Technologies to meet new challenges in sewage treatment

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INTRODUCTION

In the coming years, sewage treatment plants (STP) will face new challenges regarding the removal of micro pollutants. For this, existing STP-processes must be adapted or supplemented and enhanced by new techniques.

In a pilot research project, conducted by Xylem and IVL Swedish Environmental Research Institute, during a 24-month period at Hammarby Sjöstadsverk (Sweden), various techniques have been combined with each other in order to examine the effectiveness and compliance with international standards for various water qualities.

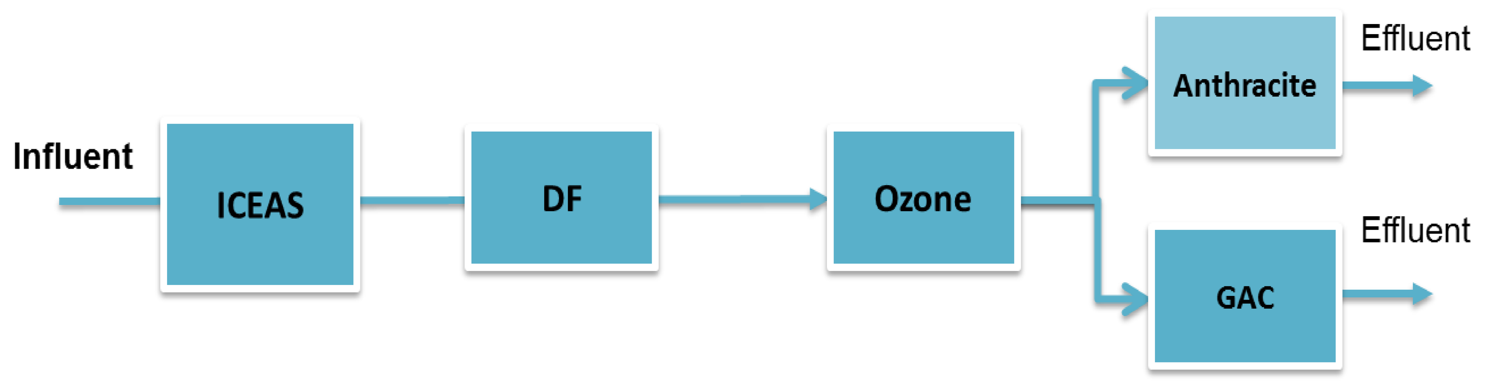
The goal of this project was the treatment of sewage including the removal of micro pollutants such as pharmaceuticals and other persistent chemicals, including a cost analysis (LCC) for an optimal process combination containing:

- Biological treatment (Modified SBR called ICEAS™, Xylem)
- Oxidation by ozone (Wedeco, Xylem),
- Filtration by anthracite and granular activated carbon (GAC) (Leopold, Xylem)
- Disinfection by UV (Wedeco, Xylem)

MATERIALS AND METHODS

Four treatment processes focused on in this study involved:

1. SBR (ICEAS) process
2. Disc Filter (DF, 10µm)
3. WEDECO Ozone system (up to 16 mg ozone/L or 1,2 g ozone/g TOC)
4. LEOPOLD filter (anthracite and Granular Activated Carbon (GAC) as media)



During the experiments the pilot plant has been thoroughly investigated in terms of

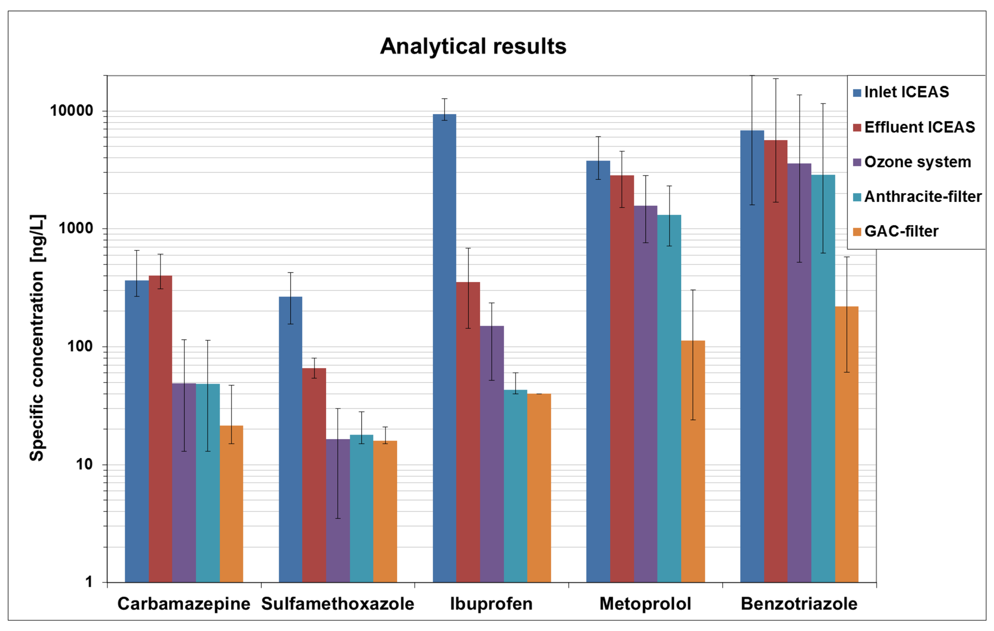
- cleaning effectiveness
  (Micropollutants TOC, COD BOD_5, UV-T, ammonia and TSS) and
- total costs
  (LCC assuming a 20 years-lifetime of the plant and an interest rate of 5.5%)

