Nutrient recovery from municipal wastewater by capacitive deionization (CDI)

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 as such a new technology.

Fundamentals of CDI

Capacitive deionization (CDI) is a technique based on the applying of a potential difference over two porous carbon electrodes. The goal is to remove the ions from the wastewater stream during the electrosorption stage (at 1.2.V) and to release the ions back into the stage (at 0 V). As a result, two watersmaller volume concentrated solution at the electrodesorption streams are obtained: recovered water and concentrated solution.

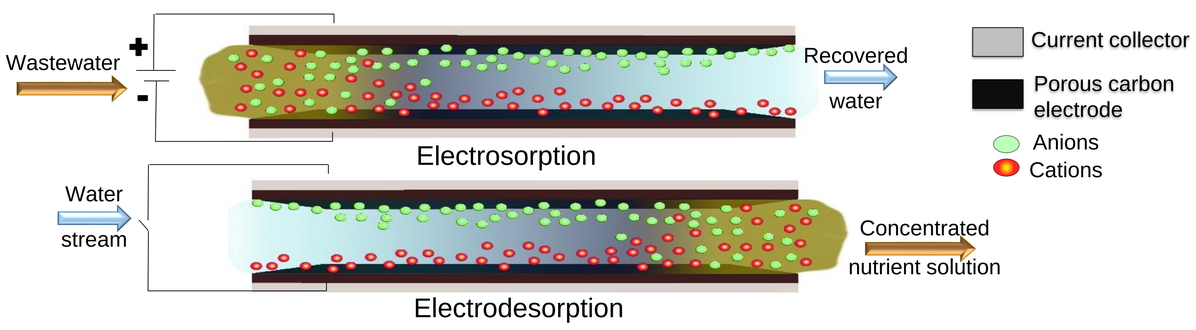

Figure 1. Principal of CDI operation.

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

Experimental work

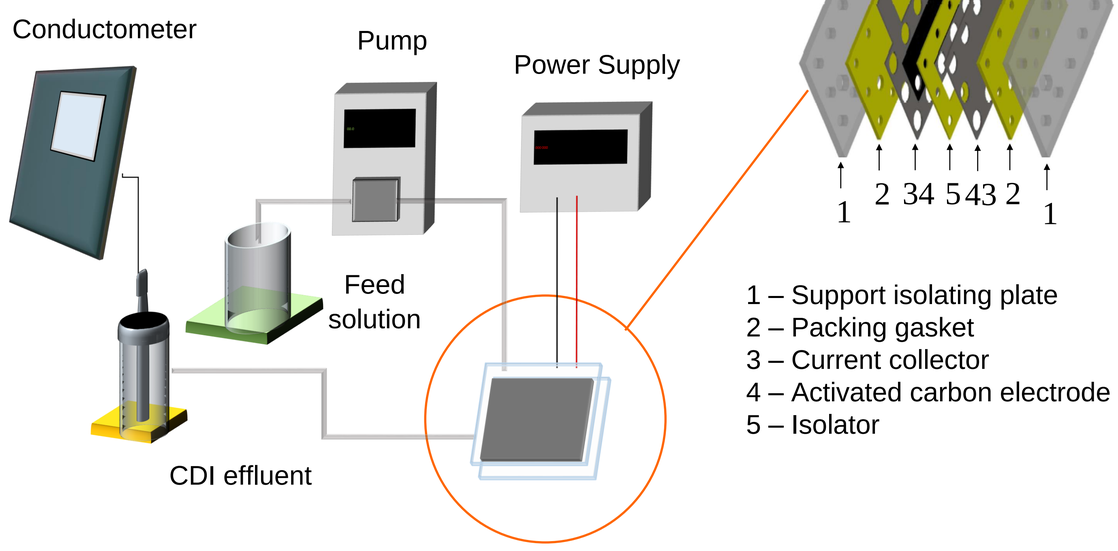

Figure 2. Schematic of the experimental setup.

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

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

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

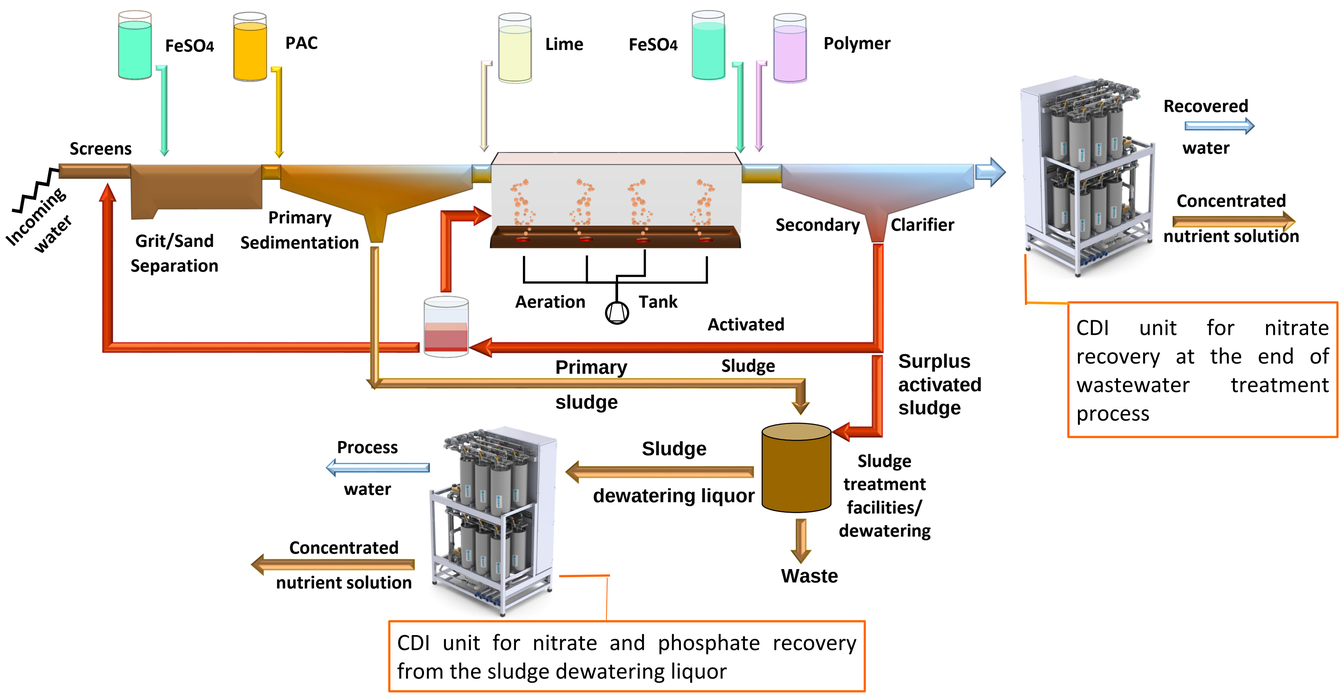

Figure 3. CDI units integrated into the conventional wastewater treatment system..

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		*WW **SDL
	100 212	Nitrate recovered	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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