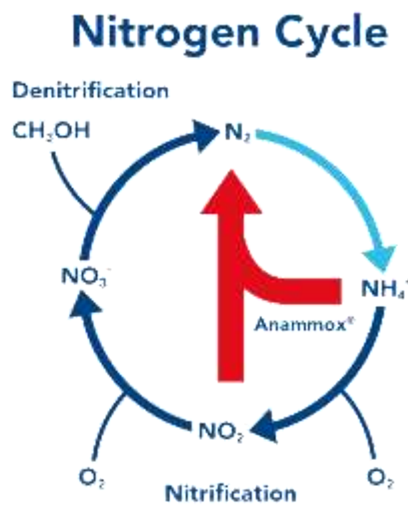
Introduction of Reseach

Prof Dr. Mari Winkler is conducting research to reduce water pollution by improving nitrogen, carbon and phosphate removal in wastewater treatment plants. Currently two projects are available for student project in the area of aerobic granular sludge technology. Aerobic granules can be described as dense spherical biofilms that may grow to average diameters of approximately 1.0 to 3.0 mm, settle rapidly and compact to high solids concentration resulting in bioreactors with greatly reduced area. The growth of granules in well-defined engineered bioreactors has contributed to a revolution in the wastewater treatment field since it combines all necessary conditions on micrometre scale for biological carbon, phosphate and nitrogen removal in one single reactor configuration. Therefore, no settling tank is required and excessive recycle flows are avoided, resulting in a space reduction of up to 70%, capital cost savings of up to 30% and up to 25% less energy demand compared to conventional municipal wastewater treatment systems.

Project 1

Anaerobic ammonium oxidizing bacteria (Anammox) can "jump" the typical nitrogen cycle, and convert ammonium (NH_4+) and nitrite (NO_2-) to nitrogen gas (N_2) (deammonification) in the absence of oxygen at approximately. Key advantages of the deammonification process over the established autotrophic nitrification/heterotrophic denitrification process are 1) nitrogen removal without carbon, 2) about 60% less energy for aeration 3) about 75% less sludge production, and 4) lower emissions of CO_2 and N_2O greenhouse gases. Unlike denitrification, N_2O is not produced in anammox metabolism. Currently Anammox and Ammonium Oxidizing Bacteria (AOB) are grown together to remove ammonium from the water. AOB aerobically convert ammonium to nitrite, which is needed for the Anammox reaction. However, using AOB comes with some problems. Nitrite Oxidizing Bacteria (NOB) can snatch away the nitrite from the anammox and convert it to nitrate (NO_3^-), which pollutes the effluent.



Research Aim

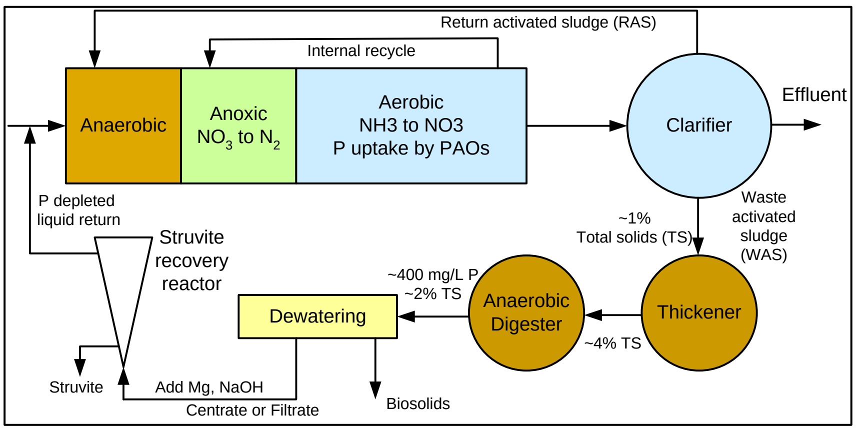
We want to use a newly discovered Ammonia Oxidizing Archea (AOA) that can convert the ammonia to nitrite and survive at much lower oxygen concentrations than AOB and NOB. We aim to operate a granular sludge bioreactor with the Anammox and AOA living together at very low oxygen levels so that AOB and NOB cannot survive in the reactor. If we are able to do this, than anammox will be much easier to use in wastewater treatment plants.

Lab Tasks

A student can expect to work with PhD student Kathryn Cogert to start up a pure culture AOA reactor and therefore it is expected that the student knows how to work sterile. In a later stage of the project we will transition the isolated AOA culture we currently have to the anammox granular sludge reactor. In addition, the student will need to do analytical tests as well as to examine the culture by molecular methods.

Project 2

Phosphorus is non-renewable resource that is essential for all life. An estimated 40 million tons of phosphorus rock is used for fertilizer each year for food crops and at the present population growth rate phosphorus reserves are estimated to be depleted by 2090. The U.S. has about 7% of the known phosphorus reserves but the major amount is found in China (42%) and Morocco (26%). Phosphorus recovery at WWTPs can have a significant impact on extending the life of phosphorus reserves and fertilizer cost. Phosphorus recovery has been implemented at full-scale facilities by processes that produce a slowly-releasing fertilizer in the form of magnesium ammonium phosphorus (MAP - $MgNH_4PO_4 \cdot 6H_2O$), which is referred to as struvite. The struvite production processes treat recycled flow from anaerobic digestion sludge dewatering and a typical WWTP schematic with struvite recovery is shown in Figure below.



Such systems also employ enhanced biological phosphorus removal (EBPR) in which the phosphorus removed from the liquid treatment is contained in waste activated sludge biomass. The sludge is broken down in the anaerobic digester by which phosphorus is released into the liquid phase hence producing a phosphorus-rich stream for the struvite recovery process.

EBPR provides a cost-effective method for phosphorus removal with little or no chemical addition. However, the number of wastewater treatment plants that can employ phosphorus recovery by this treatment scheme is very limited as there are only 544 WWTPs with anaerobic digestion out of over 16,000 WWTPs in the United States.

Research Aim We want to expand the application of phosphorus recovery at WWTPs by applying EBPR and granular sludge technology that can be installed in existing activated sludge WWTPs, which do not have digesters. In addition, it is expected that designs will be able to increase treatment capacity and reduce energy consumption.

Lab Tasks

A student can expect to work with PhD student Stephany Wei to start up an aerobic granular sludge reactor and therefore it is expected that the student knows to work with biological mixed culture systems. Batch tests will be conducted to assess biological phosphate release mechanisms at different substrate loadings. In addition, the student will need to do analytical tests as well as to examine the culture by molecular methods.

General matter:

The tuition will be covered by Dr. Winkler however no funds will be available for salary or living expenses. University of Washington rakes 14th in ranking among worlds universities. The Mercer Quality of Living Survey 2015 ranked Seattle on place 44 in the world.