

The background of the slide is a photograph of a dark, circular sewer pipe. A bright yellow rope is stretched across the frame, passing over the top of the pipe. In the center of the pipe, a camera lens is visible, suggesting an inspection or monitoring activity. The overall scene is dimly lit, emphasizing the interior of the sewer.

Sewers as Active Bioreactors: The Future of Urban Wastewater Management

Hiroyasu Satoh
The University of Tokyo, Japan

Self-purification in sewer?

- Streams have self-purification capacities.
- Sewers also have self-purification capacities. But it is too small when compared with pollutant loads.
- Can we make sewer self-purification capacity big enough to matter in sewage management?



We have found...

- By installing microbial attached media in sewer pipe ($\phi 150$), 2-3 g of organic pollutant as total oxygen demand can be removed per day in one meter pipe.
- If pipe length per capita is around 10m/capita, removal capacity will be 30g/d.



Removal capacity

3 g/m/d



100 g/c/d

Pollutant load generation



Contents

- Expected merit (example)
- How to enhance self-purification in sewer?
- Studies so far...
- Studies on-going
- Concluding remarks





Application to city center may not be suitable.

How about periphery of a growing city?

Step-by-step model



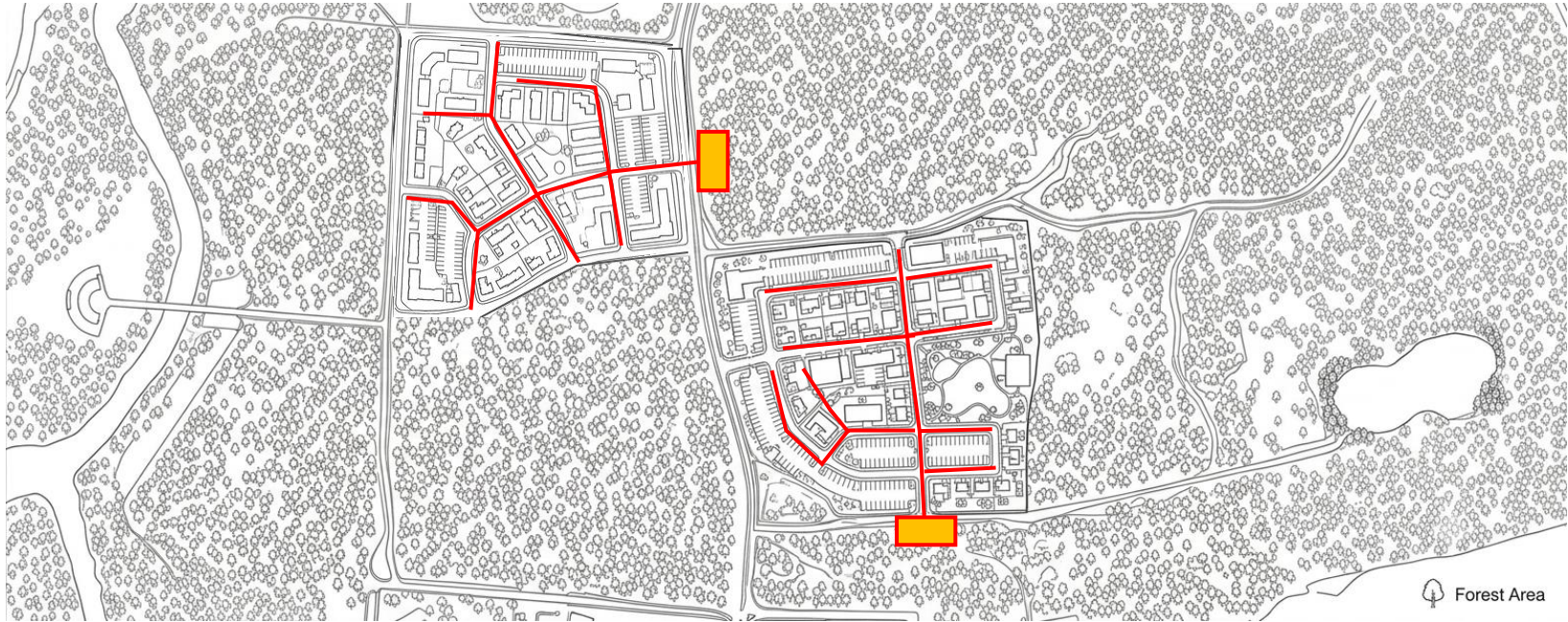
Step-by-step model

Pipe with enhanced sewer self-purification + polishing plant



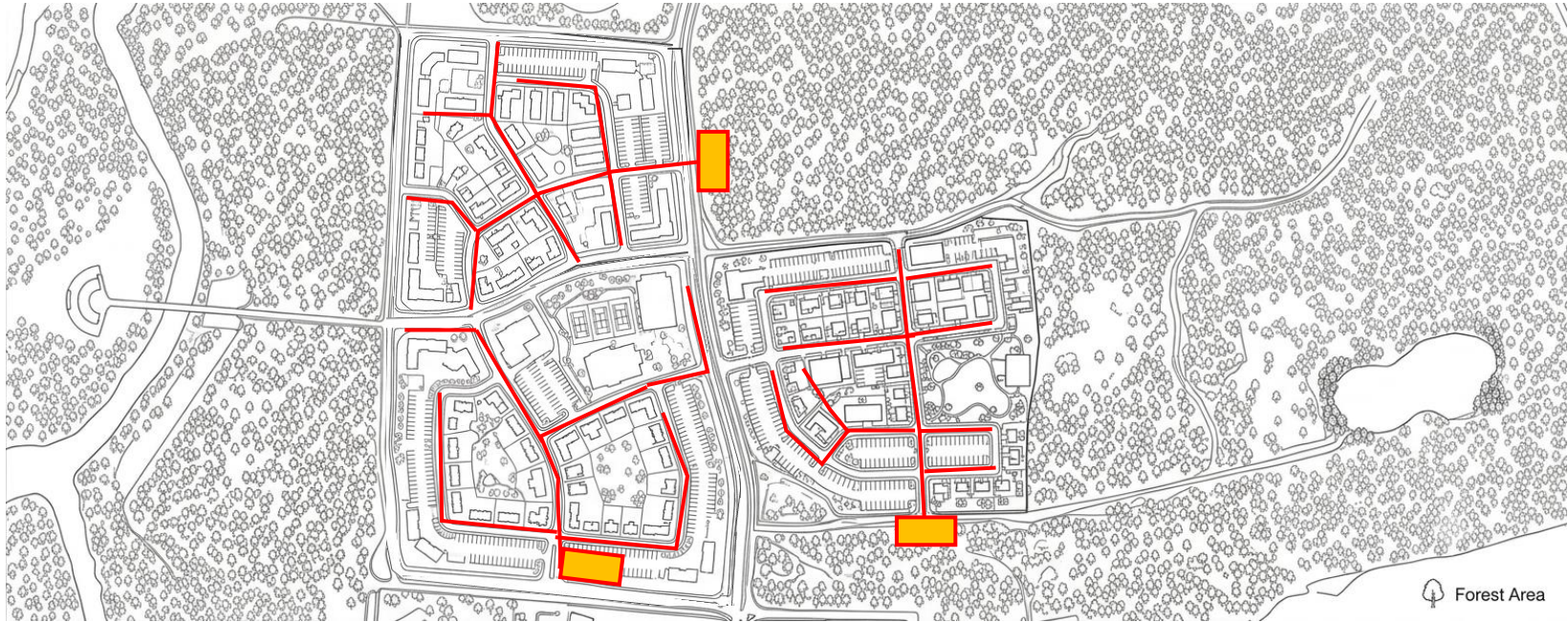
Step-by-step model

Another development



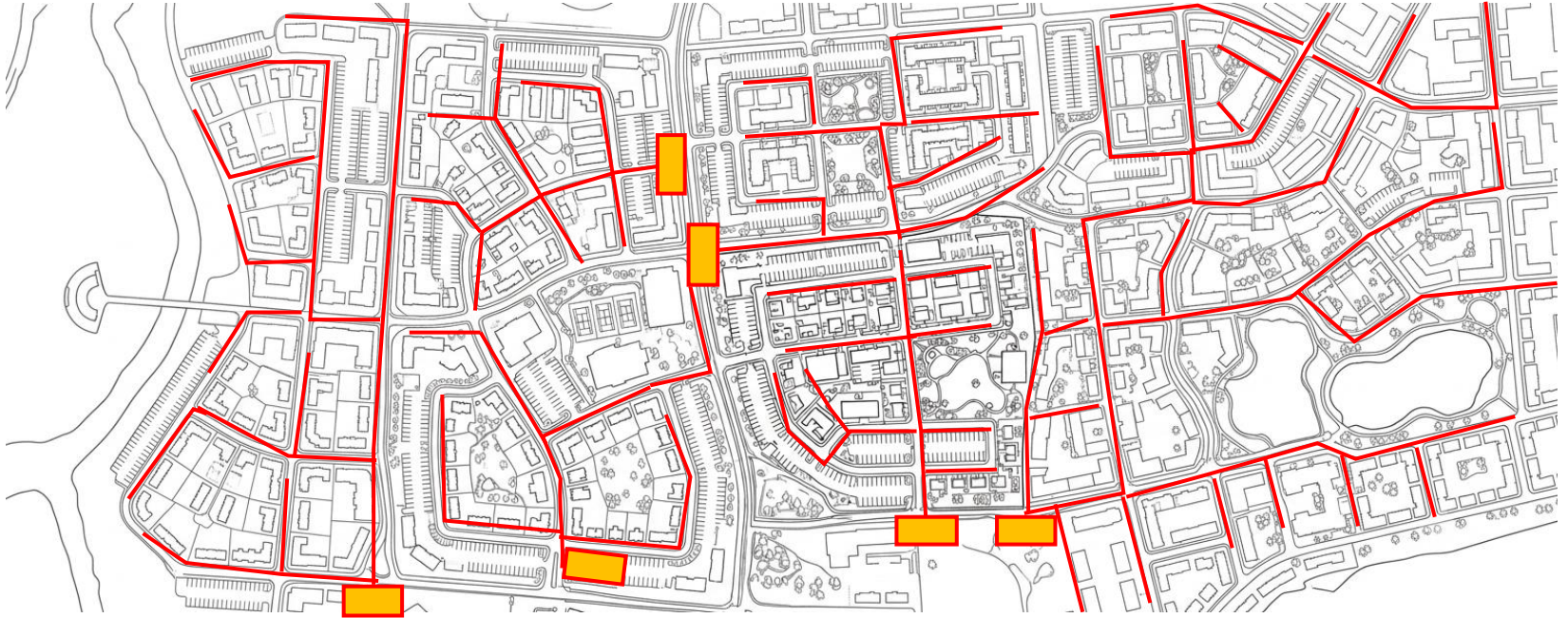
Step-by-step model

Another development



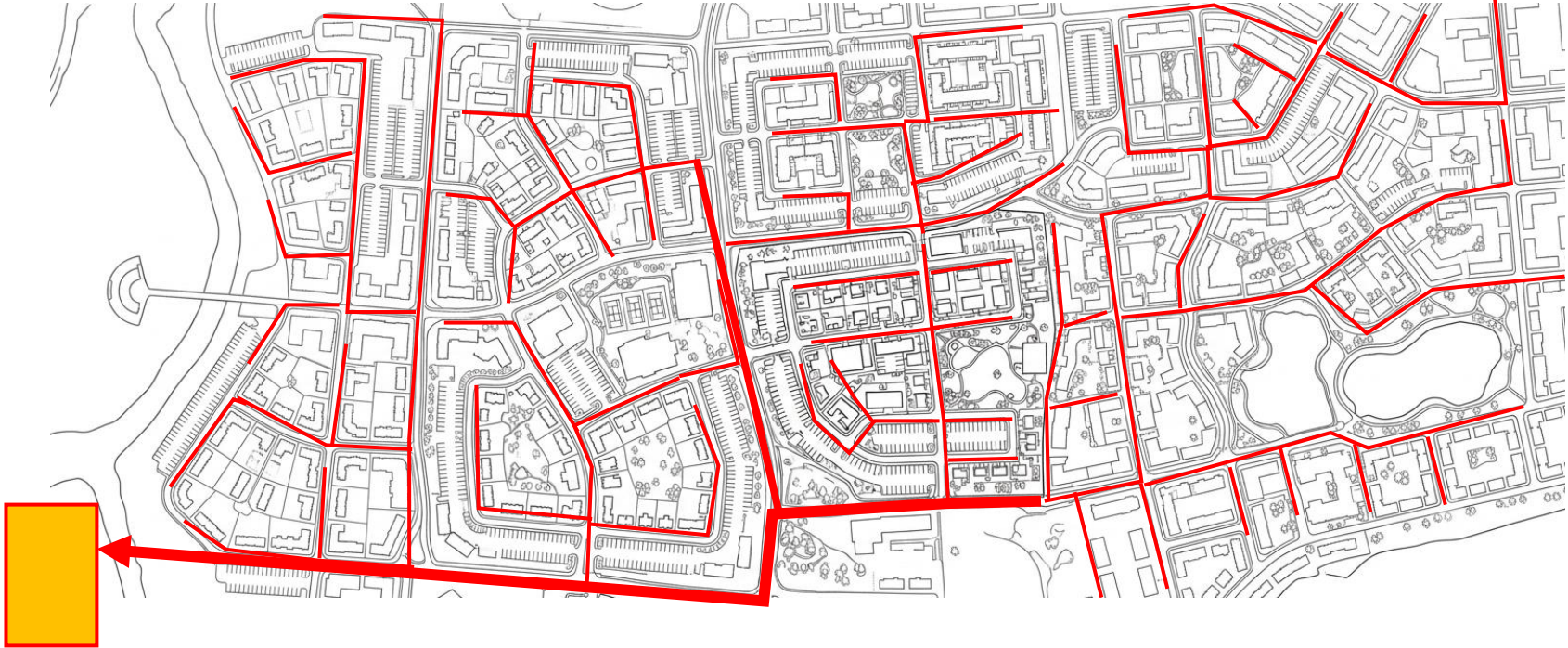
Step-by-step model

Close to final stage



Step-by-step model

