
# Life Cycle Assessment of an Ion Exchange Technology for Nutrient Removal and Recovery from Municipal Wastewater

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**Abstract:** Recovery of nutrients as well as the requirement to meet low effluent values are recent challenges for municipal wastewater treatment plants (WWTP). Therefore, an ion exchange process (IEX) was developed, which is integrated in the secondary effluent of a WWTP to eliminate and recover ammonium and phosphate. This study compares a simple WWTP without targeted nutrient removal in combination with a downstream IEX and a generic reference WWTP with biological nutrient removal in their environmental impacts, using the Life Cycle Assessment method. Preliminary results suggest that an IEX can be beneficial due to upstream energy savings in the WWTP. The results strongly depend on the technical solution for recovery of the IEX regeneration solution.

**Keywords**: Nutrient recovery; municipal wastewater, high effluent quality; Life Cycle Assessment;

**INTRODUCTION** Because WWTPs are a point source of nutrients (N and P) in surface water bodies, water authorities pursue to tighten the limits for effluent quality. Additionally, nutrient recovery is targeted to get closer towards a circular economy and become more independent of phosphorus imports. New technologies are coming up to meet these targets. Life Cycle Assessment (LCA) can help to compare the environmental footprint of new technologies with conventional processes to see if material recovery is associated with environmental benefits in a holistic perspective. This study investigates ion exchange (IEX) as an innovative process for nutrient removal and recovery with LCA, comparing it to a conventional WWTP.

**METHODS** New technologies such as the IEX for municipal wastewater are associated with environmental impacts and benefits. To gain a distinct overview of these effects, two different scenarios for small and large WWTPs with a corresponding baseline (a generic conventional WWTP) are defined in Table 1.

**Table 1.1** Overview of the configuration and targets of the two LCA scenarios.

| | **Small WWTP (10,000 pe)** | **Large WWTP (100,000 pe)** |
|---|---|---|
| Targets | Nutrient recovery | Nutrient recovery and effluent polishing |
| Effluent quality | 1-2 mg/L TP, 10 mg/L $NH_4$-N | 0.5 mg/L TP, 3 mg/L $NH_4$-N |
| Setup of Baseline WWTP | • Trickling filter<br>• Chemical P removal (Fe dosing)<br>• Sand filtration for N removal and P removal after Fe dosing | • Nitrification for NH4 removal<br>• Chemical P removal (Fe dosing)<br>• Post-treatment with sand filtration and Fe dosing |
| Setup of WWTP-IEX combination | • BOD removal plant<br>• IEX for nutrient recovery | • BNR plant (N and P removal)<br>• IEX for polishing |

Both setups fulfil the same limits of the WWTP effluent and the sewage sludge is applied in agriculture. The system boundaries of this Life Cycle Assessment (see Figure 1.1) include:

- Direct emission of WWTP and IEX to air, surface water and ground,
- relevant background processes for operations of sewage treatment plant and IEX, such as electricity, heat, chemical and polymer demand,
- sludge treatment including sludge digestion, biogas valorisation within a CHP and the return load from thickening and dewatering,
- transportation of dewatered sludge and application in agriculture,
- infrastructure,
- credits for produced goods such as electricity via CHP or incinerator and
- credits for avoided fertilizer production due to recovered nutrients.

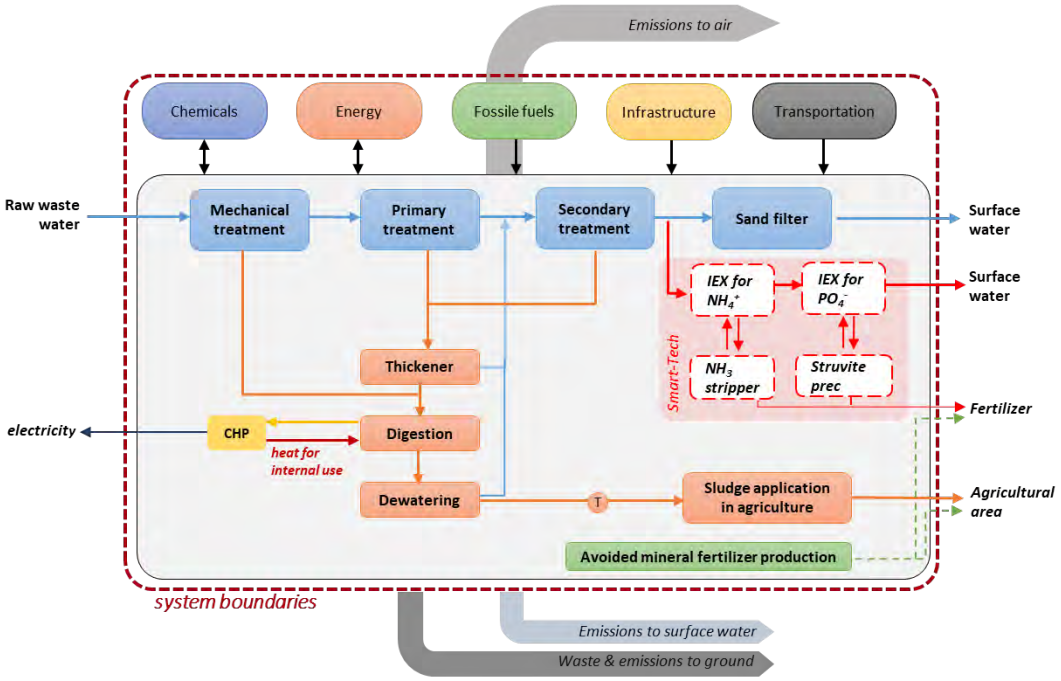


**Figure 1.1** System boundaries

This study follows the method of Life Cycle Assessment (ISO 14040 2006). All used process data concerning the IEX is based on technical scale testings of Cranfield University in the H2020 innovation action SMART-PLANT (Grant No. 690323) and data concerning the effects on the upstream WWTP is provided by Severn Trent.

## REFERENCES

ISO 140140 (2006): Environmental management – Life Cycle Assessment – Principles and framework. In, International Standardisation Organisation, Geneva Switzerland.