

Improving quality of BSR waters by advanced treatment processes, Anaerobic ammonium oxidation process in MBBR and fungal heavymetal treatment

JOINT MEETING, 8 FEB 2023

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Interreg
Baltic Sea Region



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Baltic Region context and challenges

- The highest contents of pharmaceuticals found in Estonia are: in $\mu\text{g}/\text{kg}$ dry weight in Tallinn for CIP – 1520; OFL – 134; SMX – 22 and in Tartu wastewater treatment plant.
- Pharmaceuticals have been reported to occur in coastal environments across the globe from Antarctica to the Arctic. Environmental pollution by active pharmaceutical ingredients (API) has also become a serious problem in the Baltic Sea Region.
- The most frequently detected antibiotics (ciprofloxacin, ofloxacin, sulfamethoxazole), antiepileptics drugs (carbamazepine and diclofenac), and disinfectant (triclosan) are not susceptible to biodegradation, therefore passes through a cycle of biological treatment in the unchanged form potentially causing antibiotic resistance, skin irritation, endocrine disruption or neurotoxic, and immunotoxic reactions.

Outline

Main tasks:

Providing technical know-how for development of composting and autotrophic nitrogen removal technologies and studies of the formed biomass and activity. UT is doing WP2.

MBBR viable choice for N, pharmaceutical removal. Anaerobic treatment of municipal wastewater with moving bed biofilm (MBBR) technology has been proven to be a feasible and cost-effective technology for the Baltic Sea regions.

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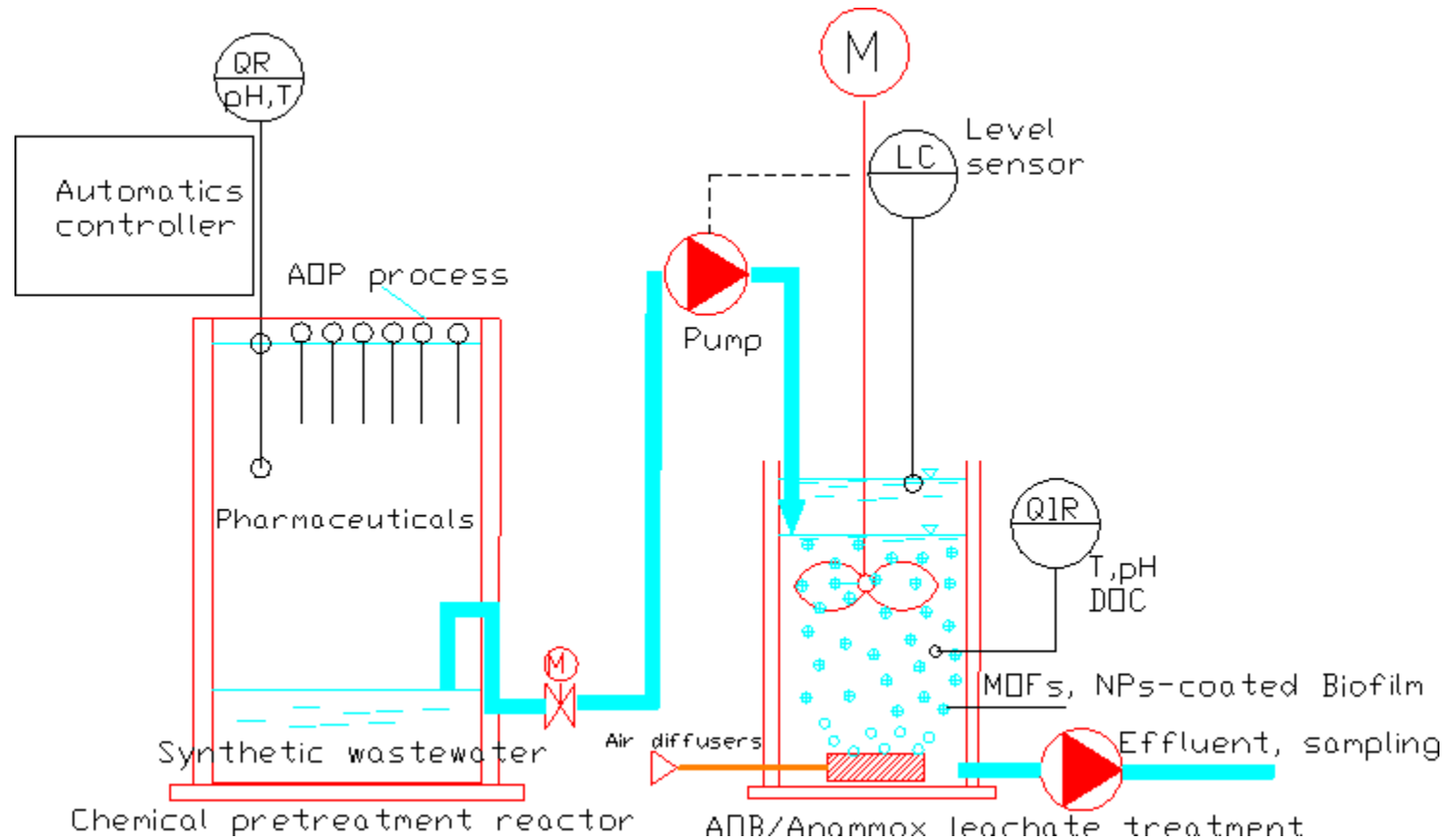
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Treatment trains



University Tartu Tasks

- Explore the possibilities of bacteria and fungal treatment testing installation construction.
- Pharmaceuticals (CIP, TC) and heavy metals (Cr, Cd, Zn, Cu, Ni, Pb) treatment and recovery by fungi, testing installation.
- Results dissemination.
- Results presentations in conferences and workshops.

