N_2O emissions under different control strategies at full-scale WWTPs

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Canada Research Chair in Water Quality Modelling

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GHGs from WWTPs

Influent shocks

Climate change ⇄ WWTPs

Greenhouse gases (GHGs)

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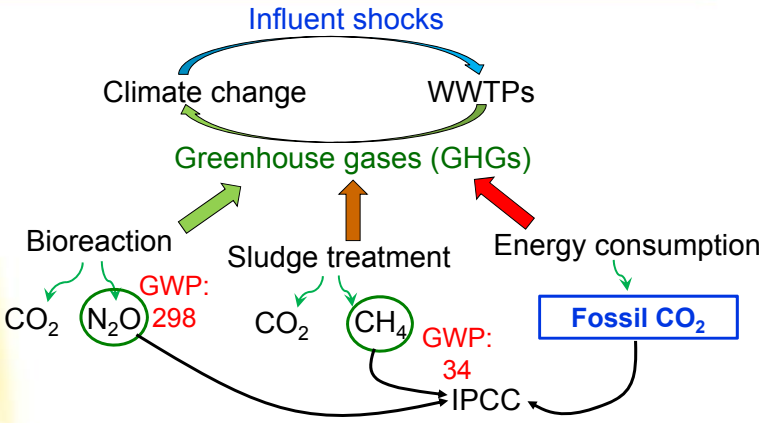
GHGs from WWTPs



GWP: Global warming potential

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Content list

- **Field N_2O measurement**
  Eindhoven WWTP (the Netherlands)
- **Current control strategy**
  Dry-weather and wet-weather conditions
- **New control strategy**
  N_2O mitigation and aeration energy saving
- **Conclusion**

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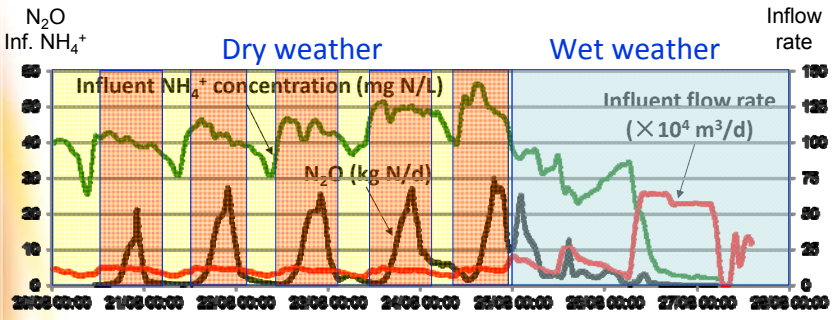
Field N_2O measurement

- Eindhoven WWTP: 750 000 PE
- 1 month measurement: August 2012, dry and wet weather
- N_2O emission: aeration zone of the second bioreactor

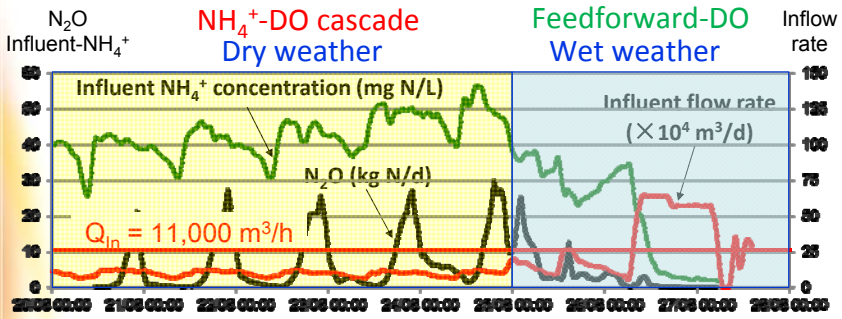
Field N_2O measurement

- Guo L. *NRR2013*. Full-scale measurement of N_2O emissions at the Eindhoven wastewater treatment plant and its relationship with plant performance.



