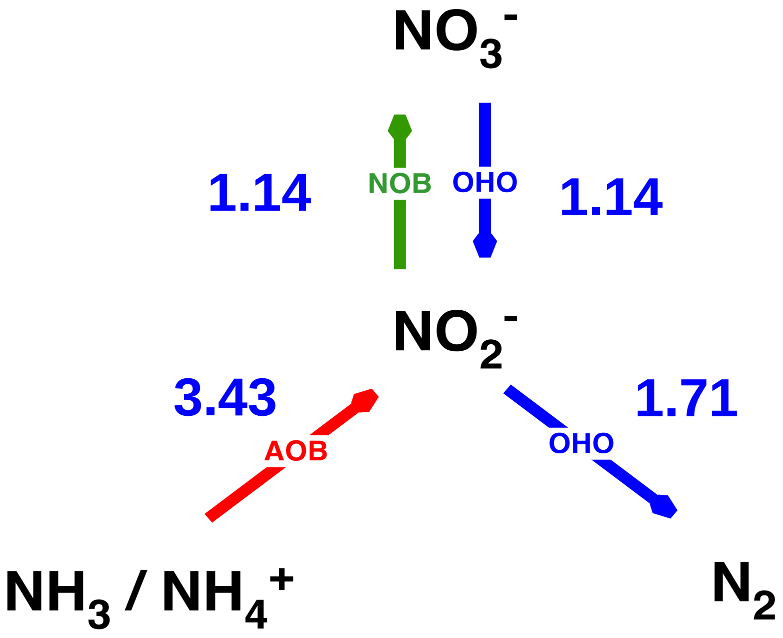
Nitrification and Denitrfication

- **Nitrite Shunt**



Nitrification and Denitrfication

- Nitrite shunt – no benefit if influent C available



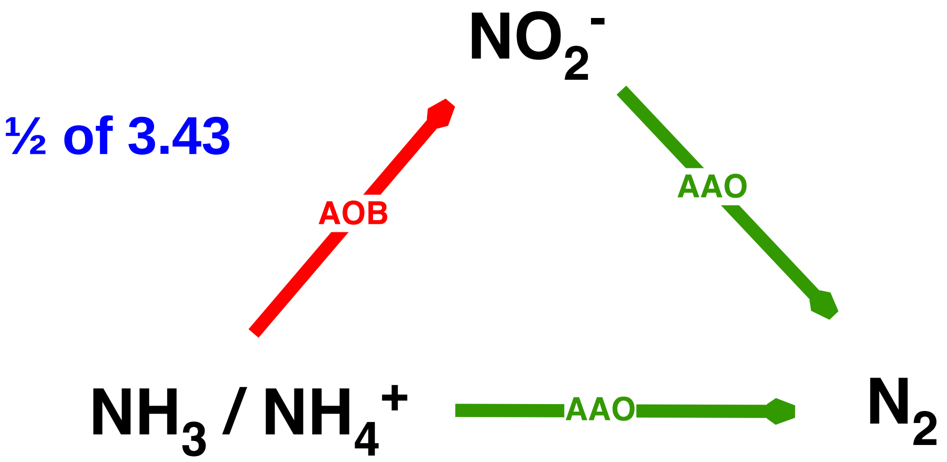
Full nite-denite:

Spend	4.57
Credit	2.86
Net cost	1.71

Nitrite shunt:

Spend	3.43
Credit	1.71
Net cost	1.71

Deammonification



NOB Washout

- **Presented as a kinetic control issue**

$$\frac{1}{f_A \cdot m_{AOB} - b_{AOB}} < SRT < \frac{1}{f_A \cdot m_{NOB} - b_{NOB}}$$

NOB Washout

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$$\frac{1}{f_A \, . \, m_{AOB} - b_{AOB}} < \quad SRT \quad < \frac{1}{f_A \, . \, m_{NOB} - b_{NOB}}$$

