Unravelling the influence of saline intrusion cycles on reactor performance and microbial communities of an Aerobic Granular Sludge system

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State of the art

- **Seawater intrusion** can directly affect the wastewater composition of nearby wastewater treatment plants (WWTPs), in which salt content fluctuates throughout the day.

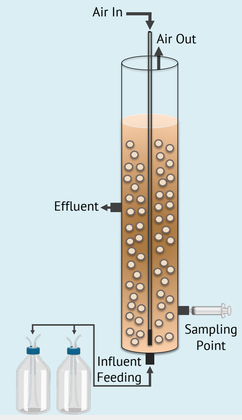
Coastal WWTP

- Aerobic granular sludge (AGS) systems are well-known for their robust treatment processes, which are characterized by efficient nutrient removal, high biomass retention, reduced footprint, and high tolerance to recalcitrant compounds.
- The impact of daily salinity fluctuations on biological removal processes in WWTPs, specifically in granular sludge systems, remains largely unexplored.
- This work aimed to evaluate the effects of daily salinity fluctuations on nutrient removal performance and microbial community diversity in an AGS system.

Methodology

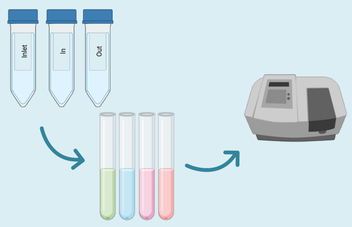
- The AGS reactor operation lasted 286 days and was split into stages I (d0-d130) and II (d131-d286). The reactor worked in sequencing batch mode with 8 treatment cycles per day.

Wastewater composition (mg/L):
$[NH_4^+]$: 46.5
$[PO_4^{3-}]$: 18.3
[COD]: 330
[Sea salts]: stepwise increase from 1.5-15 g/L (stage I), or a daily variation of 7.5 or 22.5 g/L (stage II).



Chemical analysis

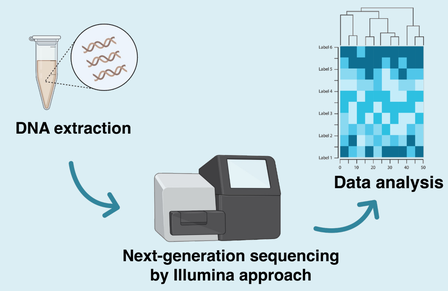
Liquid samples were collected from the reactor during three moments: feeding, aeration, and effluent withdrawal.



Determination of nitrogen (N), phosphorus (P), and carbon (C) content through photometry techniques.