University of Tartu will be responsible

- Coordination and the implementation of 3rd groups of activities and will be actively engaged in the experiments and presenting activities.
- Tartu will test innovative approaches for monitoring and removal methods for heavy metals from sludge and compost waste material by fungal treatment.
- We will prepare strategies for the use of advanced treatments by wastewater treatment plants and the recommendation of these methods to the other target groups. Up to that, scientists will benefit from the experience and acquired knowledge in the field of run testing within this project, due to all results being available in the scientific reports. UT will organise events within 3rd groups of activities.

Humana-large enterprise

- Humana will help in maintaining textile wastes for using it as biofilm and fungal growth material. Textile waste will possibly be purified by fungal bioadsorption from fire retardants (nano silver, halogenated dibenzo-p-dioxins and dibenzofurans), heavy metal and electronic compounds which are used in the textile industry for synthetic textiles manufacturing.
- Humana will be interested in knowledge enhancement about the textile wastes composition mapping and treatment possibilities knowledge transfer to the public and to textile companies themselves.
- Partner will be involved in the 1st, 3rd and 5th group of activities. They will contribute by participating in the events organized within this project and involvement in the consultations and best practices sharing as well as the cooperation within the new network.
- Removing of persistent micropollutants, including also heavy metals from waste, eg. the associated partner Humana OÜ is interested in this area.

Türi Waterworks

- Türi Waterworks will give the space for pilot construction and operation. They need to implement novel technologies to enhance their heavy metals and pharmaceuticals removal, they will help to enable enhancement of their technology at their treatment sites.
- Türi Waterworks Company's role is to help in experimental materials provision (sludge), participating in seminars, and knowledge transfer, we would help to increase their knowledge on novel processes. Türi Waterworks Company will be allowed to use field set for experiments when needed without costs.
- They will help us in setups when needed and provide sludge material for testing. Partner 2 will be involved in the 1st, 3rd and 5th group of activities. They will contribute by participating in the events organized within this project and involvement in the consultations and best practices and knowledge sharing as well as the cooperation within the new network.

Tartu, deammonification /composting integrated system for efficient heavymetals& Nutrients/ pharmaceuticals removal)

- Lab-scale reactor setup will be done in Tartu to assess the performance of Pharmaceutical, heavymetals, N removal.
- Growth of anammox microbes are being carried out at Tartu, which can be used as seed for the lab scale reactor.
- Different means of fungal growth systems on *Pleurotus ostreatus* fungi will be studied receiving the highest activity in metals binding: Cu, Ag, Cd, Zn, Cr, Ni
- Two 20 L MBBR reactor operations would be done in in Tartu with mature anammox biomass reactors for defining the strategies for pilot MBBR deammonification operation. Reactors are operated with low organic conditions (C/N of 1) (N-rich reject water feeding at temperature of 25°C) and possibly at mainstream conditions (organic-rich/low nutrient conditions (C/N>3) at temperature of 15°C).
- A publication about start- up of anammox SBR biomass will be done. A publication in SBR anammox process about the effect of nitrite and salinity is being processes by a scientific journal.

ANAMMOX benefits

Denitrification alone may not be a feasible avenue to meet stringent effluent quality

Challenge for ANAMMOX technology to treat mainstream wastewater with low ammonium content/fluctuated organics

Simultaneous removal of ammonium, pharmaceuticals from mainstream at moderate temperature

Pregrowth of biomass for seeding is necessary

Research aims

- Start-up of efficient **nitrogen removal** in anaerobic ammonium oxidation (anammox) granules and biofilms with anaerobic *inoculum*
- Cultivate anammox bacteria **from anaerobic sludge** in SBR and moving bed biofilm reactor (MBBR) also removing pharmaceuticals.
- Develop anammox processes at temperature 30° C treating digester effluents and nitrite at different salinities characteristic to wastewater and Baltic Sea water.