$\mu_{AOB} = f(NH_3, DO, T, \ldots)$

$\mu_{AOB} = f(NO_2, DO, T, \ldots)$

+ FA inhibition

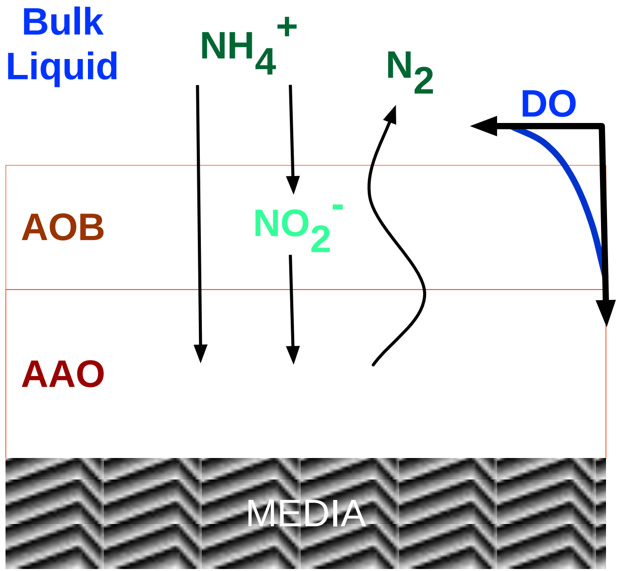
+ FNA inhibition

NOB Washout

- **Sidestream treatment (e.g. centrate)**
  - High NH_3, high T
  - Control DO and SRT/HRT
    - NOB washout
  - Integrate deammonification
    - On/off aeration
- **Mainstream treatment**
  - Some factors not available
    - FA, FNA inhibition, lower T

NOB Washout

- **Attached growth biofilm**
  - Nitritation
  - Deammonification
- **Findings / possible benefits**
  - Easy to implement sidestream AAO
  - Seed mainstream from sidestream
  - Online control simple
  - IFAS-type configurations favoured
  - Biomass retention crucial
    - MBR



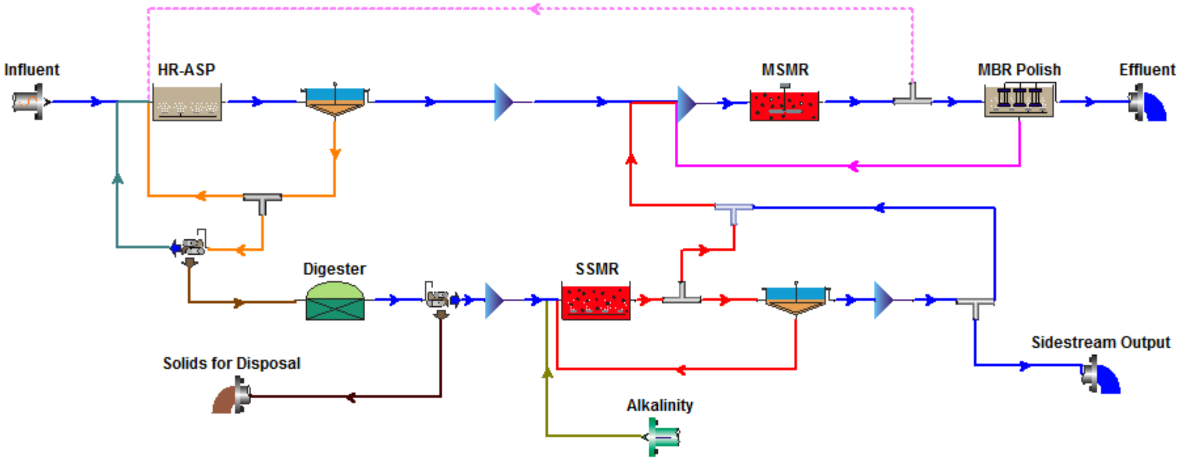
Basis of Efficient C and N Removal Schemes

- **High Rate Activated Sludge**
  - COD removal – energy recovery
- **Sidestream Media Bioreactors**
  - Handling dewatered digestate
- **Mainstream Media Bioreactors – Deammonification**
  - Seeding of AOB and/or AAO from sidestream
- **Membrane Bioreactor**
  - Polishing
  - Biomass retention - Effluent suitable for reuse

