

# **A fundamental analysis of a membrane bioreactor containing a sludge disintegration system**

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# Overview of talk

- *Motivation.*
  - Treatment of domestic/industrial wastewaters
  - Why use a sludge disintegrator unit (SDU)?
- *Formulating the model*
- *Steady-states, stability and applications*
  - Investigate reactor performance as a function of design parameters.
  - Zero excess sludge production.
- *Conclusions*

S-H. Yoon. Important operational parameters of membrane bioreactor-sludge disintegration (MBR-SD) system for zero excess sludge production. *Water Research*, **37**:1921–1931, 2003.

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Treating excess sludge can account for 50–60% of the total operating costs in a wastewater treatment plant

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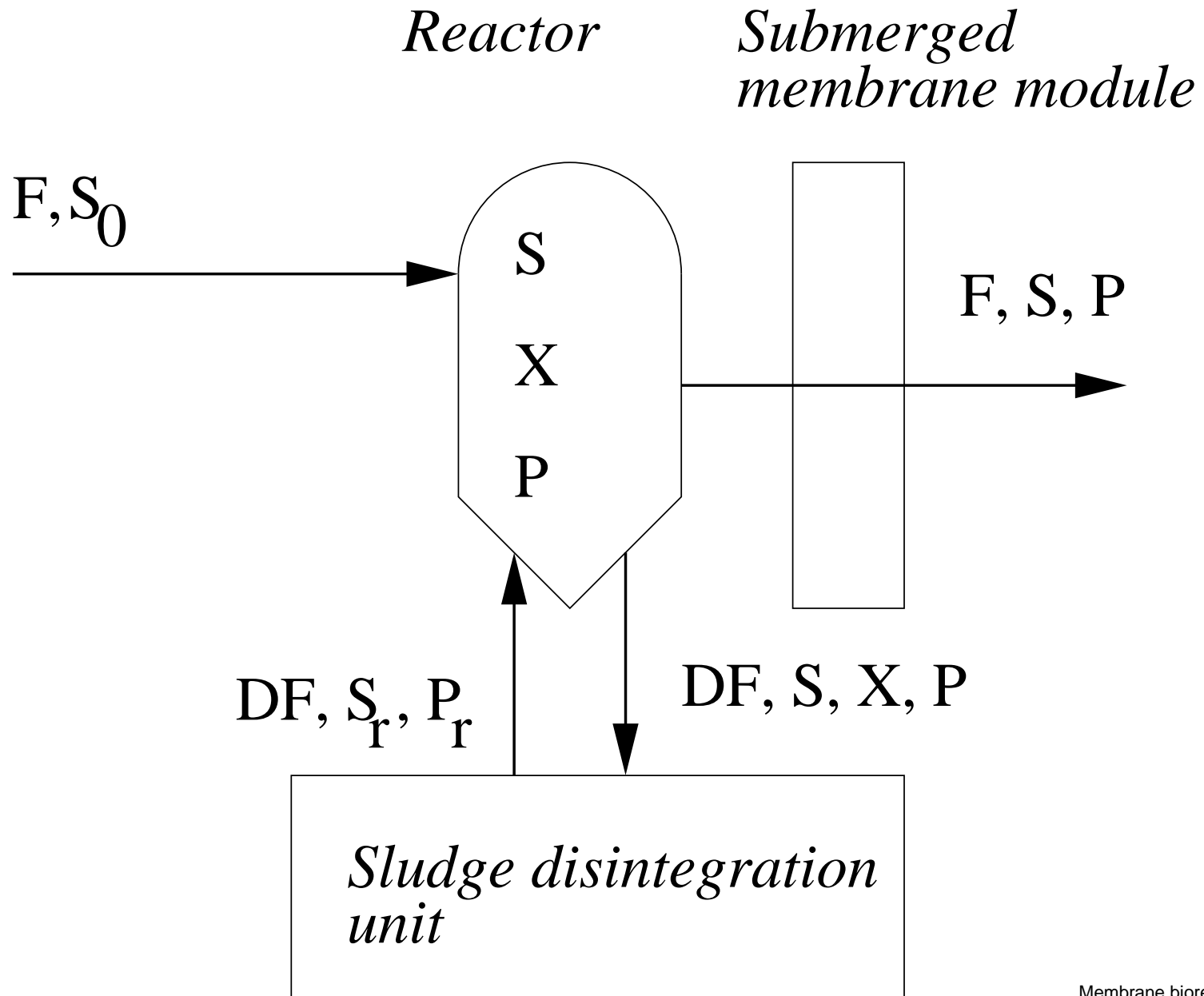
How to do it?

