# Nutrient recovery from municipal wastewater by CDI

Motivation

Prevention of water pollution is becoming increasingly coupled with nutrient recycling. To achieve both in a conventional wastewater treatment process requires the implementation of new technology and new process solutions.

This work addresses capacitive deionization (CDI) as such a new technology.
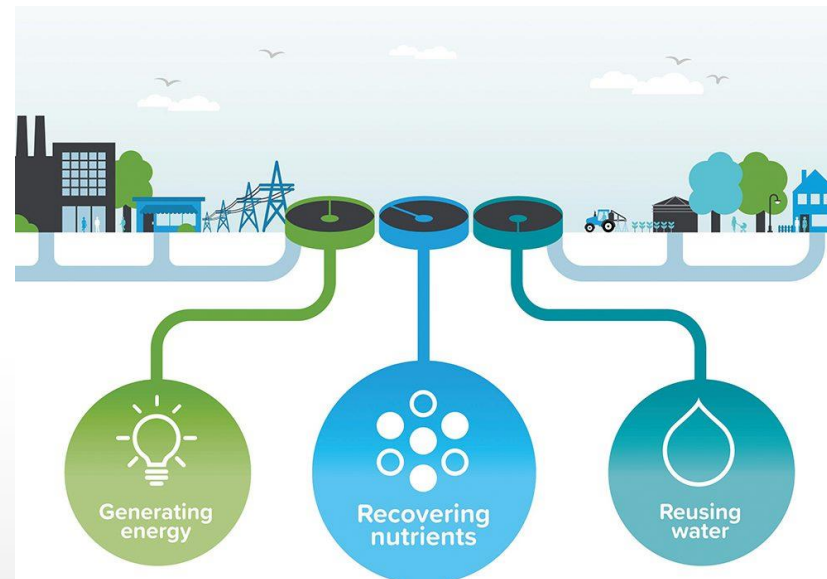
Fundamentals of CDI
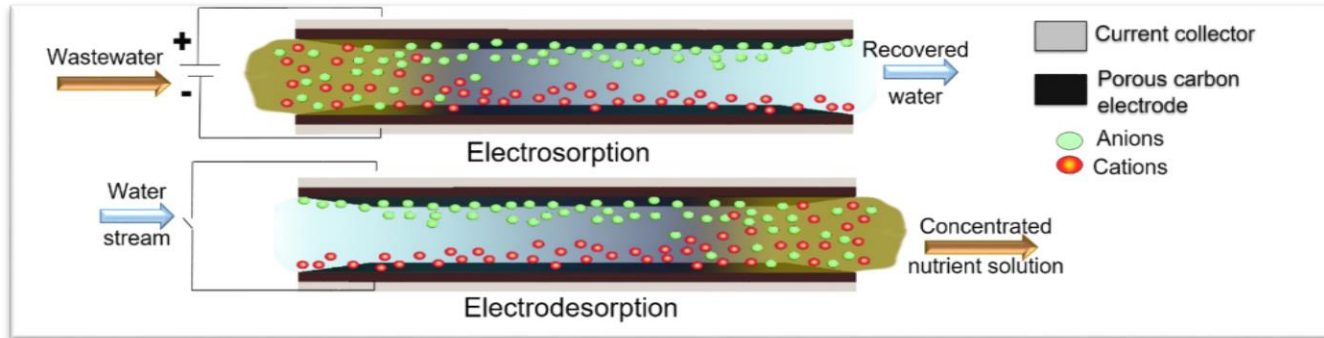
Basic phenomena: electrosorption.

Driving force: potential difference over two porous carbon electrodes.

o   Ions from the water stream migrate to the opposite charged carbon electrode;

o   Ions are electrostatically held in EDL;

o   Ions are released back from the electrodes to the water stream due to the short-circuiting of the reversed potential.

