Federal Ministry
Republic of Austria
Agriculture, Regions
and Tourism

Überarbeitung der Kommunalen Abwasserrichtlinie (91/271/EWG)

Österreichische Zahlen, Daten und Fakten zu ausgewählten Überarbeitungsoptionen

Austrian data, facts and figures on selected policy options

Vienna, 2021

Legal notice

Media owner and publisher:
Federal Ministry of Agriculture, Regions and Tourism, Stubenring 1, 1010 Vienna, Austria

Contact:
Heide Müller-Rechberger, Federal Ministry of Agriculture, Regions and Tourism, Sekt. I, Abt. 4 – Anlagenbezogene Wasserwirtschaft, Heide.Mueller-Rechberger@bmlrt.gv.at

Authors: Florian Kretschmer, Norbert Kreuzinger, Günter Langergraber, Katharina Lenz, Stefan Lindtner, Dirk Muschalla, Vanessa Parravicini, Bettina Polgar, Heidemarie Schaar, Clemens Steidl, Joseph Tauber, Karl Svardal, Matthias Zessner

Editorial: Umweltbundesamt – Environment Agency Austria

Vienna, 2021.

Vorwort

Die Europäische Kommission hat im Dezember 2019 ihren Evaluierungsbericht zur Kommunalen Abwasserrichtlinie (91/271/EWG) vorgelegt. Es zeigte sich, dass die Belastung durch bestimmte Schadstoffe aus städtischen Punktquellen verringert werden konnte. Der Evaluierungsbericht sieht aber auch Anpassungsbedarf v.a. in den Bereichen der Finanzierung, der Umsetzung, der Mischwasserentlastung und des Umgangs mit bisher nicht geregelten Schadstoffen (Arzneimittel, Mikroplastik) und weiteren Bereichen in Zusammenhang mit dem europäischen Green Deal. Derzeit wird eine Wirkungsfolgenabschätzung durchgeführt. Dabei werden Ideen zur Weiterentwicklung der Richtlinie auf Kosten und Wirksamkeit untersucht. Im Jahr 2022 will die Europäische Kommission einen Vorschlag zur Überarbeitung der Richtlinie vorlegen.

Die Überarbeitung der Kommunalen Abwasserrichtlinie zielt vorrangig auf jene Bereiche ab, die bei der Evaluierung als verbesserungswürdig erachtet wurden. Zu diesem Zweck wurden von der Europäischen Kommission verschiedene politische Optionen für die Änderung der Richtlinie vorgeschlagen, die 2021 sowohl von den betroffenen Akteuren in den Mitgliedsstaaten, als auch von einem wissenschaftlichen Gesichtspunkt her bewertet werden sollen.

In einem vom BMLRT beauftragten Projekt wurden Zahlen, Daten und Fakten zu den Optionen, die von der Europäischen Kommission entwickelt wurden, aus österreichischer Sicht dargestellt und in Factsheets zusammengefasst. Diese werden im vorligenden Bericht präsentiert und stellen die österreichische Situation zu ausgewählten Themenbereichen dar. Die Factsheets sind in Englischer Sprache verfasst, da sie der Europäischen Kommission für die Wirkungsfolgenabschätzung zur Verfügung gestellt wurden.

Preamble

The European Commission presented its evaluation report on the Urban Waste Water Treatment Directive (91/271/EC) in December 2019. It showed that the load of certain pollutants from urban point sources could be reduced. However, the evaluation report also sees a need for adjustments mainly in the areas of financing, implementation, combined sewerage, the handling of previously unregulated pollutants (pharmaceuticals, microplastics) and other areas related to the European Green Deal. An impact assessment is currently underway. This will examine ideas for further development of the Directive in terms of cost and effectiveness. In 2022, the European Commission plans to present a proposal to revise the Directive.

The revision of the Urban Waste Waste Water Treatment Directive primarily aims at those areas that were deemed to be in need of improvement during the evaluation. To this end, various policy options for amending the Directive have been proposed by the European Commission, which will be evaluated in 2021 both by the stakeholders concerned in the member states and from a scientific point of view.

In a project commissioned by the BMLRT, figures, data and facts on the options developed by the European Commission were presented from an Austrian perspective and summarized in factsheets, which are given in the current report. The factsheets are in English language, as they were provided to the European Commission in the course of the impact assessment.

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1 Factsheet – Storm water overflows and urban runoff

Authors:

Dirk Muschalla[1],

Bettina Polgar[1]

[1]Institut für Siedlungswasserwirtschaft und Landschaftswasserbau, Technische Universität Graz, Stremayrgasse 10/I, 8010 Graz, Mail: office.sww@tugraz.at

1.1 Background

The UWWTD aims to protect the environment from harmful effects that may result from the discharge of urban wastewater and from the discharge of wastewater from certain industrial sectors. It regulates the collection, treatment and discharge of these effluents. Urban wastewater is defined as domestic wastewater, a mixture of domestic and industrial wastewater and/or storm water[1].

The policy options for storm water overflows and urban runoff proposed by the EC are the following:

a) Obligation to set up integrated management plans for large agglomerations (prevention and optimal management of the collection/storage network +treatment)
b) Set up of EU fixed objectives (dilution rates, rain water treatment capacity, …)
c) Use of a risk-based approach to deal with storm water overflows and urban runoff in line with WFD objectives by allowing derogations where there is evidence that water quality of the recipient body is not affected
d) Mandatory monitoring and reporting to the European Commission (EC) of overflows and other discharges
e) Ban separate sewer discharges into surface water without minimum treatment requirements for rain waters

[1] Combined sewage is a mixture of domestic/industrial wastewater and storm water

1.2 Current situation in Austria

Legal basis	Storm water discharge • The ÖWAV Code of Practice 35 defines the state of the art in AT for the discharge of storm water into surface waters (ÖWAV, 2019) • The following laws and regulations must be considered for the discharge of storm water into surface waters: – Austrian Water Act (WRG) (BGBl. Nr. 215/1959) – General Waste Water Ordinance (AAEV) (BGBl. Nr. 186/1996) – Quality Target Ordinance/Chemical Condition of Surface Water (QZV Chemie OG) (BGBl. Nr. 96/2006) – Quality Target Ordinance/Ecological Condition of Surface Water (QZV Ökologie OG) (BGBl. Nr. 99/2010) Combined sewer overflows • The ÖWAV Code of Practice 19 defines the state of the art for the design of combined sewer systems in AT (ÖWAV, 2007). • The following laws and regulations must be considered for the design of combined sewer overflows: – Austrian Water Act (WRG) (BGBl. Nr. 215/1959) – General Waste Water Ordinance (AAEV) (BGBl. Nr. 186/1996) – Quality Target Ordinance/Chemical Condition of Surface Water (QZV Chemie OG) (BGBl. Nr. 96/2006) – Quality Target Ordinance/Ecological Condition of Surface Water (QZV Ökologie OG) (BGBl. Nr. 99/2010)
Current situation	• Although a clear state of the art was defined with ÖWAV Code of Practice 19 and Code of Practice 35 for combined sewer management and the discharge of storm water from separate sewer systems, it has not yet been achieved nationwide. No emission regulation for combined sewer systems has been enacted to date. • The ecological and chemical status of water bodies is monitored by applying a combination of surveillance and operational monitoring, and assessed in a six-year observation cycle. The requirements are defined in the Ordinance on the Monitoring of the Quality of Water Bodies (GZÜV) (BGBI. Nr. 479/2006). The results are published in the GZÜV-annual report and are used for the WFD River Basin Management Plans. • In AT the connection rate to the public sewer system is > 95 % (BMLRT, 2020), the length of the public sewer network is estimated to be about 96,000 km, of which an estimated 57,500 km are wastewater sewers, 27,500 km are combined sewers and the remaining 11,000 km are storm water sewers (BMLFUW, 2012). Again, estimated are about 10,000 combined sewer overflows and combined sewer overflow basins and 1,500 storm water treatment plants (BMLFUW, 2012). In total, 1,869 wastewater treatment plants with a design size > 50 PE, 38 of them with a design capacity > 100,000 PE and 633 of them with a design size > 2,000 PE are operated in AT (BMLRT, 2020). The following table shows the number of UWWTPs according to their organic design capacity.

Table 1: Number and organic design capacity of UWWTPs in AT (BMLRT, 2020)

Size class (PE)	Number UWWTPs		Organic design capacity [PE]	
	[n]	[%]	[PE]	[%]
51 – 1,999	1,236	66.1%	455,862	2.1%
2,000 – 10,000	367	19.6%	1,733,363	7.9%
10,001 – 15,000	46	2.5%	597,725	2.7%
15,001 – 150,000	201	10.8%	8,967,108	40.7%
> 150,000[1)]	19	1.0%	10,280,867	46.6%
Total	**1,869**	**100%**	**22,034,925**	**100%**

1) Consideration of three big industrial wastewater treatment plants with an urban fraction of wastewater > 2,000 PE

- The currently available database in AT makes a serious estimation of the deficit to achieve the formulated state of the art according to ÖWAV Code of Practice 19 and Code of Practice 35 difficult.
- In BMLFUW (2014) the wastewater volumes for the whole of Austria were calculated in accordance with the Code of Practice 19. The results are shown in Table 2.

Table 2: Wastewater volumes in Austria (BMLFUW, 2014)

Type of wastewater	Wastewater volumes	
	[mio m^3/a]	[%]
Wastewater treatment plant outlets	963	42
Storm water discharges from separate sewer	514	22
Combined sewer overflows	145	6
Infiltration in urban areas	63	3
Road runoff – direct discharge into running waters	252	11
Road runoff according to water protection system – direct discharge into flowing waters	17	1
Road runoff for infiltration	361	15
Total	**2,315**	**100**

	Combined sewer overflows only make up 6 % of the total wastewater volumes, and it should be noted that this is a mixture of sewage and storm water.
Costs	• Although the necessary investments to achieve the state of the art nationwide cannot be quantified because of the incomplete data basis, at least the value of the structures of combined water management needed for the state of the art can be estimated, for example: – The total connected, impervious surface area of all Austrian wastewater treatment plant catchments is estimated to be 154,000 ha (BMLFUW, 2014) and consists of 62,000 ha of sealed areas (e.g. buildings), additional 33,000 ha urban traffic areas and 59,000 ha rural traffic areas. – The percentage of combined sewer systems in AT is about 38%, the percentage of the separate sewer systems accordingly about 62%. In this analysis, the size of the catchment area was taken into consideration by weighting the individual connection rate over the respective impervious areas or rainfall runoff volumes (BMLFUW, 2014). – The required storage volume per hectare of connected, sealed area when implementing the ÖWAV Code of Practice 19 properly is at least 15 m^3 (ÖWAV, 2007). The cost of constructing the required storage capacity is approximately 1,000 to 1,500 €/m^3. – As a result, to implement the ÖWAV Code of Practice 19 from scratch (which is certainly not the case in Austria) would result in an estimated investment of 0.88 billion EUR to 1.32 billion EUR. With a population of approximately 8.9 million at the beginning of 2021[2], the cost per inhabitant is 99 € to 148 €.

[2] https://de.statista.com/statistik/daten/studie/19292/umfrage/gesamtbevoelkerung-in-oesterreich/

1.3 Policy options – future possibilities for implementation in Austria

1.3.1 Obligation to set up integrated management plans for large agglomerations

Possible implementation in AT	• The opportunities offered by integrated management of the sewer network and wastewater treatment plants have been widely accepted in the scientific community for decades. Only by a holistic approach the two main systems – sewer system and WWTP - can be operated optimally in terms of performance and costs. • An implementation of the integrated management can be found only to some extent in AT so far. • The consideration of the total emission and/or water quality-oriented approaches allows cost-efficient solutions that are optimally adapted to the local conditions (cf. 3.3), as existing capacities can be optimally used and referred to the receiving water body situation by the (sub-)system-wide consideration. • In the future, the interaction with the green-blue infrastructure like green roofs, retention cells and drain gardens, will be more and more in focus of urban development and urban drainage. Green-blue infrastructure has a number of positive but possibly also negative impacts on urban drainage systems and the WWTPs. Examples include the reduction of surface runoff and the eventual increase in extrinsic water runoff. • If 100,000 PE were taken as a limit for larger agglomerations, 38 agglomerations in AT would have to be considered. • In combined sewer systems, one of the most sensitive parameters for reducing total emissions is the maximum design capacity (permitted maximum inflow) of the wastewater treatment plant. Contrary to other European countries this is a fixed value in AT, preventing the best possible, dynamic use of available capacities (wastewater treatment plant and storage capacity in the sewer system). • A consequent implementation requires close cooperation and coordination between wastewater treatment plant operators, urban drainage, urban planning, green space, road management. • Comprehensive monitoring of the systems is mandatory for implementation because of the data requirements and the necessary understanding of the system • Smooth information flow on operational level and all involved actors is a prerequisite for this policy option.
Advantages	• Optimal management and use of existing infrastructure, identification of system reserves. • Possible identification of optimal strategies in terms of economic, environmental and operational goals.

Disadvantages	• Requires inter- and transdisciplinary cooperation of all urban stakeholders (hence more effort and complexity for communication). • High level of competence required of the planning and operating teams.
Costs	• Costs for data acquisition, information exchange and monitoring. • Staff costs (training and/or new hiring).