Increase the biodegradability of the sludge by disintegrating it (breaking the cell walls).



The mixture of substrate/particulates is returned to the reactor.

# Figure — MBR with SDU



# Scaled equations

$$\frac{dS^*}{dt^*} = \frac{1}{\tau^*} (S_0^* - S^*) + \frac{\alpha\beta^* D}{\tau^*} (X^* + P^*) + \beta^* k_h^* P^* - \frac{S^*}{1 + S^*} X^*,$$

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**effluent concentration**  $S^*$

**MLSS**  $X^* + P^*$

# Steady-state solutions

Washout branch

$$(S^*, X^*, P^*) = (S_0^*, 0, 0),$$

No-washout branch

$$(S^*, X^*, P^*) = \left( \hat{S}^*, \frac{S_0^* - \hat{S}^*}{(1 - \beta^*)D + k_d^* \tau^*}, \frac{(1 - \alpha)D}{\alpha D + k_h^* \tau^*} \cdot X^* \right),$$

$$\hat{S}^* = \frac{D + k_d^* \tau^*}{(1 - \beta^*)k_d^* \tau^* - D},$$

$$\text{MLSS}^* = X^* \cdot \frac{D + k_h^* \tau^*}{\alpha D + k_h^* \tau^*}.$$

# Large residence time approximation

$$S^* \approx \frac{k_d^*}{1 - k_d^*} + \frac{D}{(1 - k_d^*)^2} \cdot \frac{1}{\tau^*} + O\left(\frac{1}{\tau^{*2}}\right),$$

$$\text{MLSS}^* \approx \frac{(1 - k_d^*) S_0^* - k_d^*}{(1 - k_d^*) k_d^*} \cdot \frac{1}{\tau^*} + O\left(\frac{1}{\tau^{*2}}\right).$$