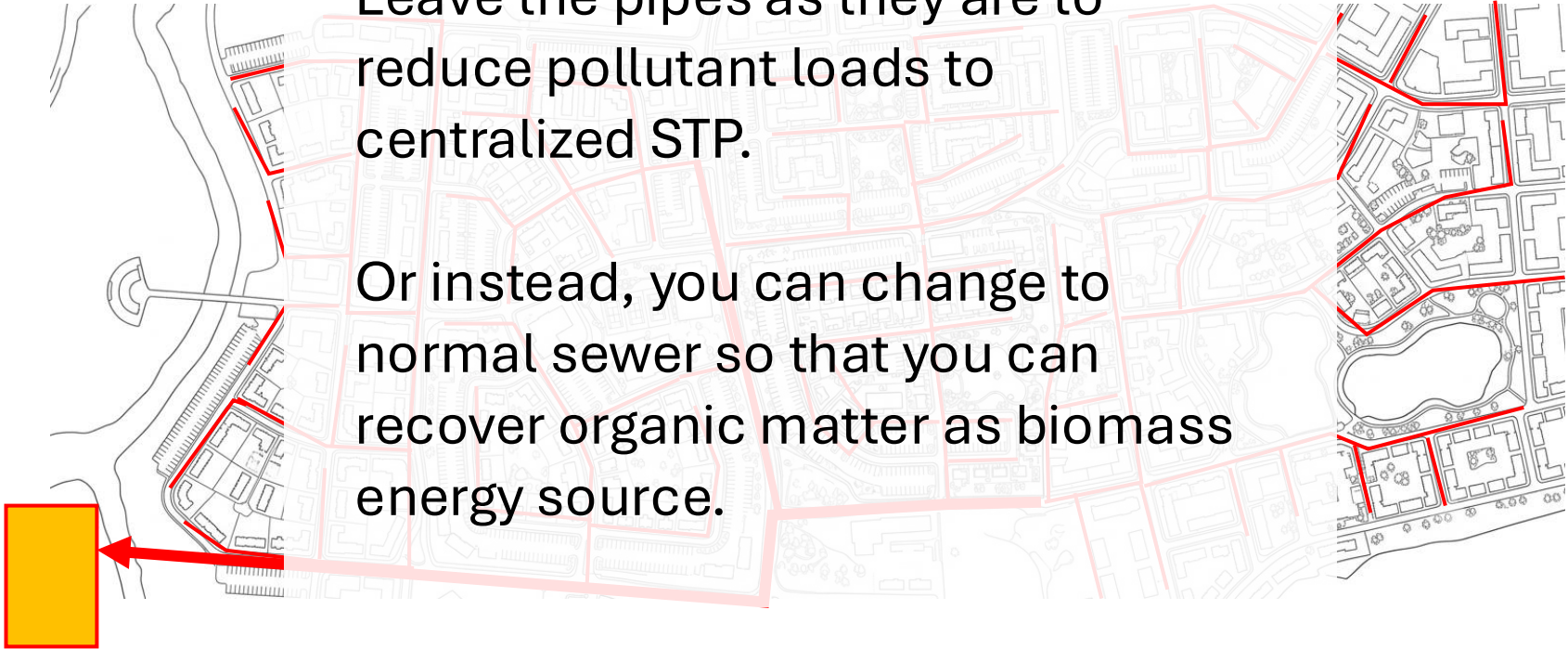
Time to convert to fully centralized system.



Step-by-step model

Leave the pipes as they are to reduce pollutant loads to centralized STP.

Or instead, you can change to normal sewer so that you can recover organic matter as biomass energy source.

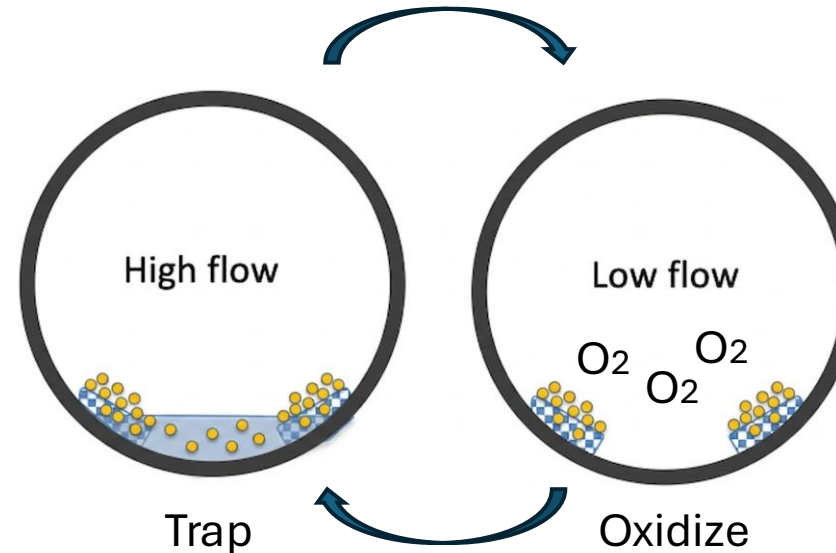


Merits

- Flexibility and scalability to city and sewer system planning
- No electrical energy need

