Sludge management within the pulp and paper industry

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Abstract
The European pulp and paper industry is committed to reduce its carbon emissions with 80%, comparted to the level of 1990, by 2050. This means that the next three decades need strategic actions to develop new energy efficient technologies and GHG mitigating concepts. In this context, upgrading of the existing industrial wastewater treatments (WWTs) that process effluents from the mills, can be a valuable contribution. Current estimations – based on thermo mechanical pulp (TMP) mills – shows that conventional WWTs based on the activated sludge process (ASP) account for annual CO_2-emissions of over 10 000 tonnes. These high values (equals to about 1.4 kg CO_2 per m^3 of treated wastewater), is primarily an effect of 1) the energy required for aeration of the wastewater, and 2) external dosing of urea and phosphoric acid needed to balance the C:N:P ratio for microbial growth. The generated biological sludge (WAS) is regarded as a waste with a cost for disposal. To minimise sludge production, the ASP is often operated to generate as low amounts of WAS as possible but this means long treatment times and high energy consumption in the ASP. The *EffiSludge for LIFE* project aims to demonstrate a system producing WAS for biomethane production while reducing carbon emissions from the WWTs by up to 50%. Reduction in sludge age from >10 days to 4-5 days will give significant energy savings within the aerobic step at the same time increasing WAS' digestibility. Furthermore, co-digestion of WAS with nutrient rich organic waste offers the opportunity for onsite nutrient recovery/reuse. Reject from dewatering of digestate is expected to completely replace urea as nitrogen source and reduce addition of phosphorus by 60%. The project is under implementation at Norske Skog Skogn mill's WWT plant in Norway. The WWT treats 20 000 m^3 of wastewater per day. At the same site a liquid biogas plant will soon be in operation (120 GWh) treating WAS together with fish waste.

Keywords (max 5)
Waste activated sludge; Industrial wastewater; Biogas; Carbon footprint;

INTRODUCTION

To reach the carbon emission target of 12 million tonnes CO_2 by 2050 the pulp and paper industry (PPI) is committed to implement innovative technical concepts (CEPI, 2016). One such concept is *EffiSludge for LIFE*. The EffiSludge concept has the potential to reduce the CO_2-emissions from industrial wastewater treatment plants. At present, this concept is applied to a full-scale project at Norske Skog Skogn paper mill in Norway. The objective is to increase the organic load and reduce the sludge age in the activated sludge process (ASP), thus reducing the need for aeration and increasing the waste activated sludge (WAS) production and also its methane potential (Ge et al., 2013). By processing WAS in co-digestion with nutrient enriched substrates such as fish waste, the recirculation of the reject from dewatered digestate into the ASP provide valuable nutrients thus reducing the need for external dosing of N and P into the ASP. A preliminary comparison between conventional ASP and EffiSludge-ASP in term of carbon emissions linked to energy demand and external nutrient addition is presented below.

MATERIALS AND METHODS

Data from the existing WWT processing effluents from the Skogn mill has been used to estimate the carbon footprint in the considered scenarios (Figure 1). The comparison between the two scenarios is based on the expected changes in overall energy demand and nutrient dosing. For the base scenario the operational parameter for the ASP corresponds to typical aeration condition (sludge age of 12-14 days with sludge production of 0.2 $kgSS/kgCOD_{degraded}$) providing energy demand for the all WWT equal to 1400 MWh/month. This is reduced to 850 MWh/month in the EffiSludge scenario (sludge age of 4-5 days with sludge production of 0.4 $kgSS/kgCOD_{degraded}$). The nutrient demand is considered equal to 750 kg N and 120 kg P per day. Those needs are provided by external dosing of urea (40% solution) and phosphoric acid (75% solution) in the base case, and by reject water from dewatering of digestate post AD of WAS and fish waste, in the case scenario (100% of N and 50% of P is provided). Carbon emissions were calculate based on ECOINVENT carbon factors applied to energy (0.484 $kgCO_2/kWh$), nitrogen (6.42 $kgCO_2/kgN$) and phosphoric acid (1.47$kgCO_2/kgH_3PO_4$).

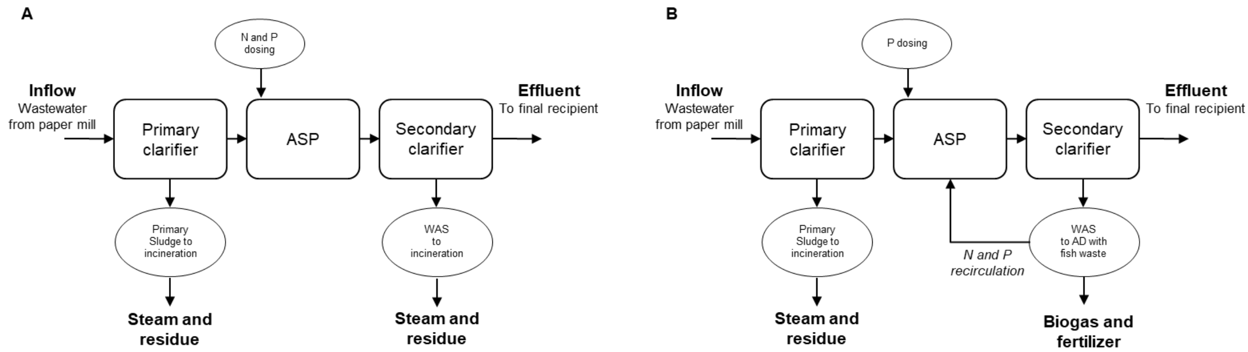

Figure 1. Base scenario (A) representing conventional WWT at pulp and paper mills, and case scenario (B) considering EffiSludge alternative approach where WAS is co-digested with fish waste.

RESULTS AND DISCUSSION

The estimated annual carbon emission for the base scenario was 10 070 ton CO_2, equals to 1.4 $kgCO_2/m^3$ of treated wastewater. The main contribution to carbon emissions was related to energy demand (82%), followed by N (17%) and P dosing (1%). In the case scenario, the energy saving in the aeration reduced carbon emissions by 3 290 ton CO_2, while the recirculation of reject from dewatering of digestate into the ASP reduced carbon emission for N and P dosing by 1 760 and 40 ton CO_2/y, respectively. Overall, the total annual carbon emission decreased to 4 980 ton CO_2 corresponding to ca. 0.7 $kgCO_2/m^3$ of treated wastewater (50% reduction). The impacts of a reduced sludge age on direct emissions from the ASP could provide additional carbon saving (Daelman et al., 2012) but are not included in this evaluation. Neither is production of biogas as a biofuel that could replace oil or fossil gas included. A full Life Cycle Assessment (LCA) are on its way for both above scenarios.

CONCLUSIONS

The implementation of EffiSludge at existing industrial WWT allows up to 50% reduction in carbon emissions per m^3 of treated wastewater.

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