Influent wastewater parameter	Unit	Minimum	Average	Maximum
Dry weather flow	m³/d	15.2	17.9	22.5
Rain weather flow	m³/d			51.0
COD (chemical oxygen demand)	mg/L	542.7	635.6	735
TSS (total suspended solids)	mg/L	236	318.0	360.3
BOD_5 (biological oxygen demand)	mg/L	287.1	355.4	450
Ammonia nitrogen (NH4-N)	mg/L	27	32.9	37.5
Total-Phosphorous	mg/L	5	6.5	7.6

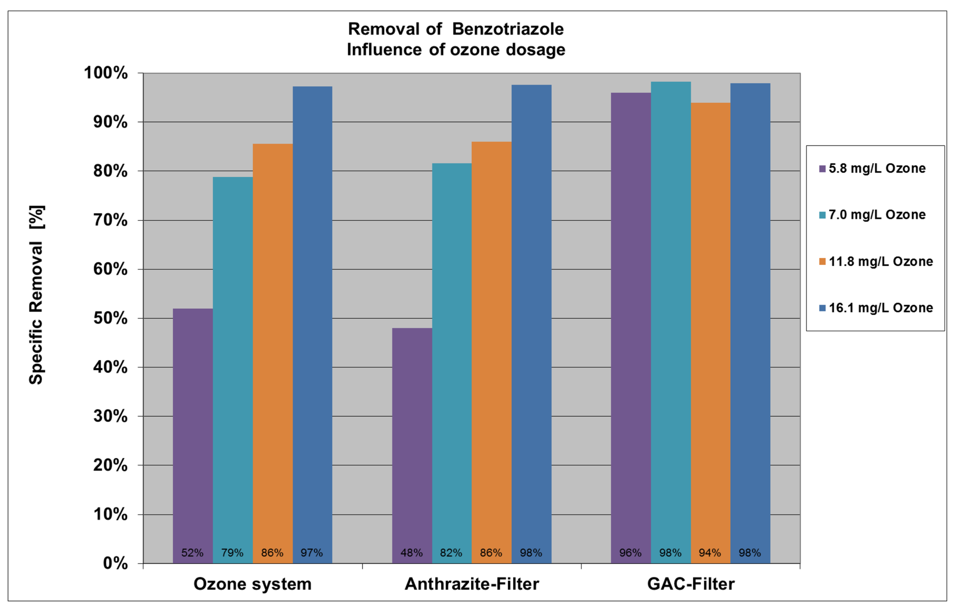
RESULTS

Parameter	Unit	Inlet ozone system	Effluent ozone system	Effluent anthracite - filter	Effluent GAC-filter
TOC	mg/L	12.6	11.8	9.1	8.5
COD	mg/L	41.9	32.2	20.3	21.2
BOD_5	mg/L	7.3	8.0	3.0	2.7
UV-T	%	53.8	73.0	77.4	77.9
NH-4-N	mg/L		0.79	0.05	0.03
TSS	mg/L		4.67	0.47	0.66