Deammonification – MBR configuration

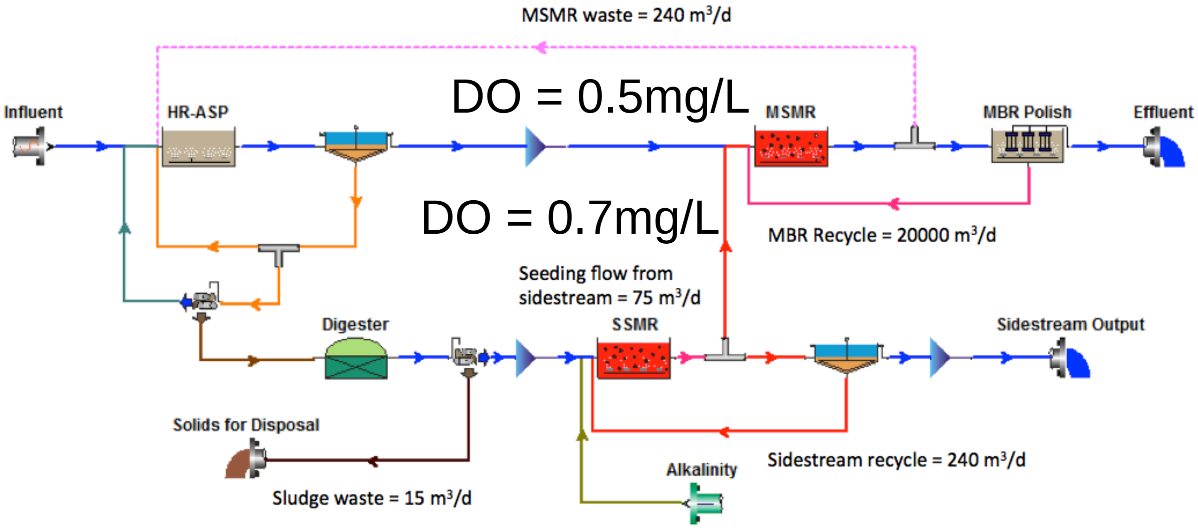
- **HR-ASP, Media Reactors, and MBR**
  - Compact, simple control strategy, energy efficient, and low N and solids-free effluent for water reuse.

Influent flow rate 24,000m^3/d, COD 500mg/L, TKN 40mgN/L.



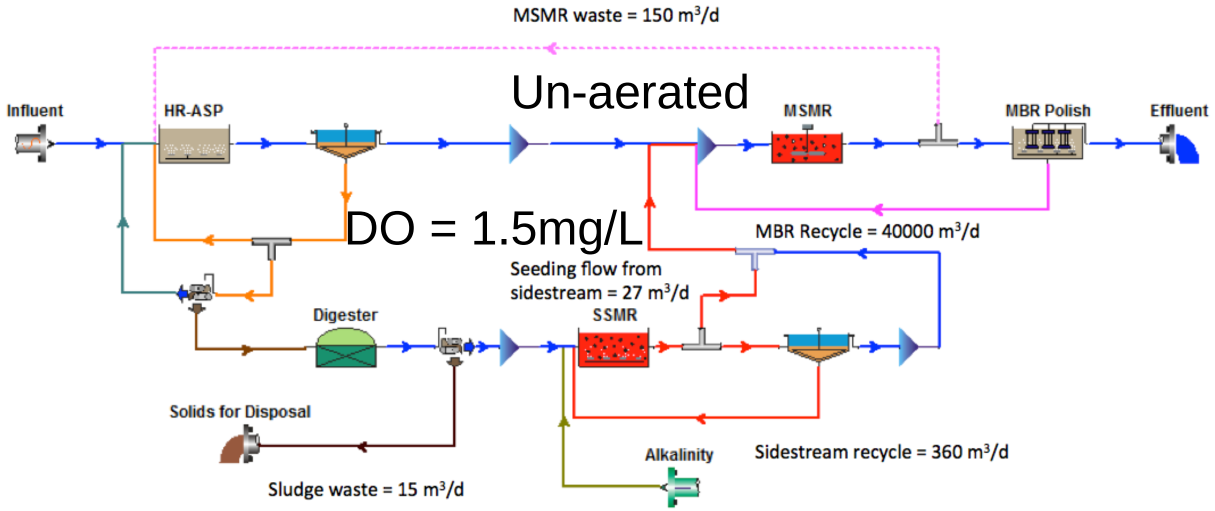
Nitrogen Removal (1)