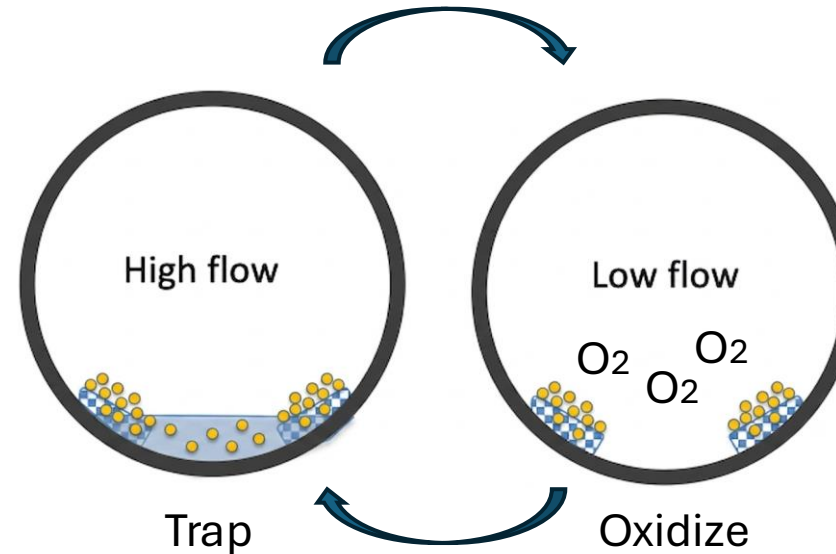
Enhancement of Sewer Self-Purification

- Introduce porous media in sewer pipes to
 - retain biomass, and
 - to increase surface area that contact with air.
- To secure flow, better to make space without media in center.
- With these basic ideas, can we achieve effective purification performance?