Current state of art

Voltea's Industrial System producing 30GPM* (110LPM) of purified water
http://www.voltea.com/products/

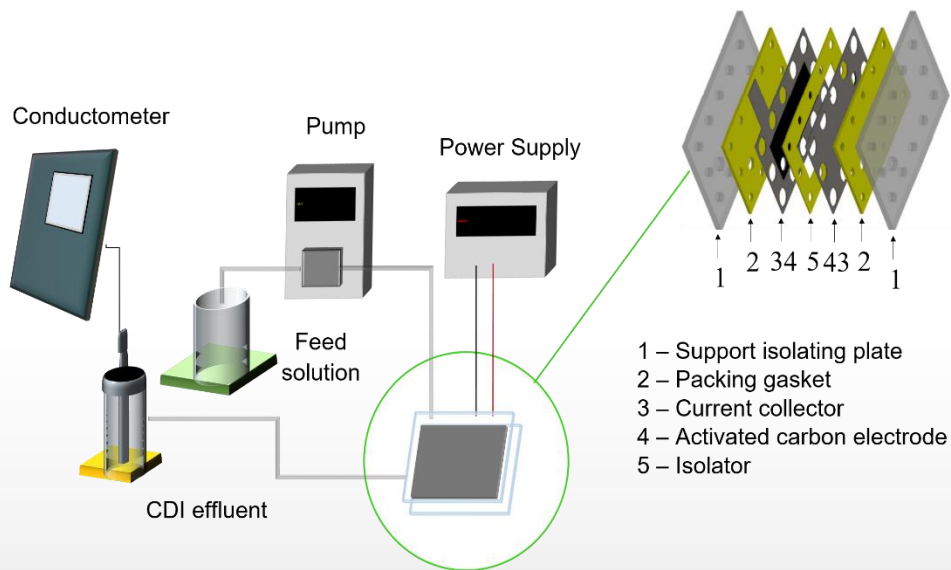| Advantages	Limitations
No additional pressure	Pre-filtration
Small applied potential ~1 – 1.2 V	
No heat source	Performance and stability of the process are depended on the electrode material
Module system	
Energy storage capability	
Suitable for low-strength streams	

Objectives of the project

OBJECTIVES

- Application of CDI for nutrient recover.

- Searching for appropriate carbon or composite materials for CDI electrodes.

- Scaling-up the CDI setup and integration into the conventional wastewater treatment plant (WWTP).

Research

RESULTS

- Essential components for fertilizers production.

- Advanced wastewater treatment.

- Transformation of waste water treatment plant to a wastewater-resource factories (WWRF).

Experimental work

Conductometer
Pump
Power Supply
Feed solution
CDI effluent

1 2 34 5 43 2 1

1 – Support isolating plate
2 – Packing gasket
3 – Current collector
4 – Activated carbon electrode
5 – Isolator

Operational conditions	Value
Operational volume of the CDI cell	1 mL
Applied potential	1.2 V
Flow-rate	2 mL/min
Mode	Continuous (single pass)
Duration of the complete cycle	16 – 20 min
Target ions	Ammonium, nitrate, phosphate
Electrodes	Pristine and modified activated carbon