1.3.2 Set up of EU fixed objectives

Possible implementation in AT

- The approaches defined in ÖWAV Code of Practice 19 use, to a large extent, clearly defined, fixed values as targets for appropriate combined sewage management.
- Worth mentioning here are:
  - The combined sewer overflow (CSO) efficiency, which specifies the percentage of dissolved substances and settleable substances in % of the pollutant loads in the sewer in the entire catchment area of the combined sewer system in the event of rainfall, which must be treated at the treatment plant.
  - The minimum dilution that, in the case of combined sewer overflows, requires that when the overflow is started, the ratio between the throttled flow and the average dry weather flow is greater than 8.
- To a certain extent, the CSO efficiency is adapted to local conditions, in this case based on the precipitation height and the size of the wastewater treatment plant (ÖWAV, 2007). The following table shows this relationship.

CSO efficiency [%] For dissolved substances / **suspended solids**	Design size of the sewage treatment plant to which the combined sewer drains	
relevant precipitation	≤ 5.000 PE	≥ 50.000 PE
r720,1 ≤ 30 mm/12h	50 / **65**	60 / **75**
r720,1 ≥ 50 mm/12h	40 / **55**	50 / **65**
	Interpolate intermediate values linearly	

- At the European level different definitions of fixed values exist as requirements for combined sewage and storm water management. Frequently found is a limitation according to the average number (and duration) of CSO per year. The following table shows selected examples for European countries

	Belgium[1]	Germany (Hessen)	France[1]	Netherlands[1]	Poland[1]	UK[1]
	Depending on vulnearability of receoving water body	Only for CSO without storage	Based on observations		Depending on vulnearability of receoving water body	
Max. number of overflow events	from 10/a to 0.1/a	50/a	20/a	10/a	from 30/a to 3/a	10/a

[1] Milieu (2016)

Advantages	• A clear advantage would be international comparability. • A common minimum standard could be implemented at the European level.
Disadvantages	• Comparability of benefits is difficult due to considerable regional differences. EU-wide harmonized specifications can only be minimum criteria due to climatic and bioregion-specific requirements. It appears more appropriate to proceed on the basis of water quality-oriented objectives, e.g. good chemical and biological water status. • The implementability depends on the chosen limits of the target (e.g., duration and frequency of overflows) and could require substantial investments.
Costs	• Not calculable.

1.3.3 Use of a risk-based approach to deal with storm water overflows and urban runoff in line with WFD objectives by allowing derogations where there is evidence that water quality of the recipient body is not affected

Possible implementation in AT

- The ÖWAV Code of Practice 35 specifies whether and which pre-treatment of storm water is to be implemented before it is discharged into a receiving water body. The areas of origin of the storm water and the capacity of the receiving water body are taken into account. Regardless of this, the chemical limit values of the WFD, which are specified in AT in the QZV Chemie OG, must be complied with in any case.
- The following table summarizes the pre-treatment requirements depending on the areas of origin and the capacity of the receiving water body according to the ÖWAV Code of Practice 35 (ÖWAV, 2019).

	standing water				running water: MQ/Q < 100				running water: MQ/Q > 100			
	without treatment	mechanical treatment	treatment with soil filter	treatment with technical filter	without treatment	mechanical treatment	treatment with soil filter	treatment with technical filter	without treatment	mechanical treatment	treatment with soil filter	treatment with technical filter
F1	a	x	x	x	a	x	x	x	a	x	x	x
F2	i.a.	i.a.	x	x	i.a.	x	x	x	a	x	x	x
F3	-	i.a.	x	x	-	i.a.	x	x	-	x	x	x
F4	-	-	i.a.	i.a.	-	--	x	x	-	-	x	x
F5	-	-	i.a.	i.a.	-	-	m	m	-	-	m	M
	x	recommended			a	allowed		MQ	Annual discharge rate in the water body			
	i.a.	individual assessment			-	Not allowed		Q	annual project area discharge			
	m	minimum requirement										
	F1	Low polluted area			F5	Heavily polluted area						

- The goal of combined sewer treatment according to ÖWAV Code of Practice 19 is to reduce total emissions from wastewater treatment plants and combined sewer overflows as much as possible. A reference to the WFD is not present in ÖWAV Code of Practice 19, but minimum requirements for a water quality-oriented assessment of the receiving water body are defined and critical cases are considered (ÖWAV, 2007). The minimum requirements for water quality according to ÖWAV Code of Practice 19 are shown in the table below.

Hydraulic load	NH4-N (NH3-N)		Dissolved Oxygen	TSS
	Salmonids	Cyprids		
$Q_{e,1} < 0{,}1$ to $0{,}5 \cdot HQ_1$	max. 2.5 mg/l	max. 5 mg/l	min. 5 mg/l	50 mg/l
	(0.1 mg/l)	(0.2 mg/l)		(PE/MNQ > 25)

Advantages

- Selection of economically most effective solutions possible.
- Individual solutions adapted to the local situation and explicit consideration of local conditions possible.

Disadvantages

- High level of knowledge and interdisciplinary skills required for assessment.
- Area of influence of impacts is often difficult to determine.
- The renunciation of minimum requirements may result in unequal handling of sewer operators, as the water right permit issued earlier in time could be given preference.
- A change from the combined approach with emission-oriented minimum requirements and water quality-oriented more advanced requirements is considered as critical. If the requested emission-oriented minimum requirements are not met, there is a risk that the water quality-oriented limit values will be reached quickly. In this case no further discharge will possible, which in consequence will result in an unequal treatment of different municipalities in a river basin, as the water right permits issued earlier might be preferred. Therefore, the emission-oriented minimum and water quality-oriented more advanced requirements are an important approach to comply with the limit values of the WFD

Costs

- Estimation not possible.

1.3.4 Mandatory monitoring and reporting to the European Commission (EC) of overflows and other discharges

Possible implementation in AT

- Exact data on the number of combined sewer overflows or the number of discharges of storm water from separate sewer systems in Austria does not exist. For the larger agglomerations the data situation is better.
- The percentage of the combined sewer system in AT is about 38%, the percentage of the separate sewer system accordingly about 62% (BMLFUW, 2014). It is estimated that approximately 10,000 combined sewer overflows and combined sewer overflow tanks as well as 1,500 storm water treatment

	plants exist (BMLFUW, 2012). Exact data on the number of combined sewer overflows or the number and quantity of discharges in Austria does not exist. • For a nationwide monitoring of all combined sewer overflows, probably 10,000 structures of combined sewer systems have to be equipped with appropriate monitoring technology. This is already the case in a few systems, but a nationwide implementation is far from being realized in AT. • With this policy option, nationwide registration of the largest discharge points into water bodies from separate and combined sewers would have to be developed and implemented. • Though not yet fully implemented, Austrian state of the art documents mention regular monitoring: – ÖWAV Code of Practice 19 recommends monitoring, recording the frequency of tank filling/overflow, the duration of filling/overflow, the volume of wastewater transported in the sewer system, and the hours of operation (ÖWAV, 2007). – In ÖWAV Code of Practice 35 it is pointed out that for systems requiring a permit under the water law, according to § 134 WRG 1959, an inspection must be carried out at least every 5 years unless the water law authority prescribes a shorter inspection interval. In this context, the extent of the impact on the water body as well as the operating condition and the effectiveness of the drainage system are to be checked (ÖWAV 2019).
Advantages	• The data obtained by monitoring (duration, frequency, quantity, etc.) of combined sewer overflows and storm water discharges are important: – The system behavior can be analyzed and the main points of discharge can be identified (hot spot analysis). – The data would be an excellent basis for system optimization and target-oriented investment decisions.
Disadvantages	• Investment costs • Required maintenance • Central or semi-central data management system needed. • Collected data is of no value if it is not processed, validated and evaluated timely.
Costs	• The investment costs for sensors for CSO monitoring of quantity (frequency, duration and/or volume) can range from 200 – 15,000 € per discharge point. If only the frequency and duration, but not the discharge volume or even the pollutant loads are to be considered, the investment costs are between 100 – 1,000 € (Hofer et.al., 2018). • If pollutant concentrations and dynamics are also to be monitored, investment costs of 15,000 € or more must be expected. (Hofer et.al., 2018) • Installation costs, maintenance costs and costs for data evaluation have to be considered in addition to the investment costs.

	• A rough calculation of the required investments based on the assumptions of approx. 10,000 combined sewer overflows and combined sewer overflow tanks as well as investment and installation costs of 1000 € results in an investment of 10 mio €. If the overflow volume or even the pollution concentrations are to be monitored as well, an investment of 150 mio € and more is to be expected. In addition, the necessary costs for maintenance and data processing have to be added. With 2 to 3 necessary persons and a monthly maintenance interval, an amount of 20 mio €/a to 30 mio € /a can be estimated.

1.3.5 Ban separate sewer discharges into surface water without minimum treatment requirements for rain waters

Possible implementation in AT	• The ban on discharging storm water that has not been previously treated with regard to hydraulic stress and water quality is already included as a fundamental idea in ÖWAV Code of Practice 35 (ÖWAV, 2019). Only for less polluted, runoff-effective surfaces and/or efficient receiving surface water bodies it is permitted to discharge without pre-treatment. • In ÖWAV Code of Practice 35, the hydraulic load of the receiving surface waters is explicitly taken into account. A discharge is only permitted if the hydraulic (minimum) requirements are met, to protect the receiving water from hydraulic stress. Retention is required when storm water runoff from storm water sewers is greater than 10% to 50% of the one-year flood runoff from the receiving water body during a one-year design event (ÖWAV, 2019). • ÖWAV Code of Practice 35 has not yet been implemented nationwide. • Independent of this, the chemical limit values of the WFD, which in AT are defined in the QZV Chemie OG, must be complied with in any case.
Advantages	• Additional reduction of pollutant loads discharged by storm water. • Partial further reduction of discharges of micropollutants such as heavy metals possible.
Disadvantages	• Implementation of further measures is not critical in rural areas regarding location and space, possible problems to identify suitable location in urban areas could occur.
Costs	• Due to the incomplete data situation in Austria, it is not possible to estimate the extent of necessary measures, therefore estimation of costs is not possible.

1.4 Further data collection/ data evaluation

At the EU, national and province level, a variety of online portals exist that provide access to a comprehensive collection of geospatial and land use data. In Austria, the individual provinces also run additional online portals. BMLFUW (2015) summarizes the most important online portals, which have been extended even further in the meantime. Sewer data, for example, can be obtained via various digital sewer registers at province level. The sewer information system LIS for example is widely implemented in Austria. Hydrological data can be obtained from ZAMG, the e-HYD portal or from the hydrographic services of the provinces. Despite the many data reference options, nevertheless, significant information gaps and non-existent data exist regarding urban drainage. No complete overview is available of the exact number of discharge points - combined sewer overflows and storm water discharges. The frequency, duration, and quantity of discharges or overflows are also unknown. A comprehensive data collection and central compilation is missing here. Additionally, information is missing whether data on storm water discharge and combined sewer overflows are being collected and how these data are managed.

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2 Factsheet – Smaller Agglomerations (< 2,000 PE)

Authors:

Katharina Lenz[1]
Clemens Steidl[1]
Günter Langergraber[2]

[1]Umweltbundesamt, Spittelauer Lände 5, 1090 Wien, Mail: office@umweltbundesamt.at

[2]Institut für Siedlungswasserbau, Industriewasserwirtschaft und Gewässerschutz (SIG), Universität für Bodenkultur Wien (BOKU), Muthgasse 18, 1190 Wien, Mail: sig-office@boku.ac.at

2.1 Background

The UWWTD aims at the collection and treatment of wastewater from urban sources. In Art. 4, Art. 5 and Annex I the Directive refers to distinct treatment requirements (emission limit values, minimum reduction rates) for wastewater from agglomerations with a size (= generated load) of ≥ 2,000 PE. Art. 7 of the Directive mentions that for agglomerations with a size of < 2,000 PE urban wastewater entering collecting systems shall before discharge be subject to appropriate treatment.

The Directive defines an agglomeration as an area where the population and/or economic activities are sufficiently concentrated for urban wastewater to be collected and conducted to an urban wastewater treatment plant or to a final discharge point (Art. 2.(4)). The Directive does not lay down further details for its delineation.

The document *Terms and definitions of the UWWTD* (European Commission, 2006) clarifies that the term 'agglomeration' should not be confused with administrative entities (such as municipalities) and gives advice that the generated load of an agglomeration should consider

- the resident population + seasonal changes + non-resident population (e.g. tourism) and
- industrial wastewater being discharged into an urban wastewater collecting system or urban wastewater treatment plant and
- loads of domestic wastewater or urban wastewater from the above-mentioned sectors which should be collected by the collecting system (and/or addressed through IAS), but are not collected or do not reach the treatment plant (incomplete collecting systems, etc.)

Appropriate treatment according to the UWWTD (Art. 2(9)) means treatment of urban wastewater by any process and/or disposal system which after discharge allows the receiving waters to meet the relevant quality objectives and the relevant provisions of this and other Community Directives.

