Study of the chemical and biological mechanisms involved in iron and phosphate speciation in WWTP applied to simultaneous recovery and recycling of Phosphorus and Iron.

Summary

This work is the following step of several projects on bio-acidification applied to sewage sludge which have shown that it is possible to increase the recycling potential of phosphorus (P) but also of Iron by increasing their dissolution by a biological process without chemical addition probably because of iron reducing microorganisms.
Three main issues will be faced in this project:

- On a scientific point of view, better understanding the chemical and biological mechanisms involved in this dissolution of P and Iron in sewage sludge, drawing from works on bioremediation of metallic pollution of soils and sediments.
- On an environmental point of view, the results will sustain strategies for P removal from wastewater taking into account the recovery and recycling potential changing WWTP in factories for producing renewable resources.
- On an economical point of view recycling Iron will also decrease the running costs of WWTP.

To do so, the main objectives of the thesis will be first, to develop methods for studying the interactions between P, iron and biomass drawing from methodologies developed in soils and sediments bio-remediation. Then the hypothesis of the influence of ferri-reducing microorganisms on iron dissolution described for soils and sediments will be tested on sewage sludge. Finally strategies for P removal from wastewater taking into account the P and Iron recovery potential from sludge will be proposed and tested at pilot scale.

Context

Phosphorus recycling is becoming a crucial issue for several reasons:

- It is a pollutant responsible for eutrophication of surface water when it is in excess
- It is a non renewable resource
- Due to its location in a very few countries it is identified as a critical material for food safety in Europe

Some countries as Germany, Switzerland and soon, Czech Republic, have already defined mandatory constraints for P recycling from sewage sludge.
Since 2001, our team in Rennes (Brittany) is working about dissolving P from organic wastes like pig manure or sewage sludge to increase the recovery rate of P by crystallization as struvite. Dissolution by chemical acidification was tested first. It was efficient but non sustainable neither economically nor environmentally. A biological process (bio-acidification) has been developed. Depending on the sludge and on the P removal technology used in the WWTP, this new process is efficient to dissolve P but also up to 90% of the Iron from sewage sludge, compromising struvite crystallization. However it is possible to trap Iron on resins and to regenerate it as Iron chloride that could be recycled in the WWTP. So bio-acidification is a promising technology to combine P and Iron recovery from sewage sludge.

Objectives

- To adapt methodologies to better understand links between Iron and P in sewage sludge and the role of the biomass
- To confirm that the biological process involved in Iron dissolution in polluted soils or sediments could explain the biological dissolution of Iron and P observed in sewage sludge and to identify the microorganisms responsible for that.

- To make links between P removal technology used in the WWTP and the potential for biological P and Iron dissolution and recycling in sewage sludge
- To propose strategies for P removal in WWTP, favoring further biological dissolution of P and Iron in sludge.

Work description

1. The literature review will aim to complement the state of the art about the influence of physical and chemical parameters and organic matter on forming Iron-P compounds in relation with the physical and chemical conditions of the P removal steps in WWTP. Also on the microbial activity which could be responsible for P and Iron dissolution during bio-acidification.
2. Combination of geo-chemical modeling and kinetic parameters of experimental chemical dissolution will be used to characterize the different fractions of Iron-P compounds in sewage sludge. This fractionation will be confirmed by relevant methods stemming from the literature review to identify Iron-P compounds.
3. Microorganisms responsible for Iron-P dissolution will be identified, their activity will be quantified and the influence of physical parameters on microbial growth and activity studied.
4. Information about the conditions (pH, aerobic or anaerobic, redox…) during P removal in WWTP will be collected to draw up a relation between P removal and potential for further Iron-P dissolution during bio-acidification. Models describing the different treatment steps could be used to help to define wastewater treatment strategies to increase Iron and P recycling.
5. These strategies will be tested at pilot scale.

Organisation

The PhD student will be hosted in the OPAALE research unit (Irstea –Rennes). He will work in close relationship with the EPURE team of the REVEERSAL research unit (Irstea-Lyon) for modeling activities but also with Veolia research team who is co-financing the work. He probably should have links with other teams for Iron-P compounds analysis.

Candidate

Candidate should be qualified (master degree) in chemical and/or biological process engineering with basis knowledge in polluted soil remediation and ideally in molecular biology.
Oral and writing English are required to present the work in international conferences and write scientific articles. Speaking French may be helpful but not necessary.
He will have to design, plan and perform experimentations and analysis at lab-scale but also at pilot scale.

Contact: Marie-line Daumer, marie-line.daumer@irstea.fr, +3322348219