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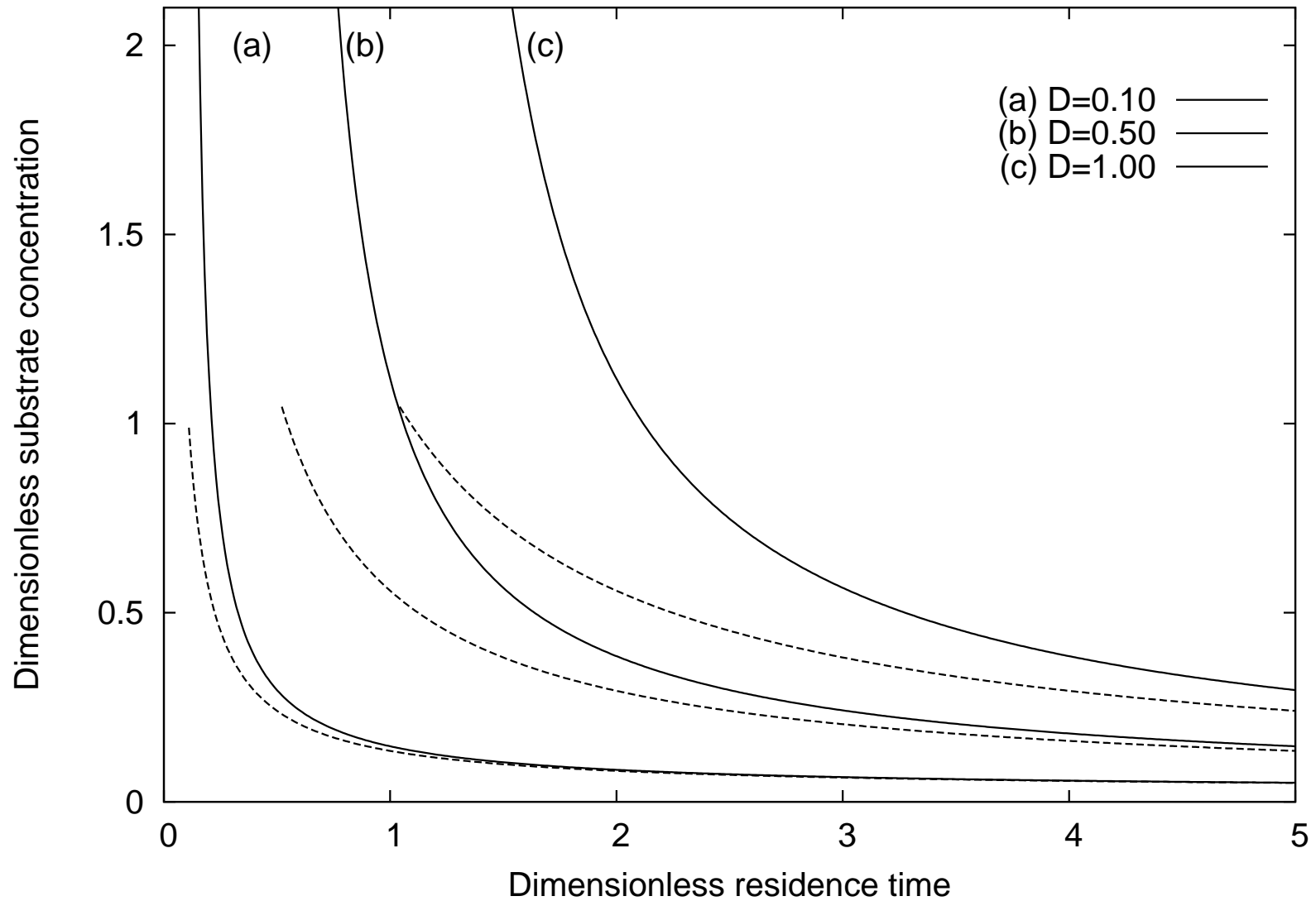
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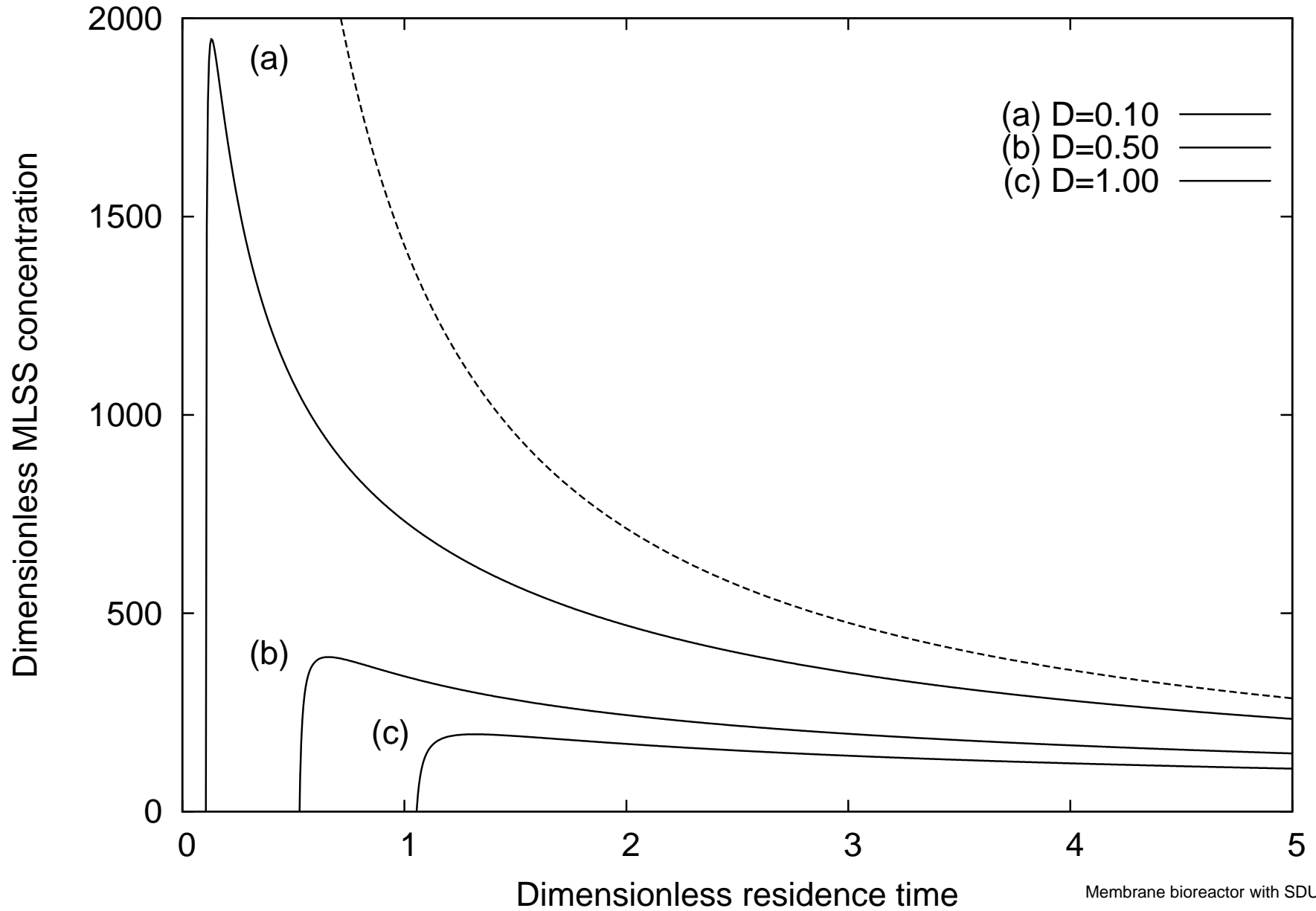
At large residence times:

- SDU slightly increase effluent concentration.
- SDU has no effect on MLSS.