The policy options proposed by the EC are the following:

a) Decrease the threshold to 1 000/ 500/ 200 PE
b) EU fixed approach of PE per ha

c) Use risk-based approach via derogations where there is evidence that water quality of the recipient body is not affected (in line with WFD objectives)

2.2 Current situation in Austria

Legal basis

- In AT the UWWTD is implemented by means of the General Waste Water Ordinance (AAEV, BGBl. Nr. 186/1996) and the First wastewater emission ordinance for UWWTPs > 50 PE (**1^{st} AEVkA**, BGBl. Nr. 210/1996). The latter one gives emission limit values and removal rates for UWWTPs with a size of >50 PE. For wastewater treatment plants ≤ 50 PE the general principles for treatment according to the AAEV apply with no lower limit. In the permitting process, emission limit values (ELVs) for WWTPs ≤ 50 PE are set on the basis of individual judgment, with the ELVs of the AAEV serving as guide values (§ 4 (4) AAEV). For single objects in remote (mountainous) areas (in AT mainly alpine huts), the Third wastewater emission ordinance for urban wastewater (3. Abwasseremissionsverordnung für kommunales Abwasser, 3^{rd} AEVkA , BGBl. II Nr. 249/2006) applies.
- For BOD_5 and COD, the 1^{st} AEVkA foresees stricter standards than the UWWTD (Table 3). Additionally, the Austrian regulation requires removal of NH4-N for all UWWTPs, i.e. a maximum effluent concentration of 10 mg/L NH_4-N and 5 mg/L NH_4-N applies for UWWTPs ≤ 500 PE and > 500 PE, respectively, for wastewater effluent temperatures higher 12°C.

Table 3: Treatment requirements according to the UWWTD and the 1^{st} AEVkA

Parameter	Requirement	UWWTD (91/271/EEC) (Effluent concentration or minimum reduction rates apply)	Austrian legislation (1^{st} AEVkA)
BOD_5	Effluent concentration	UWWTPs serving agglo. ≥ 2,000 PE: 25 mg/L	UWWTPs > 50 PE: 25 mg/L
	Minimum reduction rate	70–90 %	UWWTPs ≥ 1,000 PE: 95%
COD	Effluent concentration	UWWTPs serving agglo. ≥ 2,000 PE: 125 mg/L	UWWTPs > 50 PE: 90 mg/L
	Minimum reduction rate	75%	UWWTPs ≥ 1,000 PE: 85%

- According to the province-specific Building Laws and/or the Sewer Connection Acts (see chapter 2.5.1), connection to existing sewer systems is mandatory according to the provincial legal regulations. Under certain circumstances there can be an exemption of the obligation to connect.

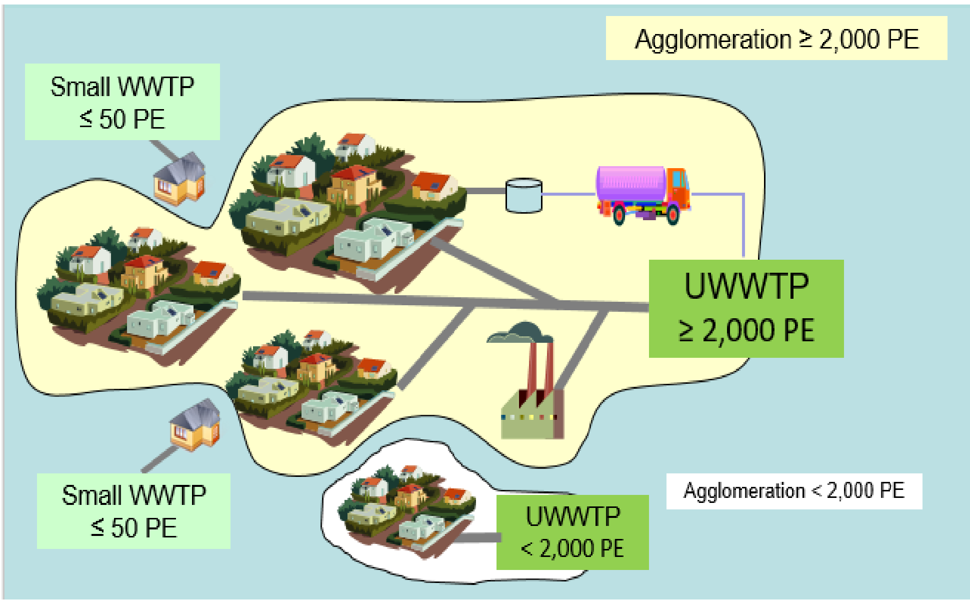
Current situation

- For the definition of agglomerations ≥ 2,000 PE in accordance with the UWWTD, AT has chosen the approach that an agglomeration is the catchment area of an UWWTP with a size (= organic design capacity) ≥ 2,000 PE. This approach means that the size of an UWWTP is equal to the size of the agglomeration (see Figure 1). This is in line with the general provisions of the Directive, which are clarified in the document *Terms and definitions of the UWWTD* as follows:

"It should be underlined that the agglomeration coincides with the sufficiently concentrated area itself and not with the de facto situation of the existing "catchment area" of a collecting system (i.e. network of sewers) within the agglomeration.

However, when the collecting system is fully in place, the limits of the agglomeration under the Directive may coincide with the limits of the collecting system. In other words, the "catchment area" of a collecting system coincides with the limits of the agglomeration where the connection rate for the agglomeration is 100 %."

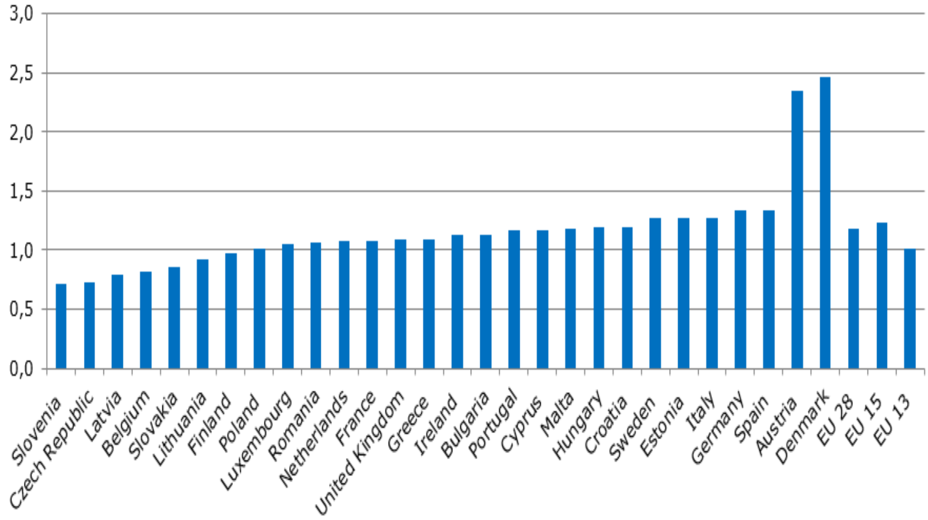
Figure 1: Current delineation of agglomerations' borders in AT



- Information about the methodology of defining agglomerations is not requested by the EC on a regular basis. Several Member States (MS) define the generated load of agglomerations based on population density while other MS use the incoming load of a UWWTP multiplied by a weighting factor (e.g. Germany, Netherlands).

  In the 6th UWWTD Expert group meeting on 18/19 May 2017 the EC presented an evaluation of the ratio between the generated load of agglomerations ≥ 2,000 PE and the resident population for the reference year 2014 (Figure 2). The high ratio for AT is due to the fact, that the definition of agglomeration size in AT considers the organic design capacity of UWWTPs (PE), which represents a design parameter. It takes into account the maximum wastewater inflow and future developments as regards the connected inhabitants, indirect discharges from industries and tourism. While the organic design capacity of UWWTPs ≥ 2,000 PE was 22.0 mio PE in 2018, the incoming load (= load entering the UWWTPs) was 15.0 mio PE, of which 8.5 mio originated from inhabitants (E) and 6.5 mio PE from industrial discharges.

Figure 2: Ratio between the generated load from agglomerations ≥ 2,000 PE and the number of inhabitants per Member State (European Commission, 2017)



- In the data model for reporting under the UWWTD, the AT approach is reflected in a 1:1-relation between agglomerations and UWWTPs (one agglomeration is connected to one UWWTP). The data model also foresees the possibilities of a 1:n-relation (one agglomeration connected to several UWWTPs) and a n:1-relation (several agglomerations connected to one UWWTP).

- In 2018, there were 29,380 WWTPs with a total organic design capacity of 22.3 mio PE. Out of these, the around 28,750 wastewater treatment plants < 2,000 PE cover 3.3 % of the total organic design capacity in AT (see Table 4).

Table 4: Number and organic design capacity of wastewater treatment plants in AT (2018)

Size class (PE)	Number of treatment plants		Organic design capacity of plants		Reference
	[n]	[%]	[PE]	[%]	
≤ 50	27,452	93.4%	260,500	1.2%	Langergraber et al. (2018)
51 - 5001)	1,040	3.5%	180,000	0.8%	ÖWAV (2019)
501 - 1,9991)	255	0.9%	287,356	1.3%	ÖWAV (2019), BMLRT (2020)
≥ 2,0002)	633	2.2%	21,579,063	96.7%	BMLRT (2020)
Total	**29,380**	**100%**	**22,306,919**	**100%**	

1) The figures differ from the figures for WWTPs of the size class 51 – 1,999 PE presented in the UWWTD Art. 16-report (1,236, BMLRT, 2020). The reason is that for Table 4 an additional database was taken into account (OWAV, 2019)

2) Consideration of three big industrial wastewater treatment plants with an urban fraction of wastewater > 2,000 PE

- At national level, detailed information about UWWTPs ≥ 2,000 PE is collected annually based on the UWWTD, the Austrian Water Act (BGBl. Nr. 215/1959) and the National ordinance on an emission register for point sources (EmRegV-OW, BGBl. II 207/2017).
  Detailed information as regards UWWTPs < 2,000 PE is not collected regularly at national level, but in the context of the execution of water law at the level of the nine provinces and/ or the approx. 100 districts of AT. This is due to the fact that for the execution of the Austrian water law, the federal government uses the services of the provinces (indirect federal administration). Every two years the provincial governments provide aggregated data on UWWTPs in the size class 51 – 1,999 PE to the national authority, as this information is required for reporting under the current UWWTD.
- In 2018 AT counted 2,096 municipalities (= administrative units), of which 1,144 were municipalities < 2,000 inhabitants. Out of these, 1,026 municipalities were connected to UWWTPs ≥ 2,000 PE. Wastewater from the remaining 118 municipalities < 2,000 inhabitants is treated in UWWTPs with a size of 51 - 1,999 PE, small and domestic wastewater treatment plants (≤ 50 PE) or collected in water-tight septic tanks and transported to a UWWTP by truck (BMLRT, 2020).
- The connection rate of the AT population to wastewater collecting systems with treatment in UWWTPs ≥ 50 PE in 2018 was 95.9% (BMLRT, 2020). The remaining

	4.1 % are not connected because of the settlement character of Austria (numerous scattered settlements). Those households dispose their wastewater via small WWTPs (wastewater treatment plants ≤ 50 PE) or watertight cesspools (disposal contents are transported to larger urban treatment plants or agricultural recycling)
Costs (estimates)	• The costs for the federal annual data collection from UWWTPs ≥ 2,000 PE under EmRegV-OW amounts to around 54,000 € (in 2018 EMREG-OW covered 633 UWWTPs (72%) and 246 industrial facilities (28%). The estimated costs originate from the percentual allocation of the entire annual costs for the data collection under EmRegV-OW). These costs do not include the costs for data collection at the level of UWWTP-operators and provinces. They do also not include the costs for maintenance and operation and the further development of the EMREG-OW database. The latter one amounts to approximately 155,000 €/a.