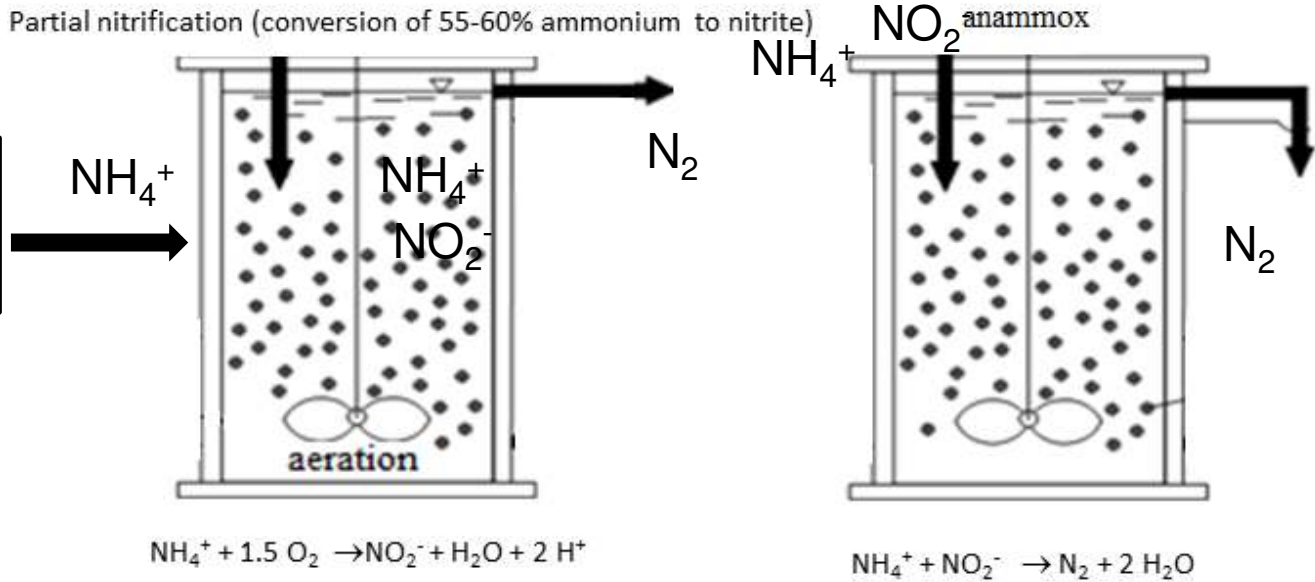
Metal binding tests

- Türi (fresh, 1 year, 2 year, 4 year composted) and Tartu wastewater treatment sludges will be used.
- Fungi (*Pleurotus ostreatus*, Shiitake) will be attached to sludge mass with fabric material.
- ICP-MS for metal measurements.
- Illumina sequencing for fungal and bacterial biodiversity and abundance detection.
- Nitrogen measurements will be done by Nessler method, IC.
- Oxytop respiratory will estimate sludge stabilization stage.

Our 20 L lab Deammonification and anammox systems (nitrification-anammox)

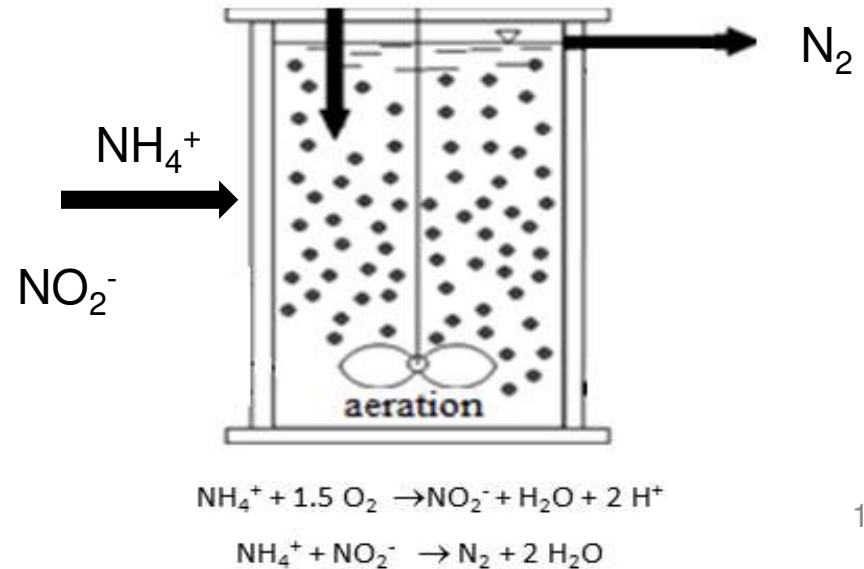
Partial nitrification (conversion of 55-60% ammonium to nitrite)