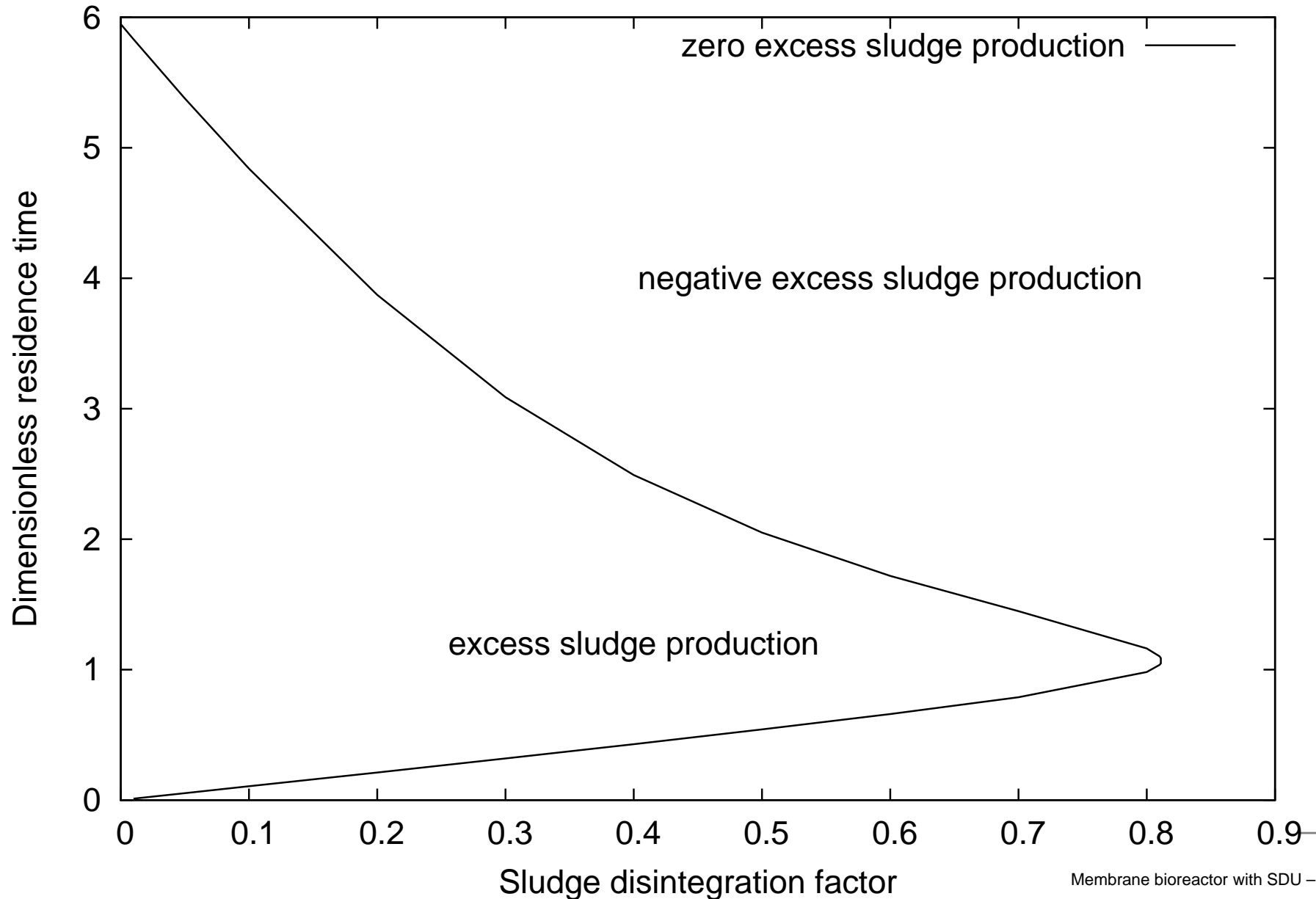
# Figure — effluent concentration



# Figure — MLSS



# Figure — zero excess sludge



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8. A good project!