2.3 Policy options – future possibilities for implementation in Austria

2.3.1 Decrease the threshold to 1,000/ 500/ 200 PE

Possible implementation in AT

- The 1st AEVkA foresees stricter treatment standards than the UWWTD currently does. If the treatment standards of the UWWTD do not change, a lowering of the threshold for the consideration of agglomerations under the UWWTD to 1,000 PE/ 500 PE/ 200 PE would not require an upgrade of existing UWWTPs.
- The exact number of UWWTPs in the size classes 1,000 –1,999 PE, 500–999 PE and 200–499 PE is only available on the level of the provinces. From the information, which is currently published (ÖWAV, 2019; BMLRT, 2020), only the agglomerations in the size class > 500 PE to 1,999 PE could be calculated (255 UWWTPs with an organic design capacity of 287,356 PE = 1.3% of the entire organic design capacity). If the threshold of agglomerations is lowered to 500 PE, these UWWTPs would have to additionally report under EmregV-OW.
- The AT bank, which finances infrastructure (Kommunalkredit, KPC) has information about those small UWWTPs, which it has co-financed since 1993. On the basis of this data, the number of small UWWTPs was estimated as follows:

Size class	number of UWWTPs		Factor
	KPC co-financed	data from other publications	
500 PE - 1,999 PE	**184**	**255**	**1,39**
Estimates by factor 1.39	KPC co-financed	Total	
200 PE - 499 PE	202	280	
500 PE - 999 PE	97	135	
1,000 PE - 1,999 PE	87	120	
Total	**386**	**535**	

Advantages

- Central and regular availability of data on smaller UWWTPs and their treatment performance on the national level (data to be used for water management planning on federal level)

Disadvantages

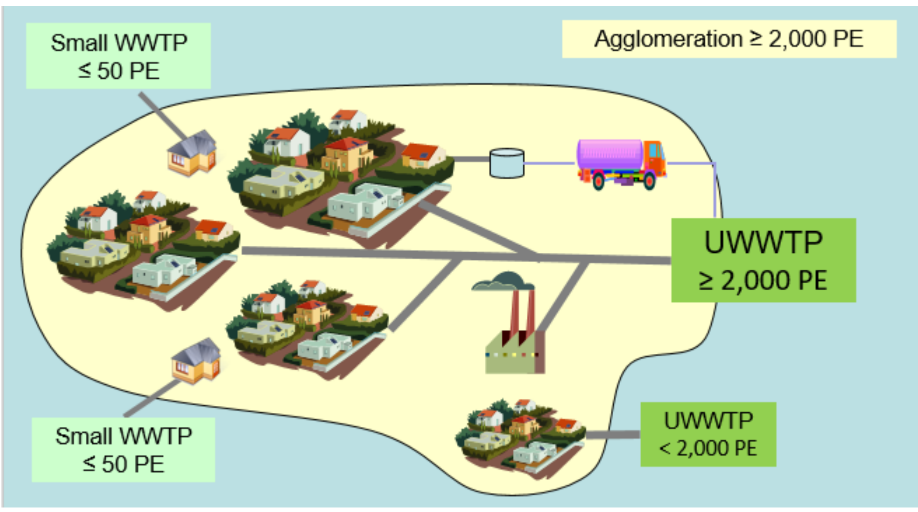
- A reduction of the threshold would result in an additional reporting burden. Assuming that UWWTPs of the size class 500 PE - 1,999 PE are additionally collected in EMREG-OW, the number of UWWTPs reporting in EMREG-OW

	would rise by more than 1/3, while only 1.3% of the additional organic design capacity is covered (high costs versus minor benefit) • The provincial authorities have to inform the national authority about master data of UWWTPs. As in some provinces, information on UWWTPs < 2,000 PE is mainly available at district authorities the reporting efforts for district authorities would rise.
Costs	• 255 additional UWWTPs with a size of 501 – 1,999 PE: collection of data under EmRegV-OW: around 22,000 €/a (based on current costs, which are approximately 85€ per UWWTP). These costs do not include the costs for data collection at the level of UWWTP-operators and provinces. They do also not include the costs for maintenance and operation and the extension of the EMREG-OW database.

2.3.2 EU fixed approach of PE per ha

Possible implementation in AT	• In case of an EU fixed approach for the definition of agglomerations based on PE/ha the definition of agglomerations in AT has to be reviewed. The required information for revision includes: – GIS layers with the boundaries of the built-up areas – GIS-layer: Corine Landcover – Data on resident population – Data on tourism – Information on industrial facilities connected to public sewer systems • An altered approach could lead to the situation that the relation between agglomerations and UWWTPs changes from 1:1 to 1:n (see Figure 3) or to n:1.

Figure 3: Relation between agglomerations and UWWTPs of 1:n



Advantages	• Better comparability of agglomerations among MS

	• Generated load (PE) is closer to real generation of wastewater loads (BMLRT, 2020).
Disadvantages	• In case of a 1:n relation between agglomerations and UWWTPs, the situation could appear that an agglomeration has a central UWWTP but is also connected to several (small) WWTPs (e.g. within the boundaries of the agglomeration Vienna, there are 25 UWWTPs ≤ 500 PE, 12 UWWTPs with a size of 51–500 PE and 13 WWTPs ≤ 50 PE) (Langergraber et al., 2018). This would result in the necessity to establish, prove and document the treatment requirements of the UWWTD also for UWWTPs < 2,000 PE and to report regularly to the EC. Additionally, WWTPs ≤ 50 PE would have to be reported as Individual and appropriate systems (IAS), which are excluded from detailed reporting under Art. 15 in the current UWWTD.
Costs	• Additional costs, mainly for data generation and reporting, could not be evaluated

2.3.3 Risk-based approach via derogations where there is evidence that water quality of the recipient body is not affected

Possible implementation in AT	• It is assumed that this policy option means that for smaller agglomerations treatment requirements under the UWWTD may be lowered in areas with evidence, that the water quality of the recipient body is not affected. • As AT provides clear standards for wastewater treatment in UWWTPs > 50 PE, but also for wastewater treatment plants ≤ 50 PE, this policy option would not affect AT. • A risk-based approach allowing less stringent requirements in the case the recipient water body is not affected is not applied in AT except for very specific cases, where a stringent permitting procedure is in place including the possibility of the Federal Ministry to file a complaint. Stringent emission-based effluent requirements apply in the whole country independent of the recipient water body. If required by the recipient water body, more stringent requirements are requested. The risk-based evaluation of the recipient water body is carried out during the case-by-case evaluation when granting the permissions for operating WWTPs by local authorities.
Advantages	• AT applies the combined approach with emission-oriented minimum requirements for all UWWTPs laid down in ordinances. For AT this approach would not bear advantages.
Disadvantages	• Possibility to individually weaken the treatment requirements of the Directive • Less comparability between MS as derogations may be granted in different ways in different MS • Difficult evaluation of data across Europe

	• Potential pressure from stakeholder for AT to lower existing standards acc. to UWWTD
Costs	• Costs for this policy option could not be evaluated

2.4 Further data collection/ data evaluation

Specification of further data collection

- Number and organic design capacity of UWWTPs in the size classes 1,000 – 1,999 PE, 500 – 999 PE, 200 – 499 PE, and 51 – 199 PE
- Analysis of fixed approach of PE per ha

2.5 References

2.5.1 Legislation Austria

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Vienna Sewer Systems and Confluence Charges Act (Wiener Kanalanlagen und Einmündungsgebührengesetz). Available at: https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=LrW&Gesetzesnummer=20000025

2.5.2 Guidance documents/ Codes of practice

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2.5.3 Reports and publications

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3 Factsheet – Individual and appropriate systems (IAS)

Author:

Günter Langergraber[1]

[1]Institut für Siedlungswasserbau, Industriewasserwirtschaft und Gewässerschutz (SIG), Universität für Bodenkultur Wien (BOKU), Muthgasse 18, 1190 Wien, Mail: sig-office@boku.ac.at

3.1 Background

The UWWTD does not provide general guidance for agglomerations smaller than 2,000 PE. Article 3(1) states that "*where the establishment of a collecting system is not justified either*

a) *because it would produce no environmental benefit or*
b) *because it would involve excessive cost,*

individual systems or other appropriate systems which achieve the same level of environmental protection shall be used."

Additionally, Article 7 states that "*Member States shall ensure that … urban wastewater entering collecting systems shall before discharge be subject to appropriate treatment as defined in Article 2(9) in the following cases:*

- *for discharges to fresh-water and estuaries from agglomerations of less than 2,000 PE,*
- *for discharges to coastal waters from agglomerations of less than 10,000 PE"*

Article 2(9) defines "appropriate treatment" as "*treatment of urban wastewater by any process and/or disposal system which after discharge allows the receiving waters to meet the relevant quality objective*".

The term IAS (individual or other appropriate systems) is used in EU legislation to describe these smaller WWTPs within agglomerations. According to the UWWTD, IAS should be the exception and the connection to a collection system should prevail. The justification of IAS instead of collecting system shall be based on a cost-benefit analysis. IAS are thus required to be a much cheaper option (avoidance of excessive costs) and to deliver equivalent protection (e.g. depending on agglomeration size, area sensitivity, type of receiving water body).

According to the *Terms and definitions of the UWWTD* (EC, 2007), IAS are considered a compliant approach under the following conditions:

- Requirements for design, construction and maintenance of IAS ensure the same level of environmental protection as a collecting system
- IAS can be used only after a case-by-case assessment and justification concerning:

- absence of environmental benefit from having a collecting system, or
- collecting system would involve excessive costs at the time being.

However, the UWWTD does not give guidance on how the cost-benefit analysis for using IAS has to be made and on the appropriate treatment IAS have to achieve. This is of special relevance for those Member States and Candidate Countries in which coherent legislation is not in place.

The policy options for adaptation of the UWWTD regarding IAS proposed by the EC are the following:

a) <u>Reduction of use:</u> Obligation to connect when there is a centralised system
b) <u>Reporting:</u> Requirement for Member States to establish a national database of IAS (location, technology, contract etc.) and report to EC when in excess of 2% in an agglomeration
c) <u>Reduction of use:</u> Require strict reduction of IAS and only let them be used if an exemption has been provided according to EU based criteria (e.g. population density, others)
d) <u>Control of design and functioning:</u> EU standards for IAS design (linked to Construction Products Regulation) combined with maintenance instructions.
e) <u>Monitoring:</u> Impose to Member States inspection strategies for regular monitoring and maintenance + Mandatory registration of individual and other appropriate systems
f) <u>Use of risk-based approach</u> via derogations where there is evidence that water quality of the recipient water body is not affected (in line with WFD objectives)

3.2 Current situation in Austria

Legal basis

- The UWWTD is implemented in AT by means of the General Waste Water Ordinance (AAEV, BGBl. Nr. 186/1996) and the First wastewater emission ordinance for UWWTPs > 50 PE (1. Abwasseremissionsverordnung für kommunales Abwasser, 1st AEVkA, BGBl. Nr. 210/1996). For wastewater treatment plants ≤ 50 PE the general principles for treatment according to the AAEV apply with no lower limit. In the permitting process, emission limit values (ELVs) for WWTPs ≤ 50 PE are set on the basis of individual judgment, with the ELVs of the AAEV serving as guide values (§ 4 (4) AAEV).
- For BOD_5 and COD, the 1st AEVkA foresees stricter limits than the UWWTD (Table 5). Additionally, the Austrian regulation requires removal of NH_4-N for all UWWTPs, i.e. a maximum effluent concentration of 10 mg/L NH_4-N and 5 mg/L NH_4-N applies to all UWWTPs ≤ 500 PE and > 500 PE, respectively, for wastewater effluent temperatures higher 12°C. For all UWWTPs > 1,000 PE and > 5,000 PE, additionally, a maximum effluent concentration of 2 mg/L and 1 mg/L total phosphorus respectively, is required. The Austrian requirements apply to both, UWWTPs ≤ 2,000 PE and IAS.

Table 5: Treatment requirements according to the UWWTD and the 1.AEVkA

Parameter	Requirement	UWWTD (91/271/EEC)	1.AEVkA
BOD_5	Effluent concentration	UWWTPs ≥ 2,000 PE: 25 mg/L	UWWTPs > 50 PE: 25 mg/L
	Minimum reduction rate	70-90 %	UWWTPs ≥ 1,000 PE: 95%
COD	Effluent concentration	UWWTPs ≥ 2,000 PE: 125 mg/L	UWWTPs > 50 PE: 90 mg/L
	Minimum reduction rate	75%	UWWTPs ≥ 1,000 PE: 85%

- For single objects in remote areas (in AT mainly alpine huts), the Third wastewater emission ordinance for urban wastewater (3. Abwasseremissionsverordnung für kommunales Abwasser, 3rd AEVkA) (BGBl. II Nr. 249/2006) applies. There is a strict definition of remote areas (e.g. only accessible by walking, not connected to power grid, etc.) but the treatment requirements are less strict, i.e. plants have to remove 70% and 80% of COD and BOD_5 respectively, as well as aim to achieve nitrification (but no strict requirement). Also, Article 4(2) of the UWWTD requires less stringent treatment "*provided that detailed studies indicate that such discharges do not adversely affect the environment*".
- In AT the following design guidelines for WWTPs < 2,000 PE apply:
  - Ö-NORM B 2502-1 (2012) for technical plants less than 50 PE (for installations produced on site),

– Ö-NORM B 2502-2 (2003) for technical plants from 51-500 PE,
– DWA A-131 (2016) for plants larger than 500 PE, and
– Ö-NORM B 2505 (2009) for treatment wetlands (vertical flow wetlands with intermittent loading) less than 500 PE.

Due to the more stringent Austrian requirements regarding nitrification, small WWTPs < 50 PE that are successfully certified according to the ISO EN 12556 standard are not automatically applicable without permit in Austria. The permit required for each WWTP is granted by the local authorities based on a case-by-case evaluation.

- Province-specific Building Laws and/or the Sewer Connection Acts: connection to existing sewer systems is mandatory according to the provincial legal regulations, in case the distance of the building to an existing sewer falls below a specific threshold (usually 30 m – 50 m).

Current situation

- In 2018, there were 29,380 wastewater treatment plants with a total organic design capacity of 22.3 mio PE. Out of these, the around 28,750 WWTPs ≤ 2,000 PE cover only 3.3% of the total organic design capacity in AT (see Table 6).