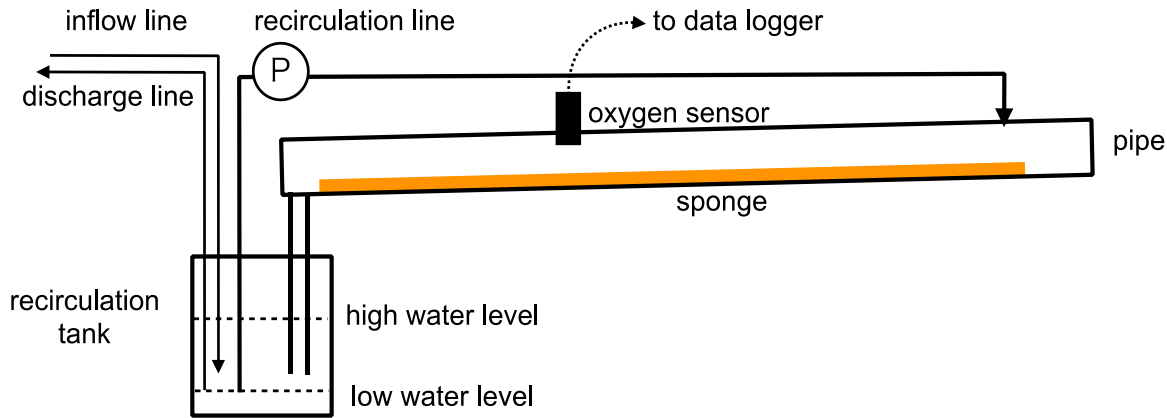


Organic pollutant removal mechanisms

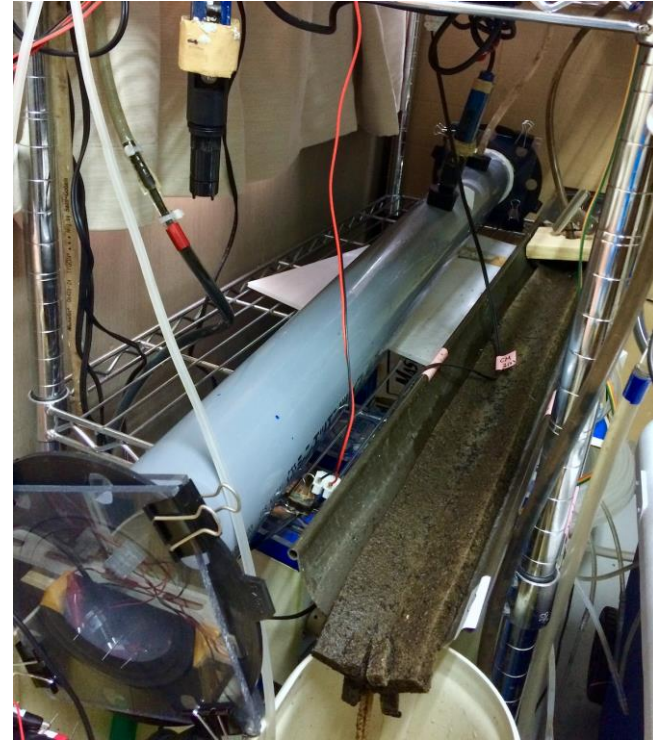
- Trap then oxidize
- How is sewage flow in sewer up-streams?
- Intermittent Contact Oxidation Process, ICOP



Performance Evaluation (1)



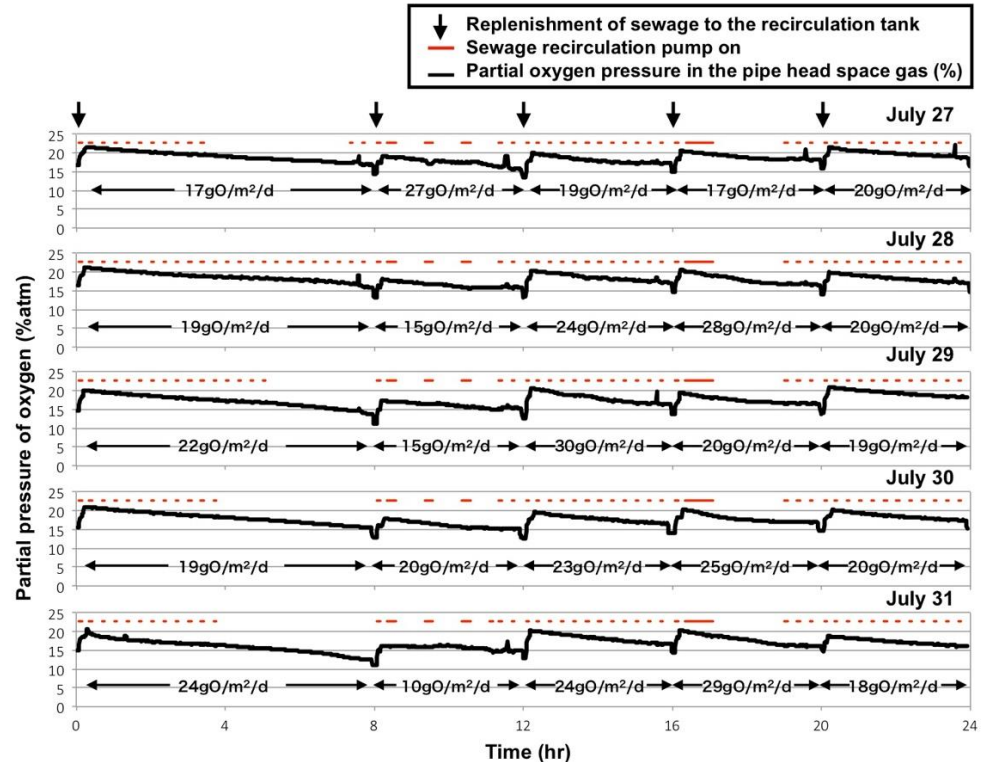
- ✓ Gas inside the channel is isolated from ambient air.
- ✓ Feed is supplied intermittently.
- ✓ Oxygen gas concentration was monitored.