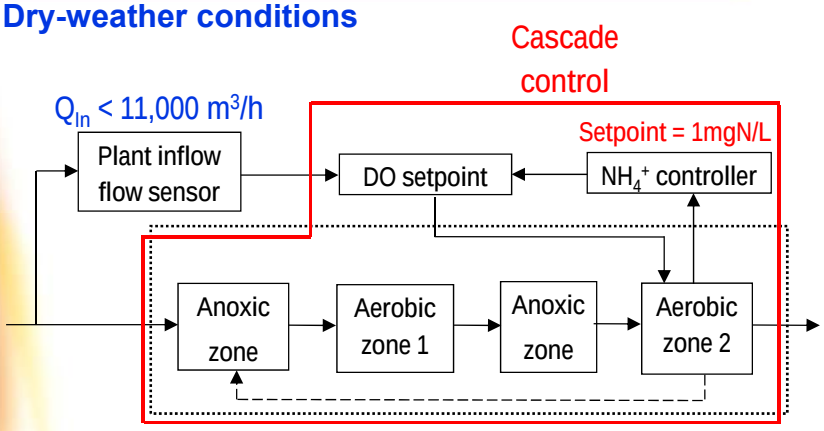
Field N_2O measurement

Control strategies



Control strategy

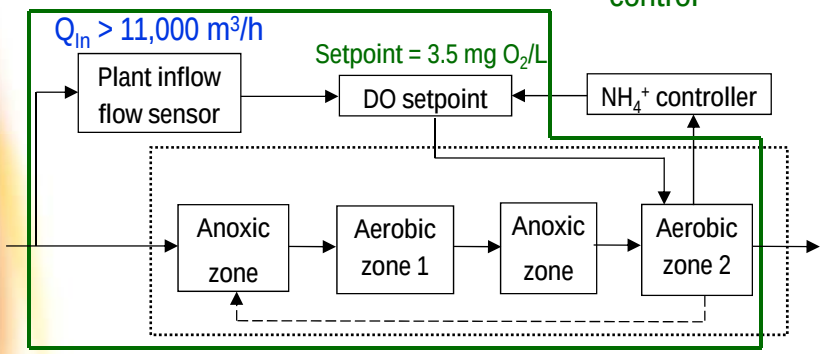
Dry-weather conditions



Control strategy

Wet-weather conditions

Feedforward control



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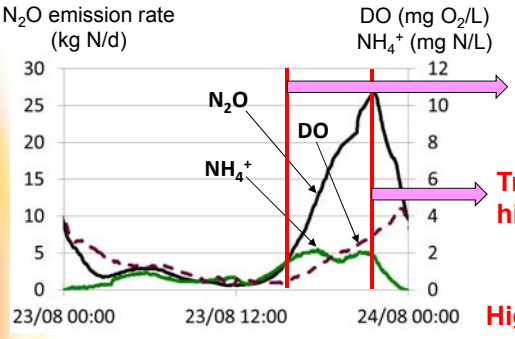
Control strategy: Why so much N_2O?

Cascade control — **Feedback** **Slow**



DO is only increased <u>after</u> receiving NH_4^+ peak

Transient conditions: high NH_4^+, median DO

High N_2O emission peaks

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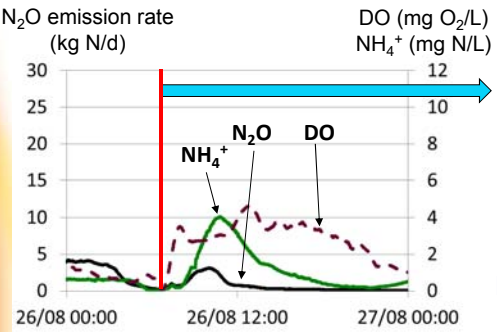
Control strategy: Why not under WW?