Table 6: Number and organic design capacity of wastewater treatment plants in AT (2018)

Size class (PE)	Number of treatment plants		Organic design capacity of plants		Reference
	[n]	[%]	[PE]	[%]	
≤ 50	27,452	93.4%	260,500	1.2%	Langergraber et al. (2018)
51 – 500 1)	1,040	3.5%	180,000	0.8%	ÖWAV (2019)
501 - 1,999 1)	255	0.9%	287,356	1.3%	ÖWAV (2019), BMLRT (2020)
≥ 2,000 2)	633	2.2%	21,579,063	96.7%	BMLRT (2019)
Total	**29,380**	**100%**	**22,306,919**	**100%**	

1) The figures differ from the figures for wastewater treatment plants of the size class 51 – 1,999 PE presented in the UWWTD Art. 16-report (1,236, BMLRT, 2020). The reason is that for Table 6 an additional database was taken into account (OWAV, 2019)

2) Consideration of three big industrial wastewater treatment plants with an urban fraction of wastewater > 2,000 PE

- In Austria, small wastewater treatment facilities can be installed either in or outside an agglomeration. In case they are installed inside an agglomeration

≥ 2,000 PE, they are considered as IAS in the sense of the UWWTD. Small wastewater treatment facilities in AT include:

- \> 50 PE (“**small UWWTPs**”):
  The AAEV and the 1st AEVkA apply clear and detailed requirements for the treatment of urban waste water.

- ≤ 50 PE:
  - **Small WWTPs**: The AAEV applies with no lower limit.
  - **Watertight cesspools:** Watertight cesspools are covered by building law

- Single objects in remote (mountainous) areas: The 3rd AEVkA applies.

- The extent of IAS use in AT was 1% in reference year 2016, reported under Art. 15 of the UWWTD (EC, 2020). These are watertight cesspools, from where the wastewater is transported to an UWWTP.
- One example for small WWTPs would be the city of Vienna: Within the boundaries of the agglomeration Vienna, there are – besides the Vienna main UWWTP with a design capacity of 4,000,000 PE - 13 WWTP ≤ 50 PE (Langergraber et al., 2018).
- At the national level, detailed information on UWWTPs ≥ 2,000 PE is collected annually based on the UWWTD, the Federal Water Act (WRG, BGBl. Nr. 215/1959) and the Emission Register Regulation (EmRegV-OW, BGBl. II 207/2017).
  Detailed information on UWWTPs < 2,000 PE is not collected regularly at national level but at the level of the nine provinces and/or the around 100 districts of AT. Every two years the provincial governments send aggregated data on UWWTPs in the size class 51 – 1,999 PE to the national authority, as this information is reported biannually to the EU (BMLRT, 2020).
- Detailed Austrian-wide data for WWTPs ≤ 50 PE were collected for the first time in the study of Langergraber et al. (2018). All small WWTPs can be found in the province's water information system ("Wasserbuch"), the public accessible register of all water use rights in AT. However, the information accessible for small WWTPs via this register is different in the provinces.
- In 2016, there were about 27,500 small WWTPs ≤ 50 PE (**Fehler! Verweisquelle konnte nicht gefunden werden.**) in Austria. About half of the small WWTPs have a design size between 5 and 10 PE. Still more than 6,200 plants are classified as having only primary treatment. These are mainly old septic tanks ("*Dreikammer-Faulanlagen*") from which mechanically treated wastewater is discharged. This technology is no longer state-of-the-art.
- Figure 4 shows the year of commissioning of different treatment technologies at small WWTPs ≤ 50 PE in AT. The total number for each technology corresponds with the total number in Table 7). Most of the small WWTPs implemented since 2010 are SBR plants and VF wetlands (Figure 4 and Table 8). The number of old systems with only primary treatment (septic tanks) is slowly decreasing.

Table 7: Number and main treatment technologies for small WWTPs in Austria's provinces (according to Langergraber et al., 2018). Primary = only primary treatment, CAS = conventional activated sludge plants, SBR = Sequencing Batch Reactors; VF wetlands = vertical flow wetlands with intermittent loading.

Province	WWTPs	Primary	CAS	SBR	VF wetlands
Burgenland	**20**	0	4	1	14
Carinthia	**6,961**	2,248	3,051	566	556
Lower Austria	**4,515**	256	452	2,513	893
Upper Austria	**2,398**	381	646	702	475
Salzburg	**1,655**	304	234	274	279
Styria	**10,665**	2,385	2,532	1,044	3,276
Tyrol	**1,096**	660	92	107	61
Vorarlberg	**129**	14	7	28	4
Vienna	**13**	1	6	3	1
Total	**27,452**	6,249	7,024	5,238	5,559

Figure 4: Year of commissioning of different treatment technologies applied for small WWTPs ≤ 50 PE in AT (the category "Unknown and others" includes 52 MBR and 131 RBC plants) (Langergraber et al., 2018)

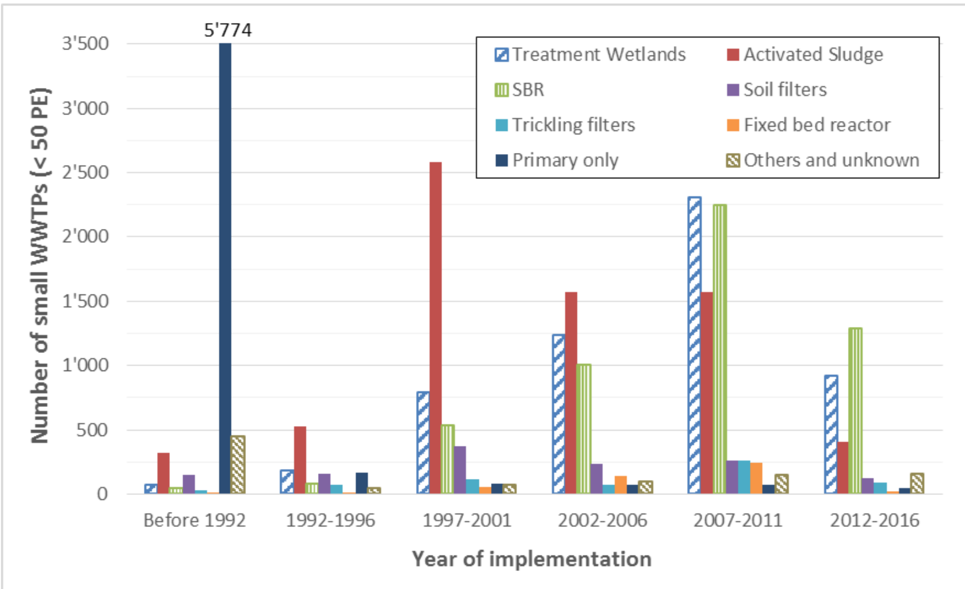

Table 8: Number of small WWTPs in Upper Austria between 2016 and 2019 (according to Engstler et al., 2019)

Technology	# 2016	# 2019	Difference
SBR	702	873	171
CAS	646	628	-18
VF wetland	475	535	60
Primary treatment only	381	302	-79
Trickling filter	100	97	-3
Total	2,398	2,526	128

- The management of small wastewater treatment facilities (i.e. permission registration, , monitoring, maintenance and inspection) is done as follows:
  - PERMISSION: UWWTPs and small WWTPs are installed after passing a permitting procedure (watertight cesspools: building permits, small WWTPs: water permits according to the Austrian Water Law). Water permits expire after a specific period, e.g. 15 years, to ensure that the small UWWTP or small WWTP is assessed again for its capacity to be state-of-the-art and compliant with the contemporary legal requirements.
  - REGISTRATION: Data for small UWWTPs are not collected centrally at national level. Every two years the provincial governments provide aggregated data on small UWWTPs to the national authority, as this information is reported biannually to the European Commission. All provinces operate water information systems ("Wasserbücher") in which information on permits related to water is made available to the public. The information available for each UWWTP and small WWTP comprises an extract from the permit. Most provinces have some information on their UWWTPs and WWTPs in electronic form (e.g. MSExcel® files or similar), but the information available is different in the provinces.
  - MONITORING and MAINTENANCE: The permit to operate a small UWWTP or a small WWTP is granted by local authorities on a case-by-case evaluation. The permit includes requirements regarding self-monitoring (for small WWTPs usually monthly sampling and analysis of temperature and pH of effluent, effluent concentration of ammonia nitrogen and settleable solids, for small UWWTPs bimonthly) and required external monitoring. Operation and monitoring are usually done by the homeowners or by designated operators if several houses are connected. Maintenance is usually required to be provided by companies with certified professionals or by certified plant operators (e.g. homeowners). Record-keeping and documentation are required in an operations diary for self-monitoring, operational and maintenance work.
  - INSPECTION (external monitoring by experts according to § 134 (2) of the Austrian Water Law Act or by the water supervision or the water rights

	authority): The interval for external monitoring is defined in the permit and can vary e.g. for small WWTPs from 4 times per year up to every three years, if there is evidence of an external maintenance contract or special education/training of the operator. Additional external monitoring is required in specified intervals (e.g. < 50 PE: from 4 times per year up to every three years, depending on the province; in some provinces the interval is extended for trained and certified plant operators). During external monitoring, effluent samples are also analysed for BOD_5 and COD. • Special training courses for operators of WWTPs < 50 PE started in 2000. These courses are organized by the Austrian Water and Waste Management Association (ÖWAV). The training for operators of small WWTPs lasts for 1.5 days and is offered more than 10 times per year in several provinces. • For operators of WWTPs between 51 and 500 PE, the ÖWAV offers a training course that lasts 2 weeks, operators of plants larger 500 PE have to enrol in the training courses for professional wastewater treatment plant operators.
Costs (estimates)	• Usually, CAPEX and OPEX of small WWTPs have to be covered by the owner of the plant. For WWTPs ≤ 50 PE, CAPEX of technical solutions (CAS and SBR) and VF wetlands are similar and in the range of 15,000 EUR for a WWTP with 10 PE. In general, OPEX of VF wetlands are less compared to those of technical solutions. VF wetlands do not require artificial aeration and can be operated without pumps if sufficient slopes are available. OPEX of WWTPs ≤ 50 PE is very site-dependent. Main OPEX are typically related to costs for external monitoring (about 200 EUR) and sludge disposal (if sludge cannot be managed on-site). • Taking into account the number of small wastewater treatment plants covering the treatment technologies CAS, SBR and VF wetlands and the average CAPEX for these technologies, around 320 mio EUR were invested in small wastewater treatment facilities in AT so far. • For CAPEX, subsidies are provided at national as well as at provincial level. The national subsidy depends on the income of the inhabitants and the specific investment costs of wastewater infrastructure in the respective municipality. Based on these criteria, the national agency handling the subsidies (Kommunalkredit Public Consulting) applies municipality-dependent subsidies between 10 and 40 % of the investment costs. For WWTPs ≤ 50 PE the procedure is simplified and a fixed amount per PE is applied as subsidy. Subsidies are also available for reinvestments in the wastewater infrastructure. Similar procedures and rules apply for subsidies from the provinces. • A popular organisational form for small WWTPs for several houses and small settlements are wastewater cooperatives. Cooperatives are bodies governed by public law, membership comprises the users of the services that share a common property, e.g. the WWTP. Cooperatives are self-determined and self-organised. Membership entails the organisation of operation, monitoring and maintenance of the assets. To support these small cooperatives, regional umbrella organisations (at federal state level in Austria) were set up to be a one-stop-shop for consulting, supporting and representing the members of the cooperatives. Additionally, the umbrella organisations provide e.g. educational

programmes (for chairpersons, cashiers, controllers, water managers, etc.) and offer a group third-party insurance.

- Small WWTPs can also be operated by larger utilities. The utility responsible for the central WWTP of an agglomeration can be also in charge of operation, monitoring and maintenance of smaller plants in remote settlements in the same or neighbouring municipalities. The policy of some municipalities is to provide all inhabitants of the municipality the same service irrespective of whether they are living in the agglomeration or in a small settlement. In such cases all persons in the municipality pay the same connection fees and consumption charges. The staff of the central WWTP is responsible for the WWTPs of small settlements.

3.3 Policy options – future possibilities for implementation in Austria

3.3.1 Reduction of use: Obligation to connect when there is a centralised system

Possible implementation in AT	• This option would not greatly affect AT as this is already common practice. Each province has individual Building Laws and/or the Sewer Connection Acts. In general, connection to existing sewer systems is mandatory according to the provincial legal regulations. Under certain circumstances there can be an exemption of the connection obligation. • This is already a point of discussion in municipalities in which the sewer network is extended and already existing small WWTPs (typically ≤ 50 PE) should be connected. One practice observed is that these small WWTPs can be operated as long as the existing permit is valid and afterwards the property owner have to connect because the permit is not extended.
Advantages	• From the perspective of national economy, the obligation to connect to a centralized system is most likely to provide a more favourable cost-benefit ratio than a centralized system with no obligation to connect.
Disadvantages	• Owners of existing small WWTPs have a stranded investment if the investment was recently.
Costs	• No additional costs are expected as this this policy option is already common practice in AT.