Deammonification, anammox MBBR



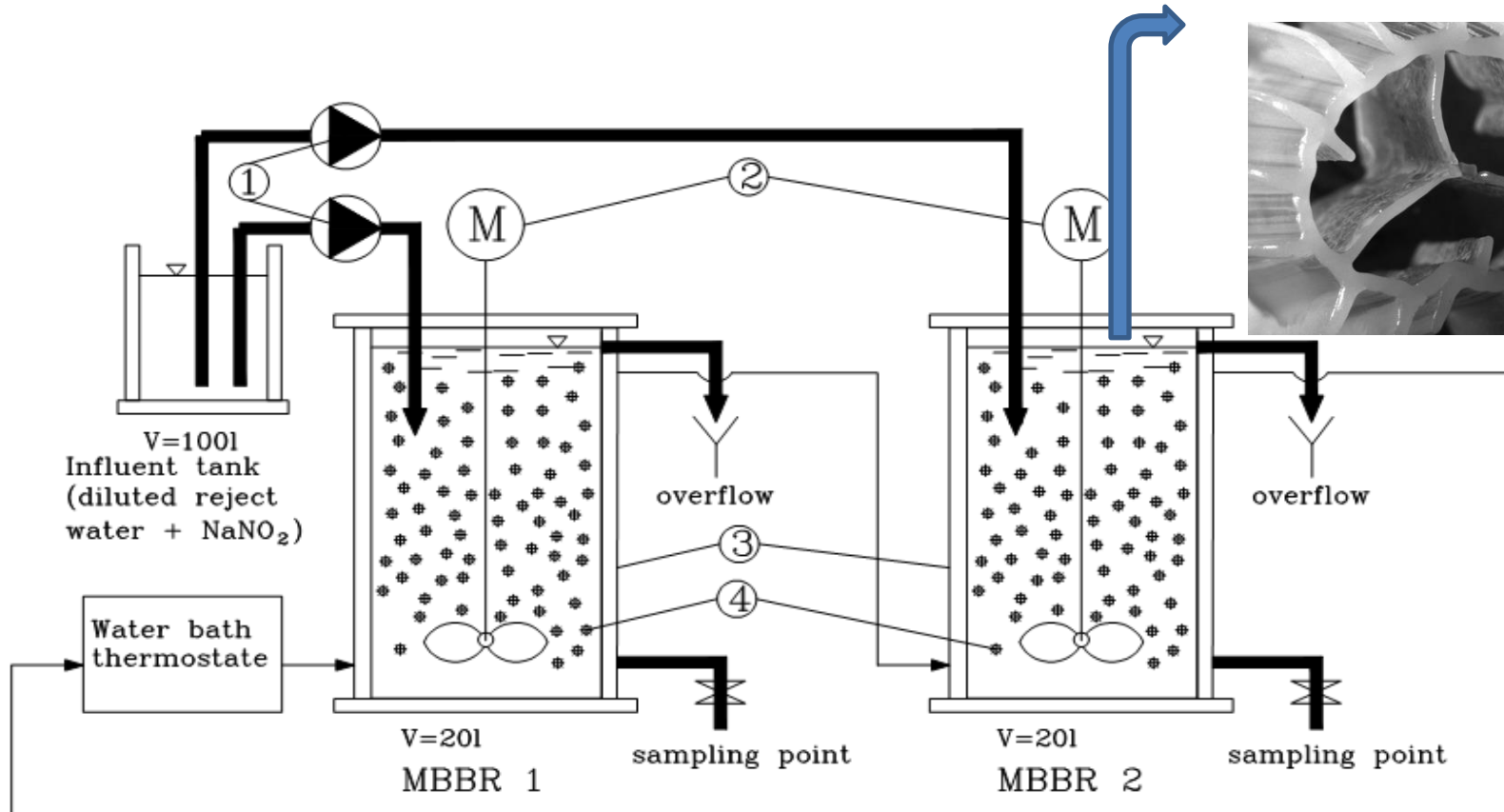
Partial nitrification-anammox

Anammox SBR



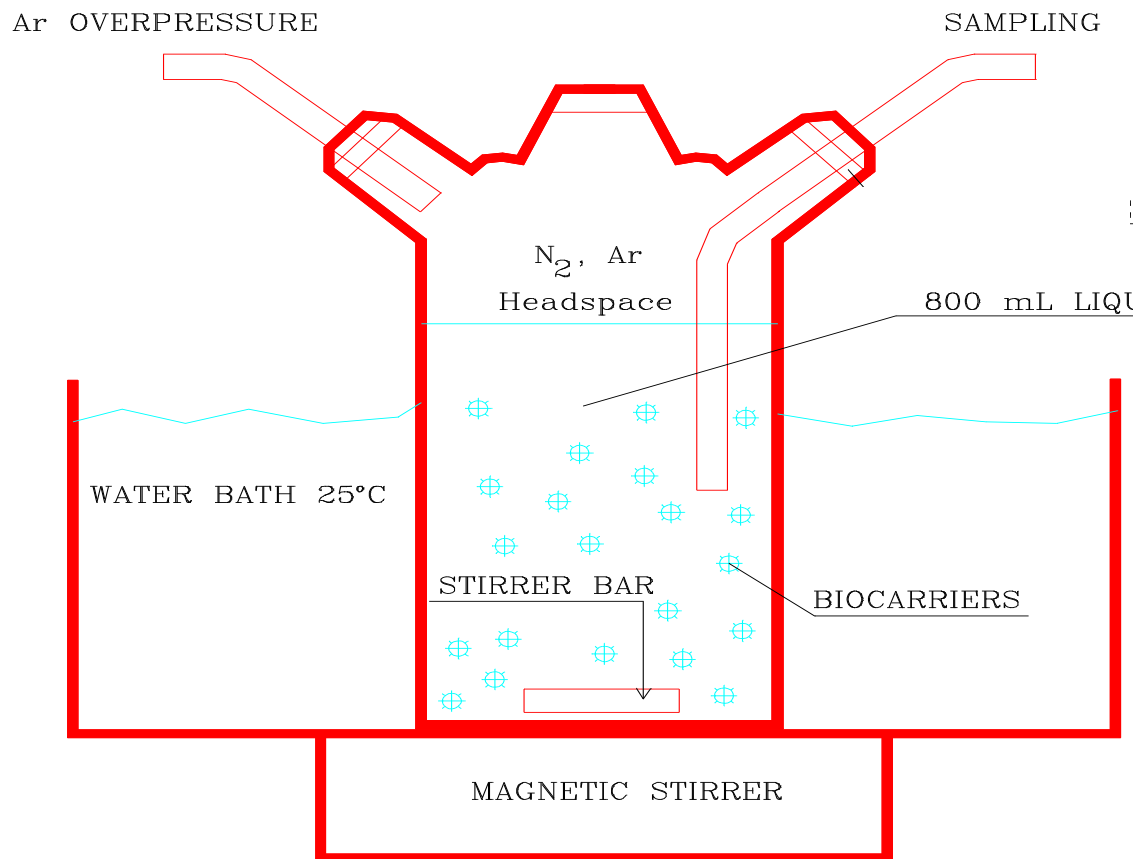
Anammox biofilm reactors (SBR, MBBR)