Feedforward control — **Feedforward** **Fast**



DO is increased <u>before</u> receiving NH_4^+ peak

and DO is high

Low N_2O emission peaks

Control strategy

Key messages from dry and wet weather comparison

- To decrease N_2O
  - Increase aeration flow rate in advance of the NH_4^+ peak hitting the bioreactor
- To save energy with effluent NH_4^+ restriction
  - NH_4^+-DO cascade control

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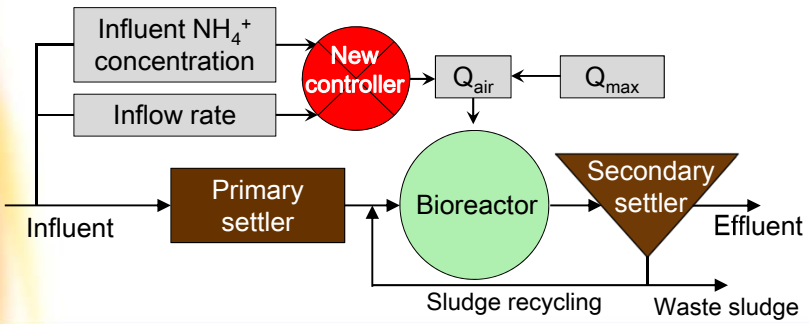
New strategy: Pure feedforward

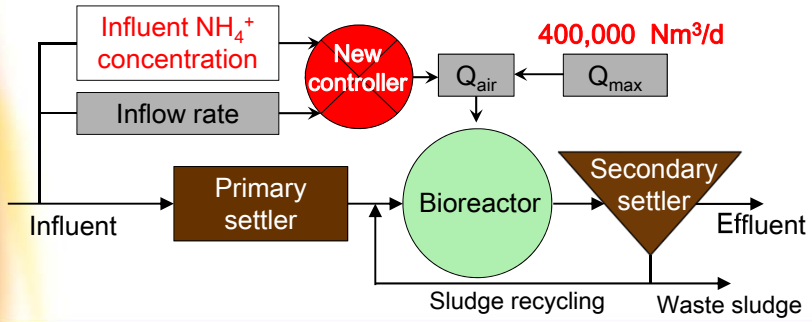
- **Feedforward control based on inflow rate and influent NH_4^+**

Dry-wet weather conditions



New strategy: Pure feedforward

If influent NH_4^+ > 45 mgN/l



New strategy: Pure feedforward

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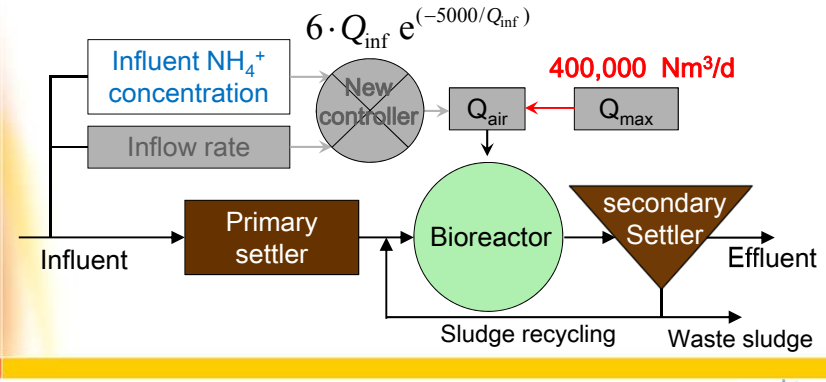
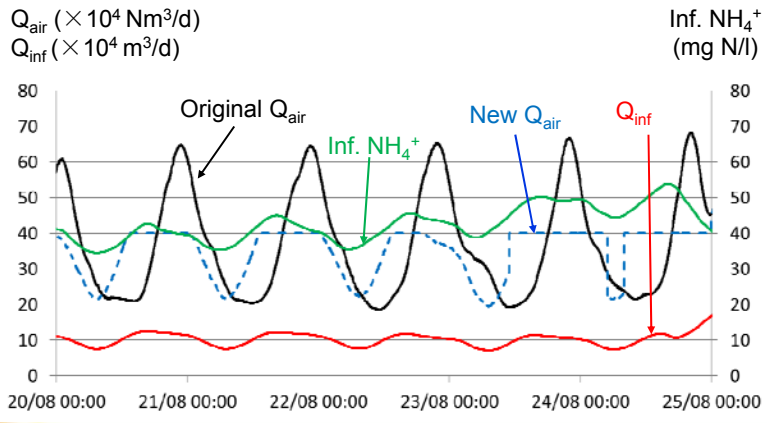