3.3.2 Reporting: Requirement for Member States to establish a national database of IAS (location, technology, contract etc.) and report to EC when in excess of 2% in an agglomeration

Possible implementation in AT	• As mentioned above, data for WWTPs < 2,000 PE are not collected centrally at national level in AT. Every two years the provincial governments provide aggregated data on UWWTPs in the size class 51 – 1,999 PE to the national authority, as this information is reported biannually to the EU (BMLRT, 2020). • All provinces operate water information systems ("Wasserbücher") in which information on permits related to water is made available to the public. The information available for each WWTPs comprises an extract from the permit. Most provinces have some information on their WWTPs in electronic form (e.g. MSExcel® files or similar), but again, the information available is different in the provinces. • For the implementation of this option, the establishment of a national database of WWTPs < 2,000 PE would be required. This would need to include a harmonization of the data collection in the nine provinces. • Maintaining the database would be simplified by adding new permits (plants going into operation, extension of existing permits, plants stopping operation) to an electronic database.
Advantages	• Good and complete overview of all existing WWTPs in operation including an overview of regional distribution of the plants. • Systems of data collection in the nine provinces could be harmonized.
Disadvantages	• Substantial effort required to compile all data from the provinces/districts and bring them to the same level of detail. • Effort for coordination and implementation to harmonize data collection in the nine provinces.
Costs	• Costs for establishing the national database of WWTPs < 2,000 PE and costs for maintaining the database (possible inclusion of new permits issued).

3.3.3 Reduction of use: Require strict reduction of IAS and only let them be used if an exemption has been provided according to EU based criteria (e.g. population density, others)

Possible implementation in AT	• This option would not greatly affect AT as this is already common practice in AT. Due to the geographical situation still a large number of small WWTPs outside of agglomerations will be required for overall coverage.
Advantages	• n/a

Disadvantages	• n/a
Costs	• No additional costs are expected as this policy option is already common practice in AT.

3.3.4 Control of design and functioning: EU standards for IAS design (linked to Construction Products Regulation) combined with maintenance instructions

Possible implementation in AT	• This is an option that would not greatly affect AT as this is already common practice in AT. As mentioned above, AT has design guidelines for small WWTPs (see previous chapter). • Design guidelines that allow reaching country/region-specific discharge limits would be required on the EU level especially for nature-based solutions such as treatment wetlands. • Best practice: WWTPs training of owners/operators to make sure that maintenance instructions are understood and applied.
Advantages	• Design guidelines would facilitate the implementation of IAS, however, they would require considering country/region-specific discharge limits.
Disadvantages	• Maintenance instructions alone, as proposed in the option, are not enough, for all operation and monitoring models of WWTPs training of owners/operators is key. • Pressure from certain stakeholders to lower existing Austrian standards if IAS design standards under the Construction Products Regulation are lower than national legal requirements for wastewater emissions from IAS and small WWTPs outside agglomerations
Costs	• No additional costs are expected as this policy option is already common practice in AT

3.3.5 Monitoring: Impose to Member States inspection strategies for regular monitoring and maintenance + Mandatory registration of individual and other appropriate systems

Possible implementation in AT	• This option would not greatly affect AT as this is already common practice. Because **all** plants require a permit, all WWTPs are registered and the permits include the requirements for self-monitoring and external monitoring as well as for maintenance

	• Regarding maintenance, the permit can request a maintenance contract or the successful completion of the training course for operators for WWTPs < 50 PE.
Advantages	• Regular maintenance will increase the lifetime • Regular monitoring and maintenance will ensure that the expected environmental benefit can actually be realized • Mandatory registration will ensure a level playing field
Disadvantages	• Expenditures for administrating the policy option
Costs	• No additional costs are expected as this policy option is already common practice in AT.

3.3.6 Use of risk-based approach via derogations where there is evidence that water quality of the recipient water body is not affected (in line with WFD objectives)

Possible implementation in AT	• A risk-based approach allowing less stringent requirements in the case the recipient water body is not affected is not applied in AT except for very specific cases, where a stringent permitting procedure is in place including the possibility of the Federal Ministry to file a complaint. Stringent emission-based effluent requirements apply in the whole country independent of the recipient water body. In case the recipient water body requires, more stringent requirements are requested. The risk-based evaluation of the recipient water body is carried out during the case-by-case evaluation when granting the permit for operating WWTPs by local authorities. Hence, this option would not greatly affect AT. • Typical examples where authorities request more stringent requirements are small sensitive receiving waters and cases where treated wastewater is infiltrated (mostly only possible close to streams). The parameters for which more stringent requirements are requested most often are: – lower maximum allowed NH_4-N discharge limit and/or reduced wastewater effluent temperatures for which the discharge limit has to be fulfilled, and – requirement of phosphorus and nitrogen removal for smaller plants (both IAS and UWWTPs < 2,000 PE) as given in the 1st AEVkA (BGBl. Nr. 210/1996). To reach these measures often a polishing stage is requested in the permit. A very typical combination is an SBR plant as main treatment stage and a VF bed as polishing stage (also for reducing the hydraulic flush load to small receiving waters).
Advantages	• Treatment requirement is adjusted to the needs of the recipient water.

Disadvantages	• Pressure of certain stakeholders to change Austrian national law and to generally allow derogations if water quality is not affected (resulting in lowering of existing national standards)
Costs	• No additional costs are expected as this policy option is already common practice in AT.

3.4 Further data collection/ further evaluation

No need for further data collection

3.5 References

3.5.1 Legislation Austria

BGBl. Nr. 215/1959 (idgF). Wasserrechtsgesetz 1959 –WRG. 1959. Available at: https://www.ris.bka.gv.at/GeltendeFassung/Bundesnormen/10010290/WRG%201959%2c%20Fassung%20vom%2019.03.2021.pdf

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https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=20004810

3.5.2 Legislation EU

Directive 91/271/EC of 21 May 1991 concerning urban wastewater treatment (Urban Waste Water Treatment Directive, UWWTD). Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A31991L0271

Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for the Community action in the field of water policy (Water Framework Directive, WFD). Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32000L0060

3.5.3 Guidance documents/ Codes of practice

European Commission (2006). Terms and definitions of the UWWTD. UWWTD-REP working group, Brussels, Belgium; Available at: https://ec.europa.eu/environment/water/water-urbanwaste/info/pdf/terms.pdf

Ö-NORM B 2502-1 (2012). Austrian technical standard for small wastewater treatment plants for facilities up to 50 PE (for installations produced on site)

Ö-NORM B 2502-2 (2003). Austrian technical standard for small wastewater treatment plants from 51 to 500 PE

DWA A-131 (2016). Technical standard for plants larger than 500 PE

Ö-NORM B 2505 (2009). Austrian technical standard for treatment wetlands (vertical flow wetlands with intermittent loading) less than 500 PE.

3.5.4 Reports and publications

BMLRT (2020). Kommunales Abwasser – Österreichischer Bericht 2020. Bundesministerium für Landwirtschaft, Regionen und Tourismus (BMLRT), Wien. Available at: https://www.bmlrt.gv.at/wasser/wasser-eu-international/europaeische_wasserpolitik/lagebericht_2020.html

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ÖWAV (2019). Branchenbild der österreichischen Abwasserwirtschaft 2020. Österreichischer Wasser- und Abfallwirtschaftsverband (ÖWAV), Wien. Available at: https://www.oewav.at/Publikationen?current=385139&mode=form

4 Factsheet – Sensitive zones

Authors:

Katharina Lenz[1]
Clemens Steidl[1]

[1]Umweltbundesamt, Spittelauer Lände 5, 1090 Wien, Mail: office@umweltbundesamt.at

4.1 Background

The following elements of the **UWWTD** are relevant in this context:

- Art. 2(11): 'Eutrophication' = enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned.
- Art. 5(1): MS shall identify sensitive areas (SA) according to the criteria laid down in Annex II of the UWWTD and review these areas every four years (Art. 5(6)).
  A water body must be identified as a sensitive area if it falls into one of the following groups:
  a) *natural freshwater lakes, other freshwater bodies, […] which are found to be eutrophic or which in the near future may become eutrophic if protective action is not taken. The following elements might be taken into account when considering which nutrient should be reduced by further treatment:*
     i) *lakes and streams reaching lakes/reservoirs/closed bays which are found to have a poor water exchange, whereby accumulation may take place. In these areas, the removal of phosphorus should be included unless it can be demonstrated that the removal will have no effect on the level of eutrophication. Where discharges from large agglomerations are made, the removal of nitrogen may also be considered;*
     ii) *estuaries, bays and other coastal waters […]*
  b) *surface freshwaters intended for the abstraction of drinking water which could contain more than the concentration of nitrate laid down under the relevant provisions of Council Directive 75/440/EEC of 16 June 1975 if action is not taken ;*
  c) *areas where further treatment than Art. 4 is necessary to fulfil Council Directives.*
- Further relevant Articles in this context are Art. 5(2), Art. 5(4), Art. 5(5) and Art 5(8).

The **Nitrates Directive** (91/676/EEC, ND) has the objective to reduce water pollution caused or induced by nitrates from agricultural sources and to prevent further such pollution. The following elements are relevant in this context:

- 'eutrophication' means the enrichment of water by nitrogen compounds, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned;

- 'pollution' means the discharge, directly or indirectly, of nitrogen compounds from agricultural sources into the aquatic environment, the results of which are such as to cause hazards to human health, harm to living resources and to aquatic ecosystems, damage to amenities or interference with other legitimate uses of water ;
- 'vulnerable zone' means an area of land designated according to Article 3 (2).
- Art. 3(1): Waters affected by pollution and waters which could be affected by pollution […] shall be identified by the MS in accordance with the criteria set out in Annex I:
    1. whether surface freshwaters, in particular those used or intended for the abstraction of drinking water, contain or could contain, if action pursuant to Article 5 is not taken, more than the concentration of nitrates laid down in accordance with Directive 75/440/EEC;
    2. whether groundwaters contain more than 50 mg/L nitrates or could contain more than 50 mg/L nitrates if action pursuant to Article 5 is not taken;
    3. whether natural freshwater lakes, other freshwater bodies, estuaries, coastal waters and marine waters are found to be eutrophic or in the near future may become euthropic […]
- Art. 3(2): MS shall […] designate as vulnerable zones all known areas of land in their territories which drain into the waters identified according to Art. 3(1) and which contribute to pollution.
- Art. 3(5): MS shall be exempt from the obligation to identify specific vulnerable zones, if they establish and apply action programmes referred to in Art. 5 of the ND throughout their national territory

The **WFD** includes eutrophication indicators among the biological quality elements that need to be considered when classifying water bodies based on ecological status. According to the WFD, MS should define quality elements that are sensitive to all pressures, including eutrophication. Different MS have defined different quality elements.

A CIS guidance document on the harmonization of eutrophication assessment was adopted in 2009 (European Commission, 2009). The main anthropogenic sources of nutrient loadings are addressed in the UWWTD, which focuses on major point sources (in particular UWWTPs) and the ND, which deals with diffuse pollution of nitrogen from agriculture. Both Directives define the term "eutrophication". The WFD introduced a comprehensive ecological status assessment of surface waters, based on a number of biological, hydromorphological, chemical and physico-chemical quality elements.

A comparison of key terms used in UWWTD, ND and WFD with regard to eutrophication is given in Table 9. The classification of water bodies not achieving the objective with regard to eutrophication under different Directives is given in Table 10 (European Commission, 2009).

Table 9: Key terms used in UWWTD, ND and WFD with regard to eutrophication (European Commission, 2009)

	WFD	UWWTD	ND
Assessment result	Water body at less than good status based on eutrophication-related biological quality elements or judged at risk of deterioration	Sensitive area (=sensitive water body) due to eutrophication	"Polluted waters"*
Location of pressures (other than those directly on the water body)	River basin or subbasin	Catchment area of sensitive area	Nitrate vulnerable zone (areas which drain into identified waters)

* “polluted waters” = “waters affected by pollution and waters which could be affected by pollution if action is not taken” in line with Article 3 of the ND (especially waters that are eutrophic or in the near future may become eutrophic)

Table 10: The classification of water bodies not achieving the objective with regard to eutrophication under different Directives (European Commission, 2009)

Directive	Classification	Comments
WFD	Worse than good ecological status (deterioration in ecological status)	Good ecological status for the algal and plant quality elements includes an absence of undesirable disturbances due to accelerated growth. Nutrient conditions must support the biology. Being worse than good ecological status for these quality elements due to nutrient enrichment implies an eutrophication issue, independent of the sources of pollution (point or diffuse). Covers all freshwaters and transitional waters, and all coastal waters […]
UWWTD	Sensitive Areas	Sensitive areas include water bodies (including freshwater bodies, estuaries and coastal waters) that are eutrophic or in the near future may become eutrophic if protective actions are not taken. Designation of sensitive areas results in action regarding wastewater treatment independent of the origin of the pollution (i.e. independent whether pollution comes from urban

Directive	Classification	Comments
		wastewater discharges or originates from agricultural sources, since both of them contribute to eutrophication).*
ND	"Polluted waters" whose catchments require designation as nitrate vulnerable zones.	Nitrate vulnerable zones must be established over the catchment of "polluted waters" which include water bodies that are eutrophic or in the near future may become eutrophic if protective action is not taken. Only applies to pollution by nitrogen from agricultural sources.