Analyses: NH_4^+ , NO_2^- , NO_3^- , COD, pH, DO, flow rate, HRT, conductivity

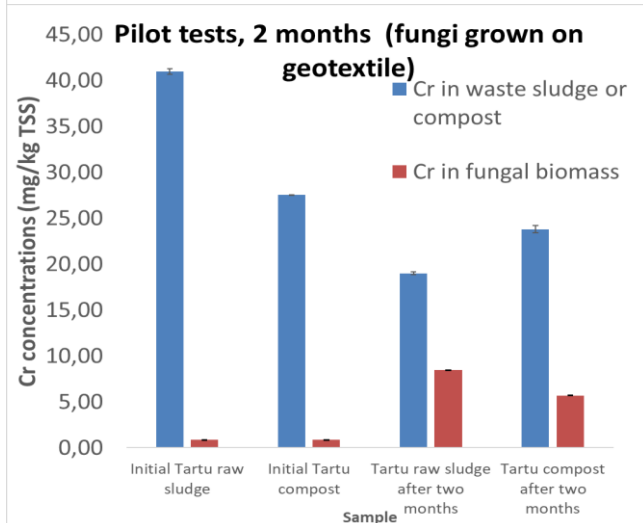
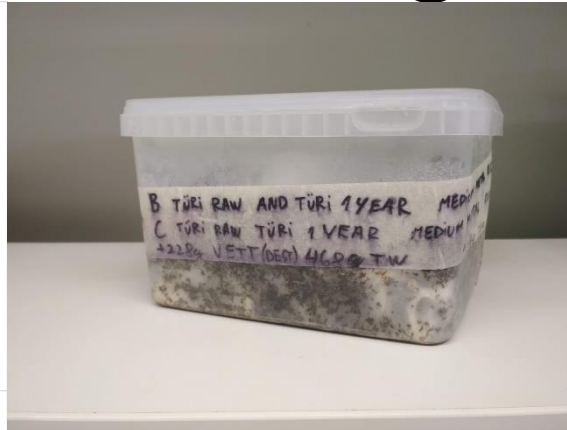
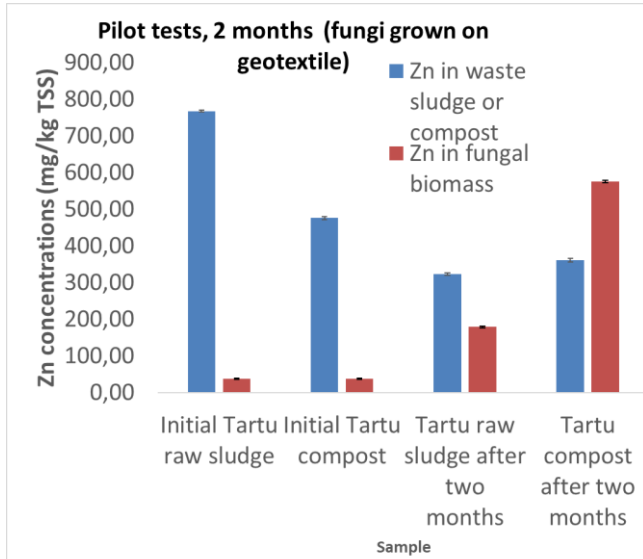