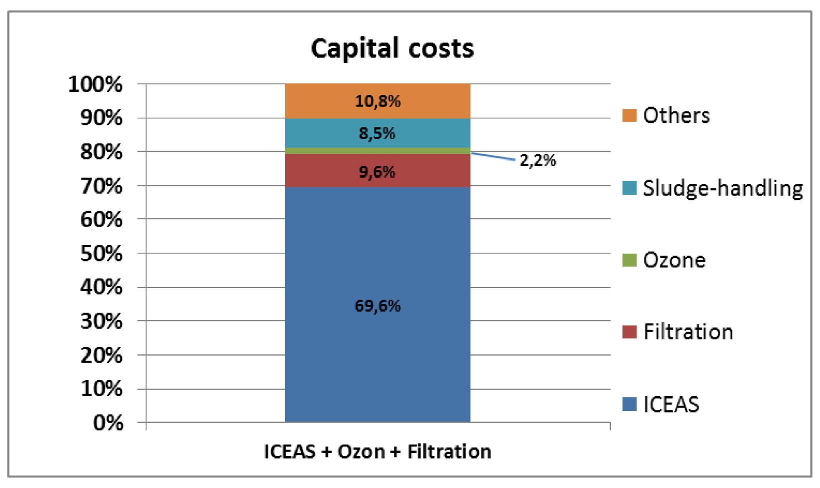
By combining ozone and filter, a more extensive removal of specific parameters is possible. Ozonation slightly reduces COD and partially TOC as contaminants and micropollutants are oxidized and made bioavailable. This is also shown by a slight increase of BOD5. Both COD and BOD5 are further reduced in biological activated filters. Depending on the ozone dosage and water contamination, the removal of COD could be more than 40%. Additionally the UV-T (important parameter for the sizing of UV-systems for disinfection) will be improved significantly. By filtration the TSS concentration is stable below 2 mg/L and ammonia nitrogen will be additionally reduced.

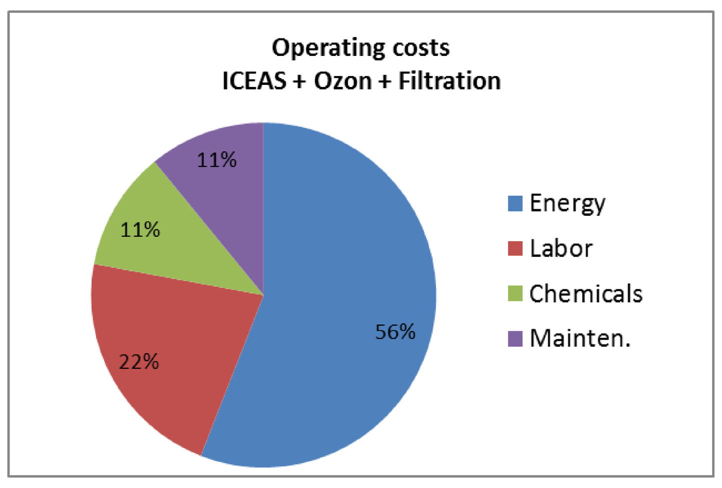


The removal of micropollutants varies between processes and substances. Deviations at the inlet of ICEAS are typical. For ozone and filtration they are mainly effected by the use of different ozone dosages. Sulfamethoxazole and Ibuprofen are reduced mainly by biological processes in the ICEAS. Ibuprofen is further reduced by ozonation resulting in an overall removal of 2.5-log. Carbamazepine, Metoprolol and Benzotriazole are not significantly reduced by the biological processes. Carbamazepine reacts very quickly with ozone and is mainly removed in this treatment process. Metoprolol and Benzotriazole show lower reactivity to ozone and reach lower removal rates (approx. 50 – 80%). Anthracite as a filter media shows only minor removal while GAC adsorbs most of these substances.



Benzotriazole is better degraded with increasing ozone dose [mg/L] while carbamazepine is reduced even at low ozone doses to the limit of quantification. However, the anthracite filter shows no appreciable degradation. However, the filter with granulated activated carbon adsorbs the Benzotriazole and reduces the concentration close to the limit of determination. A similar behavior is also observed for Metoprolol. The substances Carbamazepine, Diclofenac and hormonally active substances such as Estradiol are oxidized even at the lowest dose of ozone, down to the limit of quantification.





The combination of ozone and filtration accounts for only 11.4% of the overall investment costs (CAPEX) for the whole treatment line of 100.000 PE. This includes mechanical, civil and electrical cost with reinvestments.

The main driver for operating costs (OPEX) of the complete treatment line is energy demand (56%). Ozone and filtration require only a small portion of the total energy demand (13%).

For the overall consideration of the LCC, where the proportion of operating costs of the evaluated treatment line is 57% and the share of capital costs is 43%, the evaluated ozone + filtration accounts for only small part.

CONCLUSION

The trials show that the combination of ozone and filtration is a practical process to remove micropollutants efficiently. The magnitude of removal can be automatically adopted to the specific requirements and are related to the ozone dosage. The higher the dosage the higher the removal of micropollutants. Additionally other parameters like TSS, COD and turbidity can be significantly reduced.

Ozone combined with GAC shows the highest removal rates. Other positive affects as well as the lifetime of GAC will be investigated.

Compared to the total costs for the construction of new wastewater treatment plant the proportion of the cost for additional treatment process for the removal of micropollutants is quite small (≈ 10%). The same applies for the costs for energy consumption.

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