* According to the Judgement of the Court of Justice in the case C-280/02

Table 11: Comparison of assessment results under various policies for waters responding to nutrient enrichment. (European Commission, 2009)

	Assessment of current status		
Ecological status	**WFD normative definition**	**UWWTD**	**ND**
High	Nearly undisturbed	Non-eutrophic, designation of sensitive area is **not required**	Non-eutrophic, not a polluted water, designation of nitrate vulnerable zone is **not required**
Good	Slight change in composition, biomass		
Moderate	Moderate change in composition, biomass	Eutrophic or may become eutrophic in the near future, designation of sensitive area is **required**	Eutrophic or may become eutrophic in the near future, polluted water, designation of nitrate vulnerable zone is **required**
Poor*	Major change in biological communities	Eutrophic, designation of sensitive area is **required**	Eutrophic, polluted water, designation of nitrate vulnerable zone is **required**
Bad	Severe change in biological communities		

*Indirect effects of eutrophication (e.g. decline in dissolved oxygen) will be evident at poor ecological status.

The policy options proposed by the EC are the following:

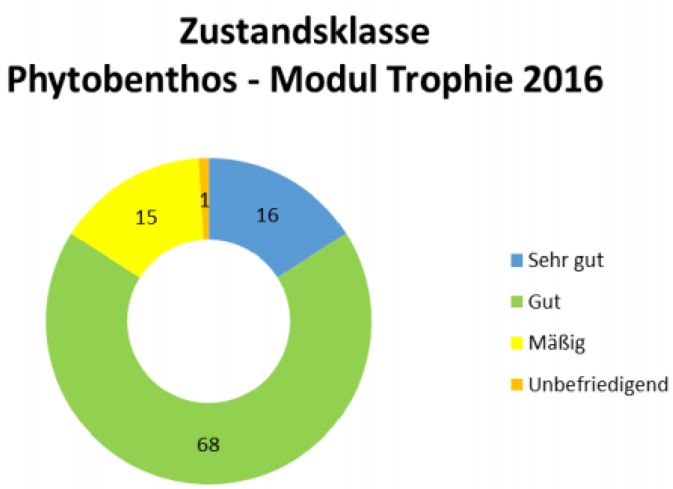
a) Align the definition of sensitive areas for eutrophication with the Nitrates Directive
b) EU thresholds defining eutrophication and /or specific UWWTD guidance on how to designate sensitive areas, also for transboundary water bodies
c) Specific reporting requirement to better understand the links between designations of sensitive areas under different legislations
d) Abandon criterion b and c of Annex II, to be dealt with under other Directives, whilst setting generally stricter N & P thresholds for all large UWWTPs

4.2 Current situation in Austria

Legal basis	• The UWWTD was implemented by means of the General Waste Water Ordinance (**AAEV**) and the national ordinance for wastewater emissions into surface waters from UWWPs > 50 PE (**1st AEVka**), which foresees a nation-wide removal of nitrogen (UWWTPs > 5,000 PE) and phosphorus (UWWTPs > 1,000 PE). AT does not have to designate sensitive areas, as it applies more stringent treatment over the entire territory. • As regards the Nitrates Directive, AT has chosen to apply an action program throughout the entire agricultural area (Ordinance on the Action Program for the Protection of Waters against Pollution by Nitrates from Agricultural Sources (Nitrate Action Program Ordinance – **NAPV**, BGBl II No. 385/2017). • The WFD was implemented by means of the Water Act and i.a. two ordinances, which define the elements of good ecological and chemical status of surface waters: – Quality Target Ordinance/Ecological Condition of Surface Water (**QZV Ökologie OG**, (BGBl. Nr. 99/2010)) defines different aquatic bioregions and individual threshold values for a) Biological elements: phytoplankton, phytobenthos, macrophytes, benthic invertebrate fauna, fish fauna b) Hydromorphological elements c) General physico-chemical elements: temperature, oxygen balance (BOD_5, oxygen saturation), acidification status (pH), nutrient conditions (PO_4-P and NO_3-N), salinity (Chloride) – Quality Target Ordinance/Chemical Condition of Surface Water (**QZV Chemie OG**, (BGBl. Nr. 96/2006)) defines threshold values for chemical elements (i.e. priority substances of Directive 2013/39/EU) and chemical elements of the ecological status (i.a. NH_4-N and NO_2-N).
Current situation	• In Austrian waters, phosphorus is generally the limiting factor for eutrophication (not nitrogen).

- **UWWTD:** In 1996 AT informed the EC that no water body in its territory corresponded to the criteria for the identification of sensitive areas. According to the Commission's verification study of 1999, three rivers should have been identified as sensitive due to the risk of eutrophication (March, Antiesen, Donaukanal). The AT authorities showed that in those areas all measures concerning wastewater treatment, even beyond the requirements of the Directive, had already been implemented.
  At the end of 2002 AT decided to apply Article 5(8) and to implement officially more stringent treatment regarding P-removal over its entire territory. In 2007 AT informed the EC that from 31.12.2006 onwards AT applies Art. 5(8) in combination with Art. 5(4). Since that date AT complies with Art. 5(8) + 5(4) and currently (reference year 2018) sees a territory-wide reduction of 81 % nitrogen and 91 % phosphorus.
- **Nitrates Directive:** In the reporting period 2015–2019, all of the 100 investigated monitoring stations in surface waters (rivers) had mean NO_3-N concentrations <25 mg/L NO_3-N (BMLRT, 2020).
  The trophic status of rivers under the ND is assessed using the biological quality element phytobenthos (trophic module) in line with the WFD. Phytobenthos is the most sensitive biological quality element to indicate nutrient pollution, as it records a summary effect, i.e. the level of primary production is determined as the result of the presence of eutrophying substances in water (nitrogen and especially phosphorus). The adjustment of the quality element to the water situation takes time, short-term fluctuations in the load have a less serious effect than the long-term development of the load situation. Therefore, statements based on this biological quality element are more meaningful regarding the pollution situation than the pure observation of the nitrate concentration.
- In the latest AT-report under the ND (BMLRT, 2020) 77 monitoring stations in rivers were not eutrophic, whereas 16 were assessed as eutrophic (Figure 5).

Figure 5:Trophic status assessed on the basis of the quality element phytobenthos (BMLRT, 2020)



	• In AT the trophic status of lakes is assessed by means of phytoplankton according to the WFD. For all of the investigated 28 lakes >50 ha a very good (22 lakes) or good (six lakes) status was observed. Mean NO_3-N concentrations were between 0.12 mg/L and 3.4 mg/L NO_3-N and mean P_{tot} -concentrations between 2 µg/L and 19 µg/L (except lake Neusiedl) (BMLRT, 2020). • **WFD:** In the Draft 3rd River Basin Management Plan (BMLRT, 2021) 8,119 surface water bodies in rivers and 62 surface water bodies in lakes were assessed for their chemical and ecological status. Failure to achieve good ecological status was identified for about 20 % of Austria's surface water bodies in rivers due to substantial pollution (mainly phosphorus loads). Resulting from the successful reduction of point source emissions, the nutrient load input from diffuse sources into surface waters became more important over the years. Only in single cases nutrient inputs or the input of organic substances from point sources still contribute to eutrophication in the water body and even more rarely to problems with regard to saprobic water quality. The WFD risk analysis showed that further reductions in point source emissions (predominantly phosphorus) are to be considered for 78 water bodies. The more relevant pathway of phosphorus into surface waters originates from diffuse sources and primarily in the low-discharge water bodies in intensively used agricultural areas. As regards chemical pollution two surface water bodies were not in good status due to NH_4-N. Ten out of the 62 lakes showed no good ecological status, two of which (Ossiachersee and Lunzersee) due to trophic elements.
Costs (estimates)	• **Wastewater management**: Since 1959, about 48 billion € have been invested for the construction of sewers and UWWTPs (almost 93,000 km of public sewers, about 1,900 UWWTPs >50 PE). • Cost for increasing P reduction at UWWTPs from 1.0 mg/L to 0.5 mg/L by additional P precipitation: 0.1 - 0.2 €/PE/a (BMLUW, 2017) • **Diffuse pollution**: Costs for the implementation of the NAPV are not available • Extensive management of agricultural areas: Under consideration of 10 m riparian strips, at least 1,000 €/km/a per km watercourse (BMLFUW, 2017).

4.3 Policy options – future possibilities for implementation in Austria

4.3.1 Align the definition of sensitive areas for eutrophication with the Nitrates Directive

Possible implementation in AT	• This option has no direct implications for AT, as neither sensitive areas under the UWWTD, nor vulnerable zones under the ND have been designated. • AT uses the approach to apply more stringent treatment as regards the UWWTD in the entire territory and to apply a nitrates action programme throughout the entire agricultural land under the ND. This means that strict standards are applied as regards nutrient pollution from point and diffuse sources (emission – aspect). Both approaches aim at the reduction of nutrient loads discharged into surface waters. • The immission aspect as regards nutrient pollution and the assessment of the ecological and chemical status is covered by the WFD. In case of failure of good status of water bodies, it is on a case-by-case level assessed, where the pollution comes from and which measures need to be taken. This is done in the context of the River Basin Management Plan under the WFD. • UWWTD, ND and WFD are currently used in a complementary way in AT. The link between the assessment of eutrophication under the ND and the ecological status concept of the WFD exists, as the ND and the WFD use the same monitoring network as well as the same water quality elements. • The CIS guidance document No. 23 (European Commission, 2009) states that in case the assessment *[of eutrophication]* under different policies leads to a different level of protection the most stringent requirement shall apply.
Advantages	• General advantages of harmonized consideration of eutrophication under the UWWTD, the ND and the WFD: • common concept to assess eutrophication in line with the ND, the UWWTD (and the WFD) • Use of common monitoring network.
Disadvantages	• Alignment of SA under the UWWTD should not be done with the ND, but vice versa. Alignment of vulnerable zones under the ND should be done in the sense of the UWWTD, as the definition of eutrophication under the latter one is interpreted in a broader sense due to EJC judgement C-280/02 (European Court of Justice , 2004). Sensitive areas due to eutrophication under the UWWTD have to be identified even when the pollutants causing eutrophication do not originate from UWWTPs. The EJC judgement was considered in the CIS guidance. The application of this guidance must lead to the same level of protection provided by a ruling independent of which EC Directive is applied.
Costs	• Could not be evaluated.

4.3.2 EU thresholds defining eutrophication and /or specific UWWTD guidance on how to designate sensitive areas, also for transboundary water bodies

Possible implementation in AT	• This option is not relevant for AT, as neither sensitive areas under the UWWTD, nor vulnerable zones under the ND have been designated. The aspect of eutrophication is considered via various ecological and chemical standards in the assessment of water bodies under the WFD. • A guidance document on eutrophication assessment in the context of European Water Policies already exists (European Commission, 2009). • In the intercalibration exercise the MS had to demonstrate that their individual ecological assessment methods and resulting classifications are comparable to those applied by other Member States across the EU. The procedures and limit values contained in Decision (EU) 2018/229 are used by Member States to set the values for classifications in their monitoring systems based on intercalibration.
Advantages	• Better comparability of sensitive areas due to eutrophication • Under the WFD eutrophication is assessed against quality standards for different bioregions. This assessment concept could also be used for the ND and the UWWTD.
Disadvantages	• None. Efforts to harmonize the identification of SA and the methodologies for measuring/ assessing eutrophication have already been undertaken.
Costs	• Could not be evaluated.

4.3.3 Specific reporting requirement to better understand the links between designations of sensitive areas under different legislations

Possible implementation in AT	• This option does not have direct implications for AT, as neither sensitive areas under the UWWTD, nor vulnerable zones under the ND have been designated. • The link to areas designated under other Directives is already provided in the current Art. 15- reporting templates (EEA, 2019). In the table 'ReceivingAreasSAParameter' there is the option to identify the Directive, under which the area is designated (parameter 'rcaCRelevantDirective'), the ID of the area defined under the Directive of concern (parameter 'rcaCIDOtherDirective'), as well as the designation date (parameter 'rcaCDateOtherDirective'). This option is considered to be sufficient to establish links between different Directives.
Advantages	• Availability of detailed individual information (exceeding the information that is already provided)
Disadvantages	• General increase of reporting burden with no direct additional positive effect to the environment

Costs	• Could not be evaluated.

4.3.4 Abandon criterion b and c of Annex II, to be dealt with under other Directives, whilst setting generally stricter N & P thresholds for all large UWWTPs

Possible implementation in AT	• This option does not have direct implications for AT, as neither sensitive areas under the UWWTD, nor vulnerable zones under the ND have been designated. As regards criterion b, AT is not using surface water for drinking water purposes (ÖVGW, 2018), therefore this criterion is not relevant. • In AT stricter threshold values for N_{tot} and P_{tot} on UWWTP-level are not relevant for UWWTD-compliance, as AT applies Art. 5(4) of the Directive for the entire territory. • Depending on the type of stricter threshold values for N_{tot} and P_{tot} and the size of UWWTPs concerned, AT could easily reach stricter threshold values for P_{tot}. For N_{tot} stricter thresholds as regards the effluent concentration might not be easily achievable at all UWWTPs (see Factsheet Nutrient removal Austria)
Advantages	• Stricter N & P thresholds for all large UWWTPs: See Factsheet Nutrient removal Austria
Disadvantages	• Stricter N & P thresholds for all large UWWTPs: See Factsheet Nutrient removal Austria
Costs	• Could not be evaluated.