Microbiome analysis

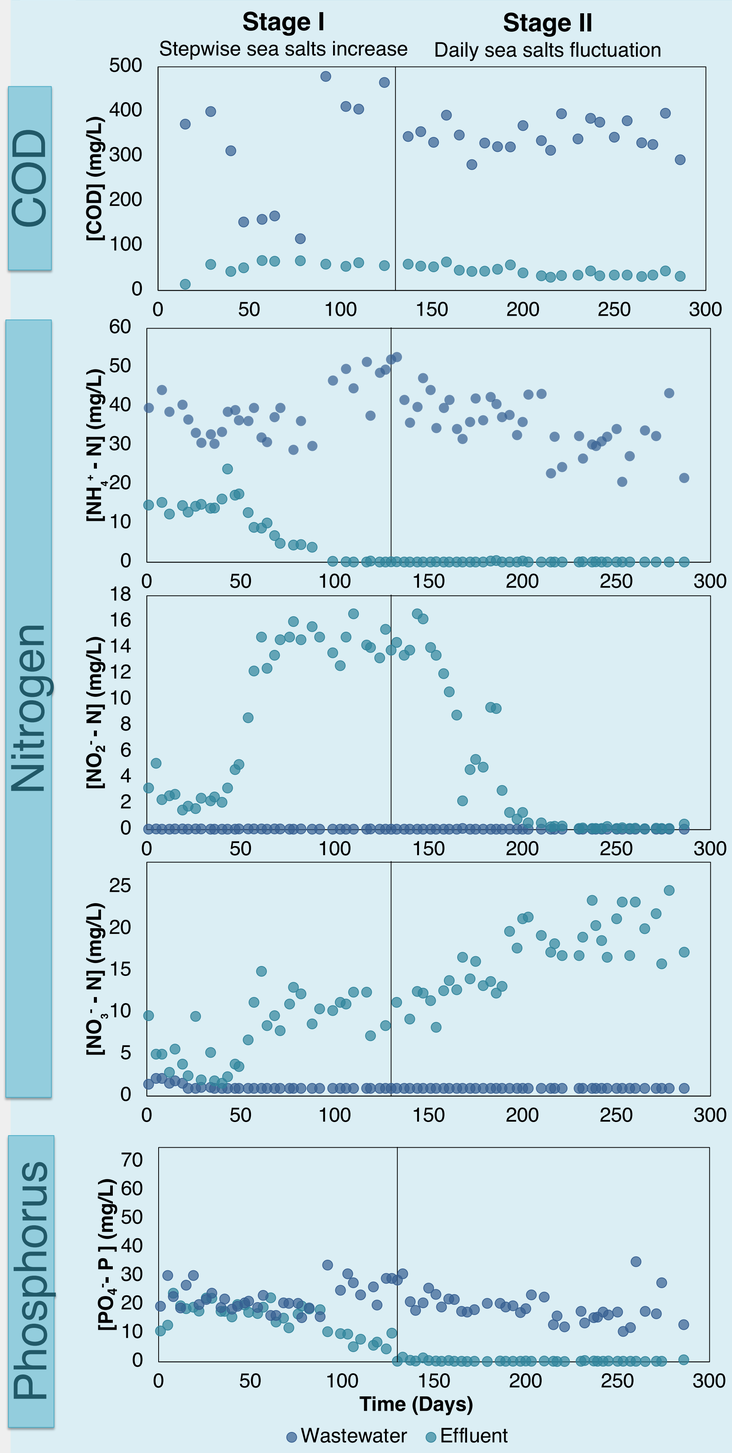
AGS samples were collected from the reactor, aseptically crushed and genomic DNA was extracted for further sequencing through the Illumina technique.



Next-generation sequencing by Illumina approach

Results and discussion

AGS reactor performance



Stages I and II

- **Carbon** content removal was **almost identical** in both stages;
- **COD** effluent content is within the **permissible discharge limit** under the EU directive (<125 mg/L O_2).

Stage I

- **Removal of the NH_4^+** from the WW enhanced over time.

Stage II

- **NH_4^+ was totally removed** from the wastewater.

Stage I

- **NO_2^- levels** in the effluent increased over time.

Stage II

- **Gradually NO_2^- removal** was accomplished along the stage.

Stages I and II

- The **NO_3^-** content in the effluent increased throughout the reactor operation, reaching higher levels in stage II.