Batch analyses 8h

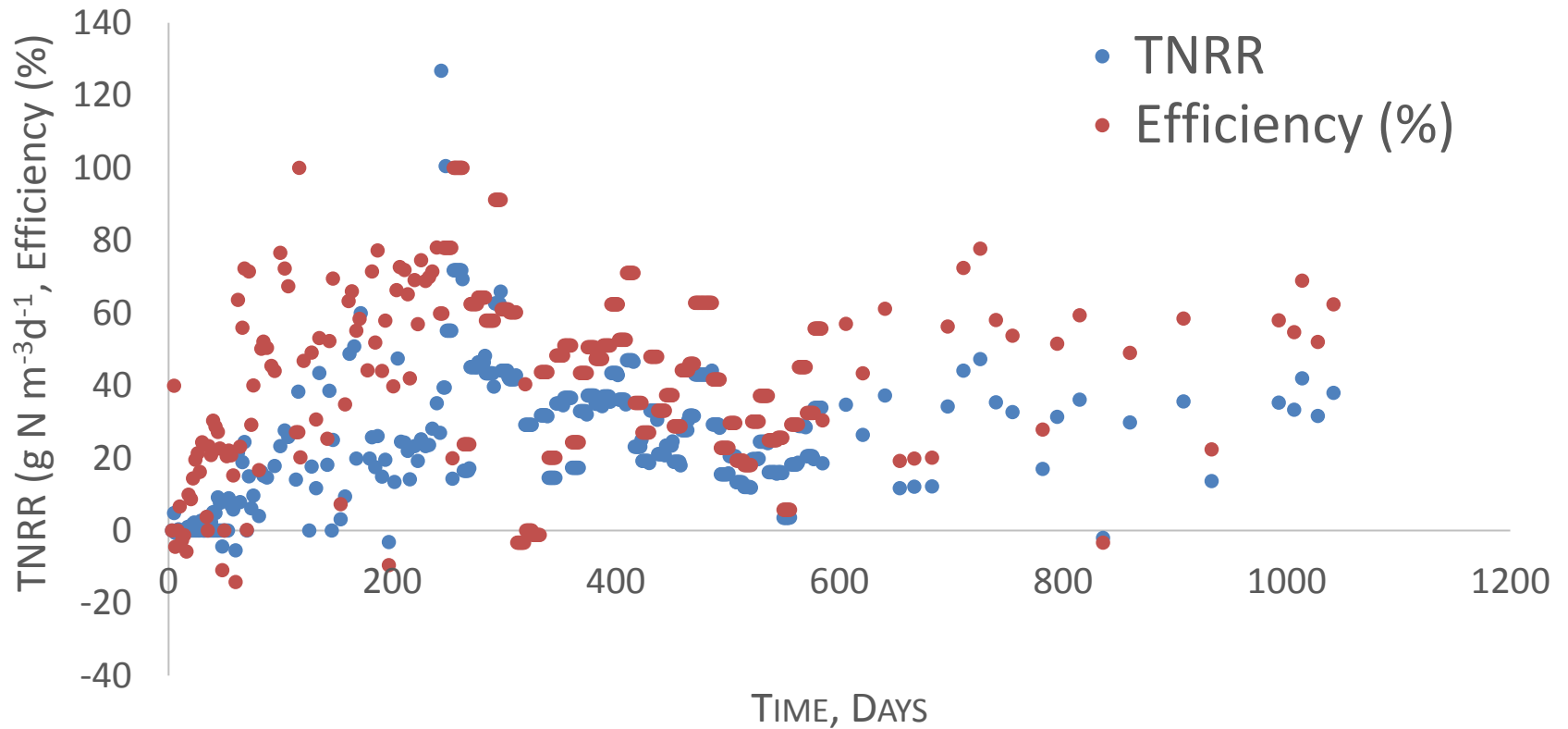
- 800 mL medium
- 200 carriers/sludge
- Sampling every 2h
- Measure NH_4 ,
 NO_2 , NO_3 , pharmaceuticals