- **Deammonification in mainstream and sidestream**
  - MSMR and SSMR are two single-stage deammonification reactors
  - AAO seeding from SSMR to MSMR



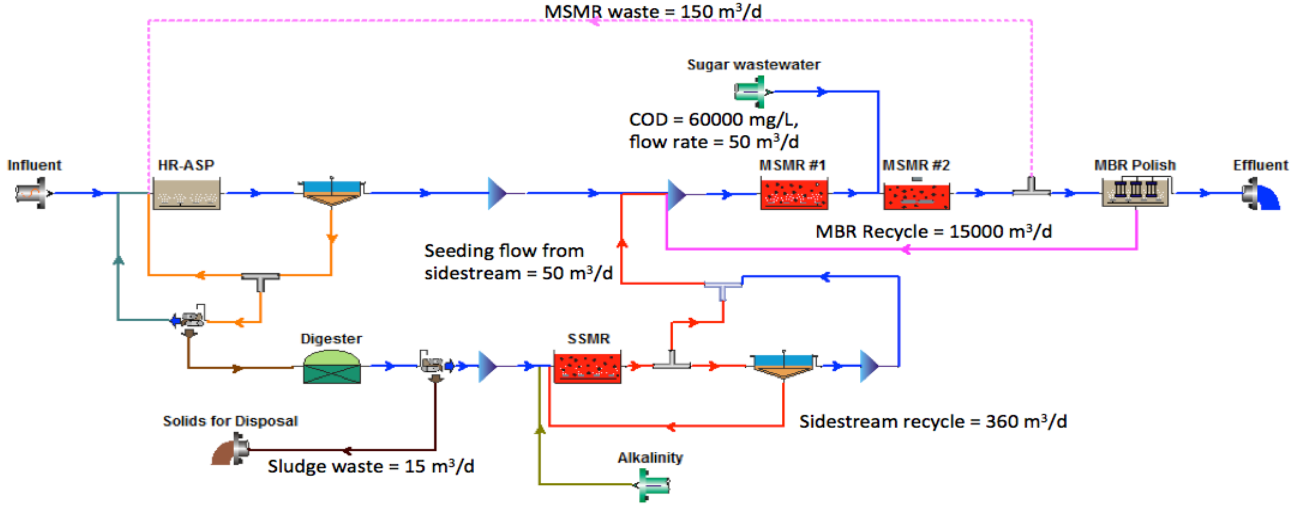
Nitrogen Removal (2a)

- **Sidestream nitritation and mainstream deammonification**
  - NOB washout in SSMR (DO = 1.5, SRT = 8 days)
  - Un-aerated MSMR favours the growth of AAOs



Nitrogen Removal (2b)

- **SSMR nitritation; MSMR deammonification & denitrification**
  - NOB washout in SSMR (DO = 2.5, SRT = 6.5 days)
  - Deammonification and nitrification in MSMR #1 (DO = 1)
  - Denitrification in MSMR #2 (un-aerated)



Conclusions

- **Energy-efficient advanced N and solids removal system**
  - HR-ASP to capture a large portion of influent COD
  - Maximized biogas generation in anaerobic digestion
  - Deammonification for N removal
  - MBR ensures a solids-free effluent – water reuse
- **Deammonification – MBR configuration**
  - TN in the effluent ~ 10 mgN/L (mainly NO_2)
- **Modified deammonification – MBR configuration**
  - TN in the effluent < 5 mgN/L (mainly NO_3)

Getting rid of NOBs

- **Mainstream treatment**
  - Kinetic and stoichiometric control