Results
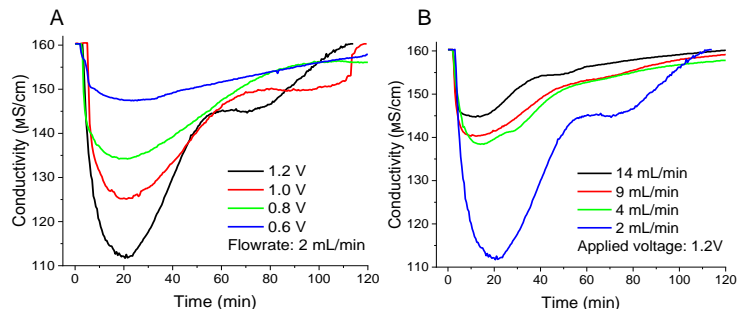
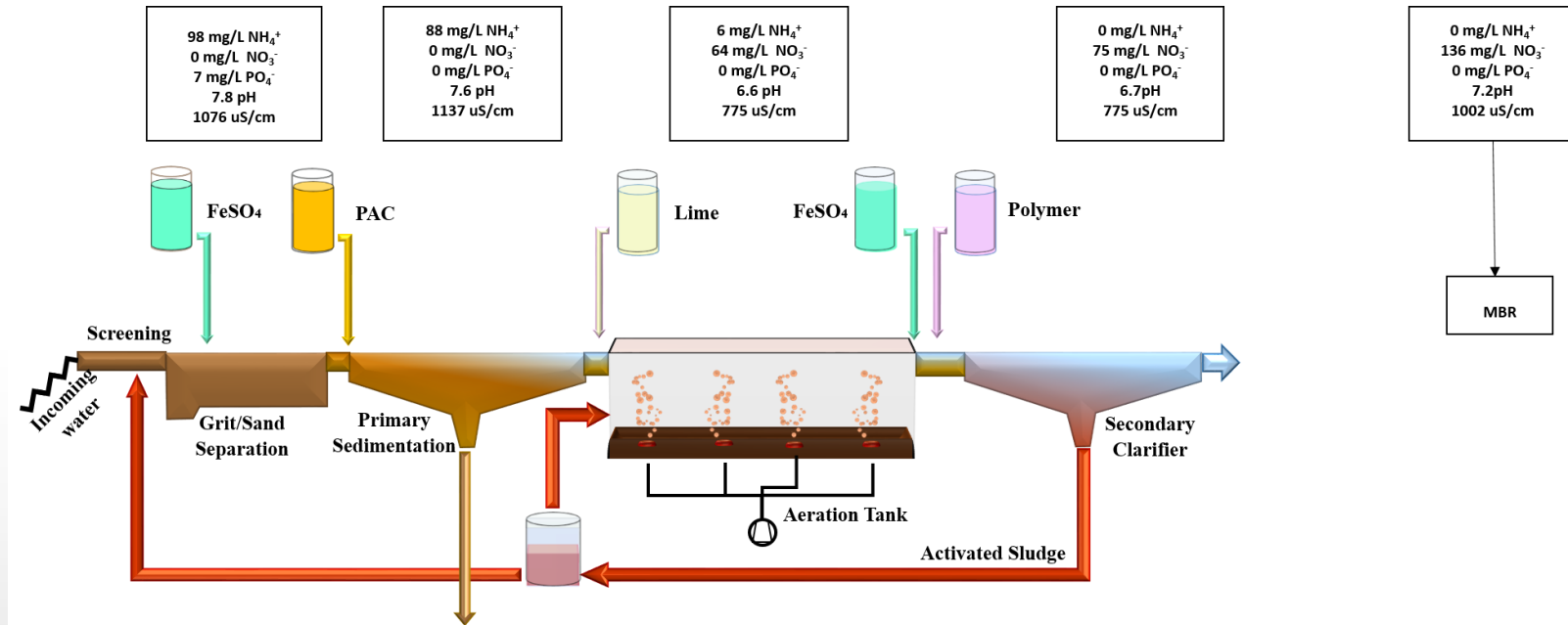Electroadsorption performance of CDI unit depending on A) applied voltage, B) flow rate.
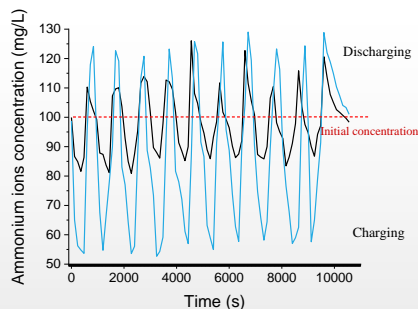
Concentration profiles of the NH4Cl solution under performance of the pristine AC and AC oxidized electrodes.

