Wastewater treatment plants (WWTP), based on activated sludge, are not designed to remove most of the micropollutants (MP), such as pharmaceutical substances from the wastewater. Even if the environmental risks are not fully established, there is a need to protect the environment from emissions of micropollutants and therefore upgrading of WWTP with advanced treatment technologies (ATT) for pharmaceuticals removal might be necessary.

Criteria to consider while applying advanced treatment

1. Investment costs → Economic profitability
2. Energy consumption → Additional energy cost
3. Monitoring of ATT → Increased workforce, influence on other technological steps, increased competence of operators
4. Maintenance aspects → Operational costs (personnel, consumables)

Oxidation with ozone

- Has relatively small footprint
- Is compact and cost-effective
- Not suitable for every wastewater - advanced decision tool needed
- Pre-treatment crucial! (mechanical/biological)
- Ozone consumption increases with increasing DOC (dissolved organic carbon)
- Post treatment needed (e.g. sand filter) to reduce potentially toxic by-products
- Special attention to presence of bromide (formation of the carcinogenic bromate)

Powdered activated carbon (PAC)

- No formation of by-products
- Possible interactions with existing treatment system
- Higher usage of polymers and precipitation solutions
- Storage and handling of PAC (explosion risk and abrasive wear of pumps and pipes)
- Pre-treatment for PAC separation needed
- Final incineration of PAC died sludge required

Granulated activated carbon (GAC)

- Alternative to PAC
- Pre-treatment crucial! (Mechanical/Biological)
- Compact and easy to replace as a fourth step of treatment
- Same advantages as PAC but no storage and handling
- Relatively high footprint

MORPHEUS
Model Areas for Removal of Pharmaceutical Substances in the South Baltic

Interreg South Baltic

European Regional Development Fund

Contact

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Advanced treatment technologies for the removal of pharmaceutical substances in WWTPs

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Criteria for choosing the removal method

1. WWTP - PE, Q, recipient

Catchment measures

- WWTP with high loads
- WWTP in the catchment of lakes
- WWTP on rivers with a fraction of wastewater > 10%
- WWTP on rivers impacting drinking water resources

2. WWTP current technology

Technological measures

- WWTP mechanical treatment
- WWTP biological step
- WWTP post-treatment
- WWTP sewage sludge management
- Available space, presence of qualified personnel, incineration plant
- Presence of bromide excludes the use of ozonation

3. Presence of pharmaceuticals in WWTP inffluent/effluent

Burden measures

- Chemical burden of WWTP and effectiveness of current technology in pharmaceuticals removal

4. WWTP additional parameters

Additional relevant measures

- Integration of various stakeholders opinions and goals
- Recognition of financing options for advanced treatment investment

Advantages/disadvantages of methods and advanced wastewater treatment techniques

Process	Method	Advantages	Disadvantages
Physical	• Reverse osmosis • Nanofiltration • Microfiltration	• Effective for a large number of different MPs • MP removal effectiveness quite/very stable	• By-product (concentrate) is problematic and costly to handle • High energy consumption
Biological	• Membrane bioreactor (MBR) • Moving bed biofilm reactor (MBBR) • Other biofilm processes	• MPs are removed from wastewater via biodegradation and adsorption to sludge (removed from the system as excess sludge) • MP removal effectiveness quite stable	• MPs removal is a substrate- and microbial-community-dependent process • Conversion and degradation of MPs is not well controlled (unknown intermediates)
Adsorptive	• Granular activated carbon (GAC) • Powdered activated carbon (PAC)	• Effective to a large number of different MPs • MP removal effectiveness quite stable	• Regular replacement/ regeneration of GAC • In PAC technology the excess sludge produced has to be dewatered and incinerated • High energy requirement for regeneration of activated carbon • In presence of DOC/TOC competitive adsorption may occur
Oxidative	• Ozonation • UV/H_2O_2 • O_3/H_2O_2	• Easily changed ozone dosage • MP removal effectiveness quite stable	• Incomplete MPs degradation • High energy consumption

DOC - dissolved organic carbon, TOC - total organic carbon, MPs - micropollutants