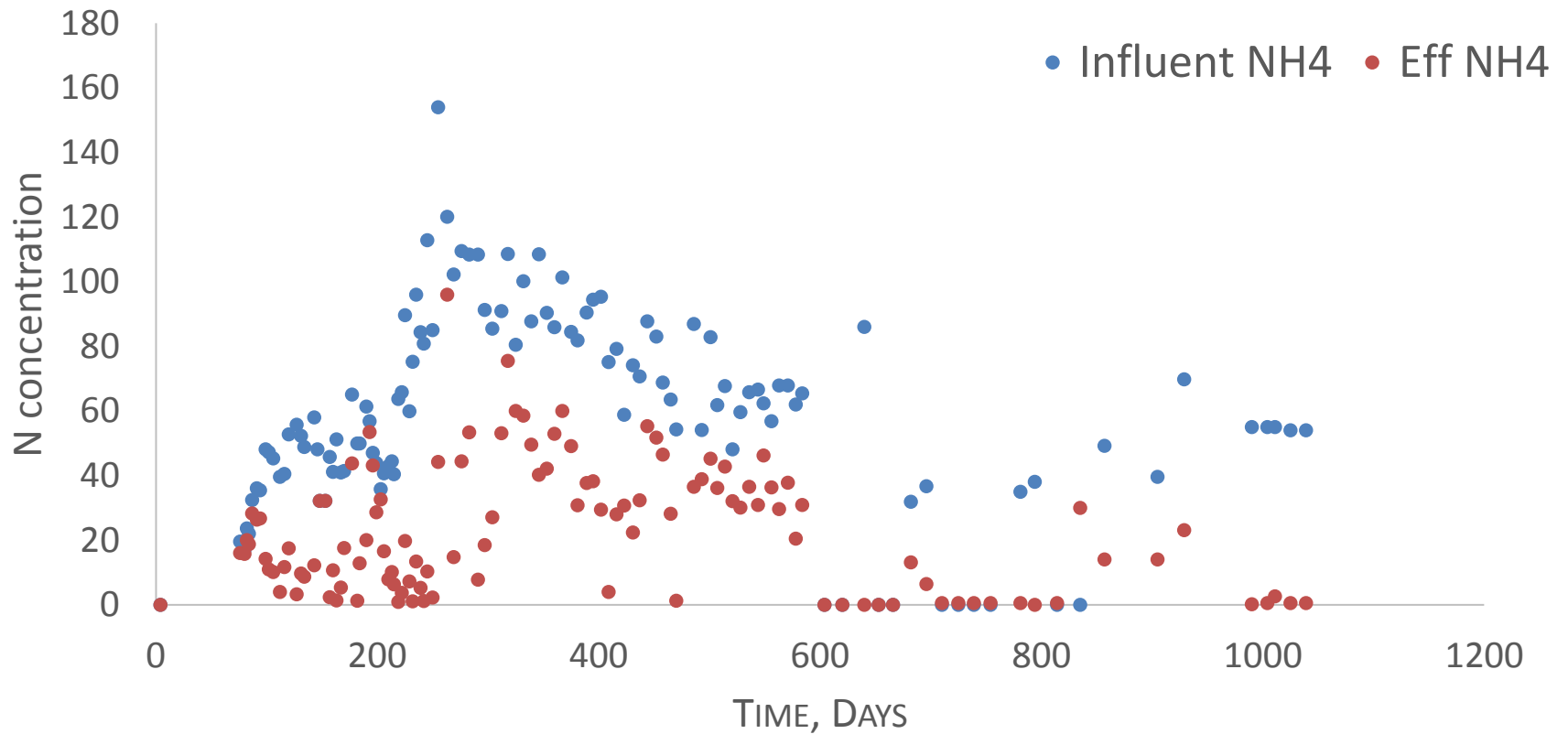
Metal binding tests



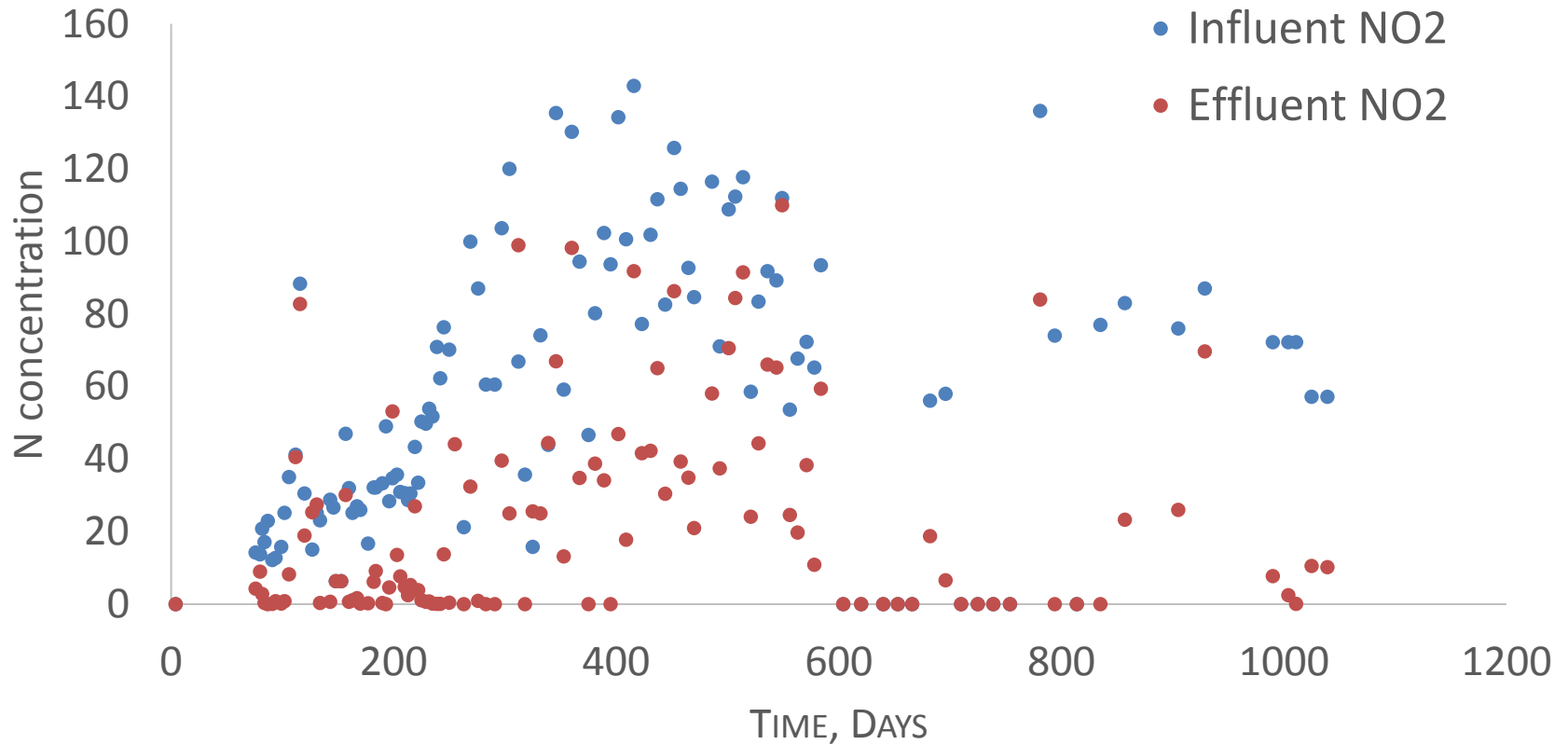
SBR Total nitrogen removal rates



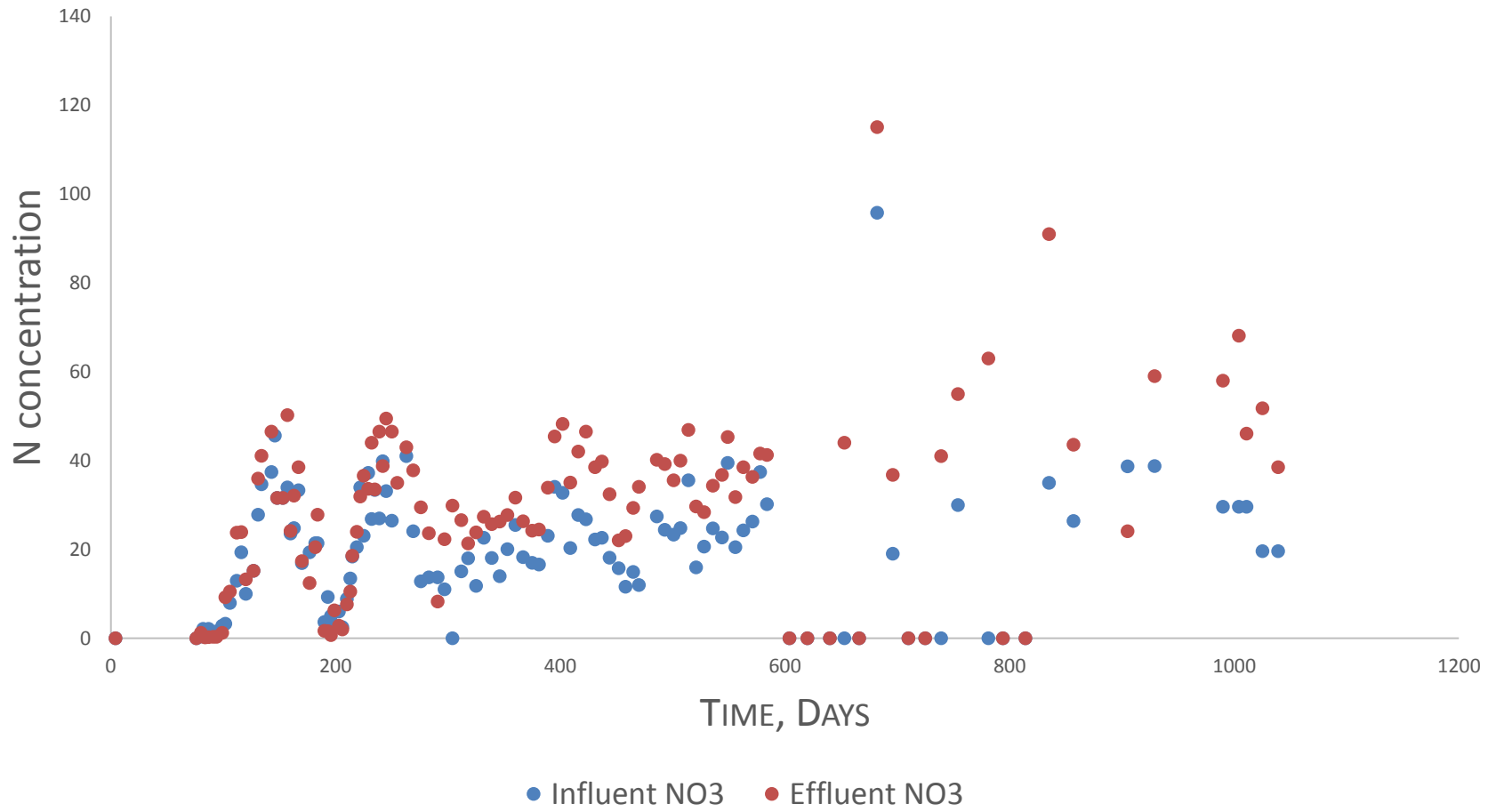
NH₄ concentration



NO₂ concentration



NO₃ concentration



Physical meeting with Uni Tartu and Gdansk Tech representative at Warsaw on 29th Jan 2023

- Plans of project proceeding
- Selection of pollutants classes in tests.
- Future papers to publish



Acknowledgments

- Thank You for being here!
- Thank for project funding :“Improving quality of BSR waters by advanced treatment processes“,