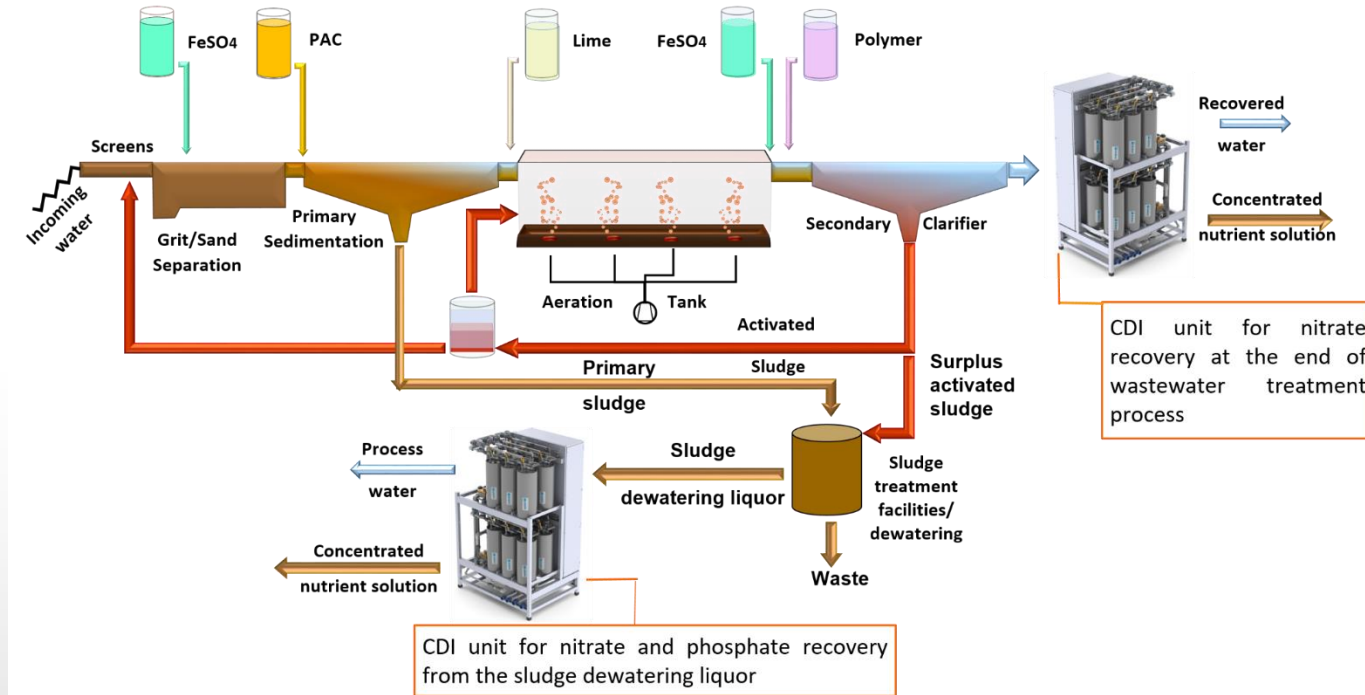| Parameter	Phosphate	Nitrate	Ammonium	
Electrode	Activated carbon (AC)			Modified AC
Removal efficiency, %	18	48	27	82
Recovery efficiency, %	15	21	10	21
Electrosorption capacity of AC electrodes, mg/g	2	5.5	3	12

Contact angle of a water droplet on the surface of the AC pristine electrode and electrodes after surface modifications.

Municipal wastewater treatment system - nutrients loading on each step (Aug-Sept 2019)

98 mg/L NH$_4^+$
0 mg/L NO$_3^-$
7 mg/L PO$_4^-$
7.8 pH
1076 uS/cm

88 mg/L NH$_4^+$
0 mg/L NO$_3^-$
0 mg/L PO$_4^-$
7.6 pH
1137 uS/cm

6 mg/L NH$_4^+$
64 mg/L NO$_3^-$
0 mg/L PO$_4^-$
6.6 pH
775 uS/cm

0 mg/L NH$_4^+$
75 mg/L NO$_3^-$
0 mg/L PO$_4^-$
6.7 pH
775 uS/cm

0 mg/L NH$_4^+$
136 mg/L NO$_3^-$
0 mg/L PO$_4^-$
7.2 pH
1002 uS/cm

FeSO$_4$ PAC   Lime   FeSO$_4$ Polymer

MBR

Screening

Incoming water

Grit/Sand Separation

Primary Sedimentation

Aeration Tank

Secondary Clarifier

Activated Sludge

Application of CDI into the current wastewater treatment system – process

Application of CDI into the current wastewater treatment system – key metrics

Conditions			Calculated parameters			
Wastewater loading	10000 m^3/day		Daily energy consumption	25000 kWh/day		
Energy consumption	2.5 kWh/m^3		Recovered water	8200 m^3/day		
Water recovery	82 %		Concentrated nutrient solution	1800 m^3/day		
Nitrate loading	*WW	**SDL	Nitrate recovered		*WW	**SDL
	100	212			36	80
	mg/L				kg/day	
Phosphate loading	*WW	**SDL	Phosphate recovered		*WW	**SDL
	-	172			-	62
	mg/L				kg/day	
Nutrient recovery	20 %		***Market value of N: 1.1 €/kg	128 €		
			***Market value of P: 1.7 €/kg	105 €		

* WW - wastewater (after secondary clarifier); ** SLD - sludge dewatering liquor
***Market value of nutrients (World bank, 2016): https://datacatalog.worldbank.org/dataset/gem-commodities

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Thank you for your attention!

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