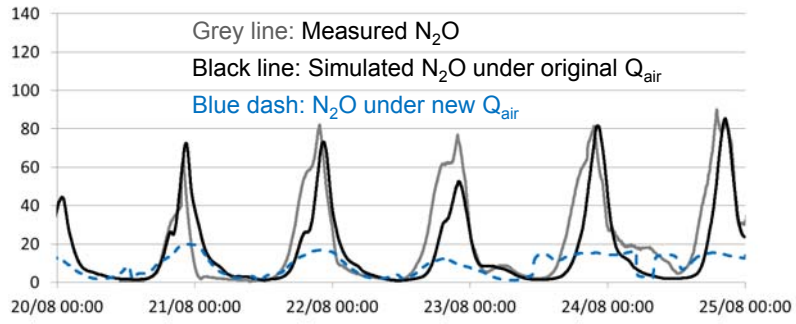
New strategy: Q_{air}



New strategy: N_2O emission

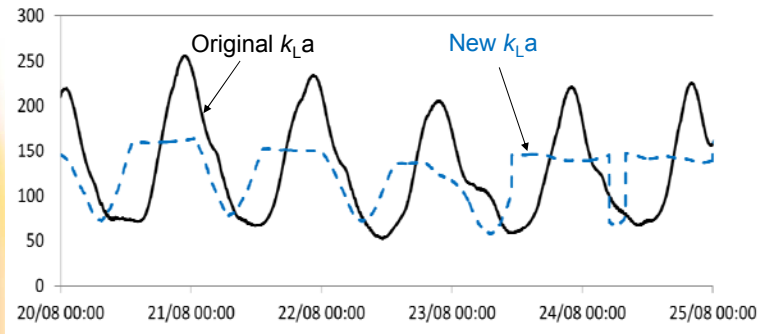
N_2O emission (×kg/d)

Big reduction in N_2O emissions under new strategy



New strategy: Aeration intensity k_La

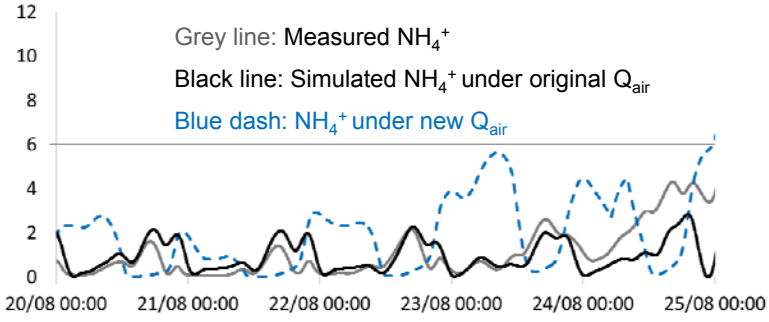
Aeration energy consumption (KWh/d):
1020 (original) vs. 386 (new)



New strategy: Effluent NH_4^+

NH_4^+ at bioreactor effluent (mg N/l)

Effluent NH_4^+ is not satisfied.
Solution?



New strategy: Further upgrade

- The feedforward control based on influent NH_4^+ and inflow rate gives:

  Good performance on N_2O and energy saving
  Poor control on effluent NH_4^+

Solution:
Combine the new strategy with traditional NH_4^+-DO cascade control

Conclusion

- Dry and wet weather comparison
  High N_2O under dry-weather conditions
  Low N_2O under wet-weather conditionss
  → Because of different control strategies
- NH_4^+-DO cascade control (dry-weather days)
  Feedback and slow controller → High N_2O
- Inflow-based control (wet-weather days)
  Feedforward and fast controller → low N_2O

Conclusion

- New strategy:
  Test a pure feedforward control
  that adjusts aeration flow rate
  based on influent NH_4^+ and inflow rate
  → Low N_2O
  → Low aeration energy
  → Not so good effluent NH_4^+
- Future work:
  Integrate new controller with NH_4^+-DO cascade control

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Thank you
Merci

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