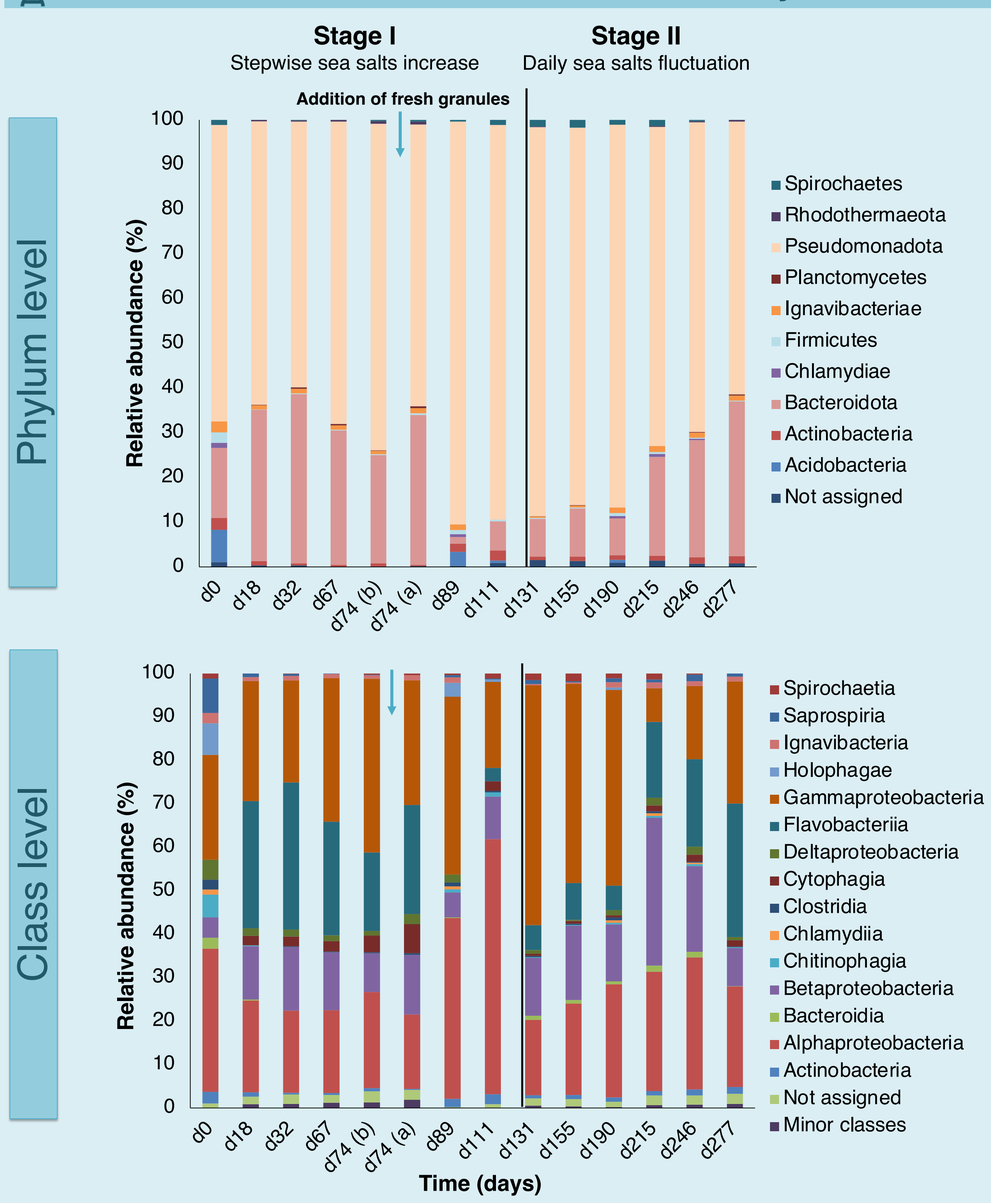
Stage I

- **Improvement** of PO_4^{3-} removal by the end of the stage.

Stage II

- **Complete PO_4^{3-} removal** from the wastewater.

AGS microbial community



- **Pseudomonadota** and **Bacteroidota** were the most abundant phyla during reactor operation;
- The **addition of new granules** performed on day-74 changed the AGS community composition;
- **Alphaproteobacteria**, **Betaproteobacteria**, **Gammaproteobacteria,** and **Flavobacteriia** were the most abundant classes within the AGS community over operation;
- A **gradual adaptation** of the AGS microbial community to the daily salinity oscillations was observed during the whole stage II.

Final remarks

- Under seawater intrusion events, the AGS reactor exhibited excellent **efficiency in removing nitrogen (N), phosphorus (P), and carbon (C)**. The levels of COD and phosphorus in the effluent complied with legislation for the discharge of treated wastewater;
- The AGS microbial community was highly **heterogeneous**, **dynamic**, and **variable** over time. Nevertheless, the microbial community was able to adapt to the daily salinity variations caused by tidal cycle events allowing for high removal performance;
- The AGS system's ability to effectively handle salt level **fluctuations in wastewater due to seawater intrusion events** highlights its promising **potential** for implementation in WWTPs, particularly those situated **along coastal areas**.

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