Satoh & Sotelo, EcoSTP 2021

Performance Evaluation (1)

- Oxygen consumption rate (OCR) per unit footprint area of media...
 - 10– 30 gO/m²/d
 - Average 20 gO/m²/d
- Sotelo et al. 2021 reported
 - 40 gO/m²/d in steady state and 60–80 gO/m²/d as maximum.



Performance Evaluation (1)

- Emergence of worms in sponge pores
- Reduce possibility of sponge pore fouling



Performance Evaluation (2)



OCR was measured by chamber method.

2–3 g/m/d (width of media 10cm)



How to install?

- We have tried different installations.
- The latest one is on the right.
- Can be installed in existing sewer.
- Also, it is removable.



Trial of installation method

- https://www.instagram.com/p/DZxAd8okcVA/?img_index=2



It is possible to
install microbial
attached media
in between
manholes!

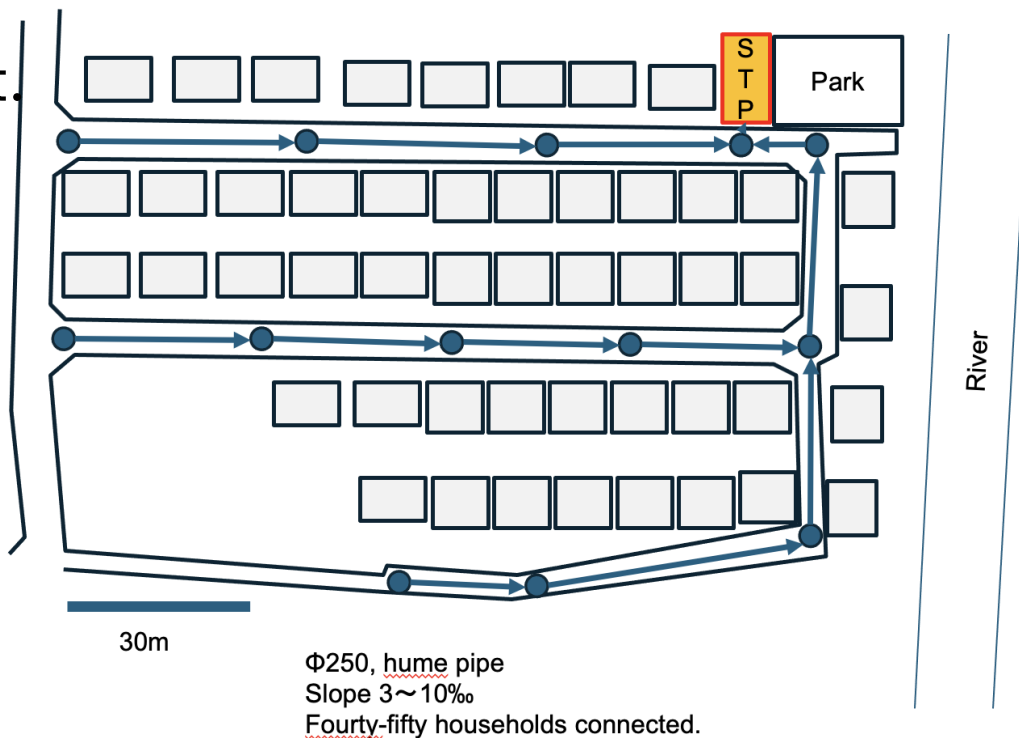


Performance in real environment?

Evaluation is about to start.

Now under preparation.

I(we) will know realities...



Concluding Remarks on enhanced sewer self-purification

Enhancement of self-purification in sewer...

- Ineligible performance
- Installation is possible
- Full scale evaluation is about to start

Concerns

- Blockage, Cost, durability...

Merits, strengths, opportunities

- No energy use
- Scalability & flexibility in planning
- Darkness good for plastic materials.
- Warmer temperature in tropical climate
- Geography (up/down)



Terima kashi

Fear of blockage...

- Water level sensor
- Stainless wire electrodes + microcontroller (Arduino)
 - Two insulated stainless wire + one uninsulated stainless wire
- Arduino based sensor + wireless module to transmit data to outside.