4.4 Further data collection/ data evaluation

- Further data collection/ data evaluation as regards areas sensitive to CECs see Factsheet Pollutants of emerging concern Austria

4.5 References

4.5.1 Legislation Austria

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4.5.2 Legislation EU

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4.5.3 Guidance documents/ Codes of practice

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5 Factsheet – Nutrient removal

Authors:

Katharina Lenz[1]
Clemens Steidl[1]
Stefan Lindtner[2]

[1]Umweltbundesamt, Spittelauer Lände 5, 1090 Wien, Mail: office@umweltbundesamt.at

[2]Ingenieurbüro kaltesklareswasser, Obere Augartenstraße 18/8/20, 1020 Wien, Mail: office@k2w.at

5.1 Background

UWWTD Art. 5(1) states that MS shall identify sensitive areas according to the criteria laid down in Annex II of the UWWTD. In brief, these criteria are i) eutrophication, ii) surface freshwaters intended for the abstraction of drinking water and iii) areas where more stringent treatment than secondary treatment is necessary to fulfil Council Directives.

According to Art. 5(2) of the UWWTD MS shall ensure that urban wastewater entering collecting systems shall before discharge into sensitive areas be subject to more stringent treatment for all discharges from agglomerations >10,000 PE. The requirements for 'more stringent treatment' are defined in Art. 5(3) and Annex I B and are summarized in Table 12.

AT does not apply Art. 5(1) of the Directive, but Art. 5(8) in combination with Art. 5(4). According to Art. 5(8) MS do not have to identify sensitive areas if they implement the treatment established under Art. 5(2), Art. 5(3) and Art. 5(4) over all their territory. Art. 5(4) states that alternatively to Art. 5(2) and Art 5(3), requirements for individual plants set out in paragraphs 2 and 3 need not apply in sensitive areas where it can be shown that the minimum percentage of reduction of the overall load entering all UWWTPs in that area is at least 75 % for total phosphorus and at least 75 % for total nitrogen.

Since 2006 Austria complies with Art. 5(8) and Art. 5(4) of the UWWTD and currently (reference year 2018) sees a territory-wide reduction of 81 % nitrogen and 91 % phosphorous in relation to the load of the influent (BMLRT, 2020).

Due to the application of Art. 5(8) and Art. 5(4) AT does not need to apply the treatment standards laid down in Annex I B on plant level. However, Austrian legislation (1st AEVkA) foresees treatment standards, which are already stricter than those of the UWWTD. Table 12 compares the requirements for discharge from UWWTPs to sensitive areas according to the UWWTD and the treatment requirements laid down in the 1st AEVkA.

Table 12: Requirements for discharge from UWWTPs under the UWWTD (discharge to sensitive areas) and the 1st AEVkA

Parameter	Requirement	UWWTD (91/271/EEC)*	Austrian legislation (1st AEVkA)
N total (N_{tot})	Effluent concentration	10,000 - 100,000 PE: 15 mg/L[1] > 100,000 PE: 10 mg/L[1]	--
	Minimum reduction rate	≥ 10,000 PE 70-80 %	> 5,000 PE: ≥ 70%[2]
NH_4-N	Effluent concentration	--	50 - 500 PE: 10 mg/L[†,3] > 500 PE: 5 mg/L[†,3]
P total (P_{tot})	Effluent concentration	10,000 - 100,000 PE: 2 mg/L > 100,000 PE: 1 mg/L	> 1,000 PE: 2 mg/L* > 5,000 PE: 1 mg/L*,[4]
	Minimum reduction rate	≥ 10,000 PE 80 %	--

*annual average, †daily average (i.e. from a specific number of samples to be taken within a year, only a specific number of samples is allowed to exceed the ELV)
[1]Alternatively, the daily average must not exceed 20 mg/L N. This requirement refers to a water temperature of ≥ 12° C during the operation of the biological reactor of the UWWTP. As a substitute for the condition concerning the temperature, it is possible to apply a limited time of operation, which takes into account the regional climatic conditions. Explanation of this paragraph: ELVs for concentration are annual means. However, the requirements for nitrogen may be checked using daily averages when it is proved, that the same level of protection is obtained. In this case, the daily average must not exceed 20 mg/L of N_{tot} for all the samples when the temperature from the effluent in the biological reactor is ≥12°C. The conditions concerning temperature could be replaced by a limitation on the time of operation to take account of regional climatic conditions.
[2]applies at a wastewater temperature > 12°C in the effluent of the biological stage of the UWWTP.
[3]applies to UWWTPs 51 – 5,000 PE at a wastewater temperature > 12°C and to UWWTPs > 5,000 PE at a wastewater temperature > 8°C in the effluent of the biological stage of the UWWTP
[4]An emission limit of 0.5 mg/L applies to a UWWTPs > 10,000 PE in the catchment area of a national or international lake.

There are several differences between the requirements of the UWWTD and the 1st AEVkA:

- The parameters investigated;
- The size classes of UWWTPs;
- The assessment of the emission limit values (ELV);
- Under the UWWTD the values for effluent concentration OR for the percentage of reduction shall apply, the 1st AEVkA foresees that both criteria must be met.

The policy options for nutrient removal proposed by the EC are the following:

a) More stringent thresholds for nitrogen & phosphorus for all large UWWTPs (appropriate size of UWWTPs to be covered to be determined),
b) Stricter nitrogen & phosphorus thresholds in general,
c) Use risk based approach via derogations where there is evidence that water quality of the recipient body is not affected (in line with WFD and Marine Strategy Framework Directive objectives).

5.2 Current situation in Austria

Legal basis	• The UWWTD is implemented into national law by means of the General Waste Water Ordinance (**AAEV**) and the national ordinance on wastewater emissions from UWWTPs > 50 PE (**1stAEVkA**). The latter one describes the requirements for nutrient removal for UWWTPs > 50 PE, the number of data sets to take, and the maximum number of data sets, which are allowed to fail to conform (see Table 12 and Factsheet Monitoring). • Since 2009 data for reporting under the UWWTD is collected in the emission register surface water (EMREG-OW) based on the national ordinance on an emission register for point sources (EmRegV-OW). This register contains data on annual incoming and discharged loads (kg/a) of total nitrogen (N_{tot}), total phosphorus (P_{tot}) and NH_4-N as well as on the annual amount of wastewater (m^3/a) per UWWTP ≥ 2,000 PE.
Current situation	• The requirements of the UWWTD (Art. 5(8) + Art. 5(4)) are met by a reduction of approximately 81 % nitrogen and 91 % phosphorus (BMLRT, 2020). • Data from 630 UWWTPs collected in EMREG-OW shows the treatment efficiency in 2010-2019 (Table 13 to Table 15 and Figure 6). For the calculation of the median all effluent concentrations from single UWWTPs per size class were considered, while for the weighted average the total effluent load of all UWWTPs [kg/a] was summed up and compared to the sum of the treated wastewater [m^3/a]. Due to little QA/QC of data in the first years of EMREG-OW, the dataset comprises outliers and therefore, data scatter strongly and the weighted average deviates from the median. This effect is more pronounced for smaller UWWTPs. While for P_{tot} the median effluent concentration decreases with growing size classes (due to stricter ELV), the situation is the opposite for NH_4-N and N_{tot}. The reason is that UWWTPs with anaerobic digestion (usually larger UWWTPs) show lower N-removal and consequently higher NH_4-N and N_{tot} concentrations in the effluent (Lindtner, 2019).

Table 13: P_{tot} annual average concentrations (median and weighted average)

Cat. 1st AEVkA	Requirements 1st AEVkA [mg/L]	Numbers of Measurements	Effluent concentration [mg/L]	
			median	weighted average
II	2.0	2,424	0.80	1.58
III	1.0	3,158	0.60	0.62
IV	1.0	666	0.54	0.62

Cat. II: 501 – 5,000 PE, Cat. III: 5,001 – 50,000 PE, Cat. IV: >50,000 PE

Table 14: NH_4-N annual average concentrations

Cat. 1st AEVkA	Requirements 1st AEVkA [mg/L]	Numbers of Measurements	Effluent concentration [mg/L]	
			median	weighted average
II	5.0	2,321	0.57	1.21
III	5.0	3,086	0.67	1.19
IV	5.0	618	0.94	1.0

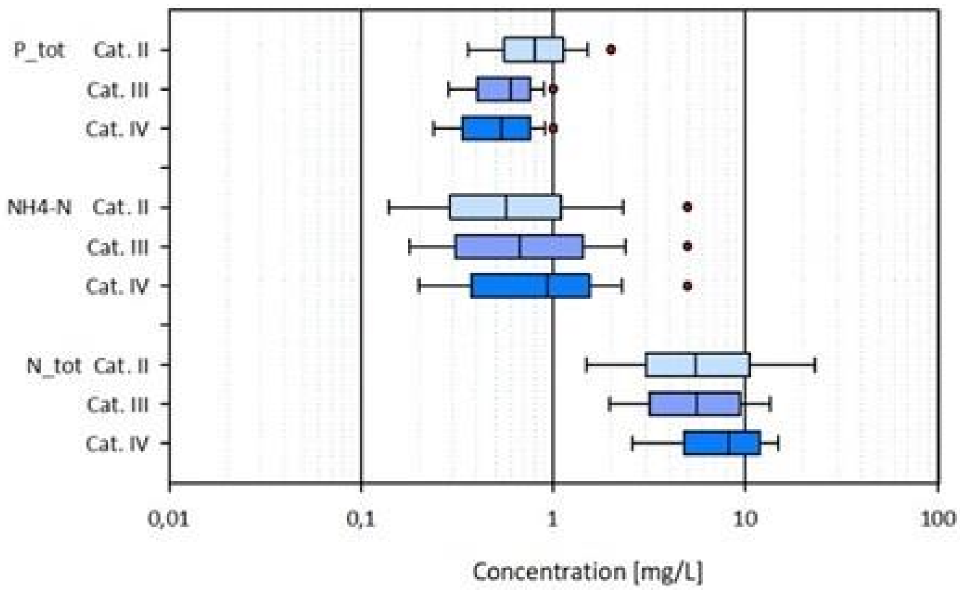
Cat. II: 501 – 5,000 PE, Cat. III: 5,001 – 50,000 PE, Cat. IV: >50,000 PE

Table 15: N_{tot} annual average concentrations

Cat. 1st AEVkA	Requirements 1st AEVkA [mg/L]	Numbers of Measurements	Effluent concentration [mg/L]	
			median	weighted average
II	-	1,425	5.48	4.81
III	-	2,953	5.87	7.32
IV	-	659	8.22	8.55

Cat. II: 501 – 5,000 PE, Cat. III: 5,001 – 50,000 PE, Cat. IV: >50,000 PE

Figure 6: Median effluent concentrations of P_{tot}, NH_4-N and N_{tot} per size class (reference years 2010 –2019) and emission limit value (red dots) according to the 1st AEVkA (box-plot showing the median, the 25% and 75%-percentile as borders of the box and the 10% and 90% percentile as whiskers)



- Table 16 shows the effluent concentrations (median and weighted average) for P_{tot}, NH_4-N and N_{tot} based on the data from the annual voluntary performance statement for UWWTPs that is organized by the Austrian Water and Waste Association (ÖWAV-Kläranlagen-Leistungsnachweis, “KAN survey”) from the year 2019. It includes 938 UWWTPs from Austria and South Tyrol with an organic design capacity of 22.9 mio PE.

Table 16: Effluent concentrations (median and weighted average) for P_{tot}, NH4-N and N_{tot} based on data from the KAN survey (2019)

	Effluent concentration [mg/L]	
	median	**Weighted average**
P_{tot}	0.6	0.6
NH_4-N	0.7	1.1
N_{tot}	6.5	9.2

Source: Lindtner, 2020

- UWWTPs in the size category 50 - 2,000 PE are only contributing 2.1% of the total share of PE in Austria, but with a number of 1,236 treatment plants as compared to 630 UWWTPs > 2,000 PE (BMLRT, 2020). With regard to the nutrient removal over the whole territory small UWWTPs can be considered insignificant.

- As regards the entire nutrient loads from AT (incoming and discharged loads from UWWTPs >50 PE) a significant decrease of effluent nutrient loads was observed from 2004 to 2010 (due to the enlargement of the Viennese UWWTP), with minor variations after 2010 (Table 17).

Table 17: Influent and effluent loads of N_{tot} and P_{tot} from UWWTPs >50 PE (Source: Reports under Art. 16 of the UWWTD. See: homepage of the BMLRT: https://www.bmlrt.gv.at/)

	N_{tot}			P_{tot}		
	Influent [t/a]	effluent [t/a]	reduction rate [%]	Influent [t/a]	effluent [t/a]	reduction rate [%]
2004	46,836	15,017	68	7,531	978	87
2006	45,921	10,591	77	7,739	918	88
2008	45,332	9,474	79	7,781	836	89
2010	47,157	9,578	80	7,563	806	89
2012	46,160	9,240	80	7,412	736	90
2014	46,634	8,625	82	7,506	767	90
2016	49,493	9,604	81	7,734	741	90
2018	50,315	9,632	81	7,196	662	91

Table 18: Influent and effluent loads of Ntot and Ptot from UWWTPs >50 PE in the AT parts of the river basins Danube, Rhine and Elbe in 2018 (BMLRT, 2020)

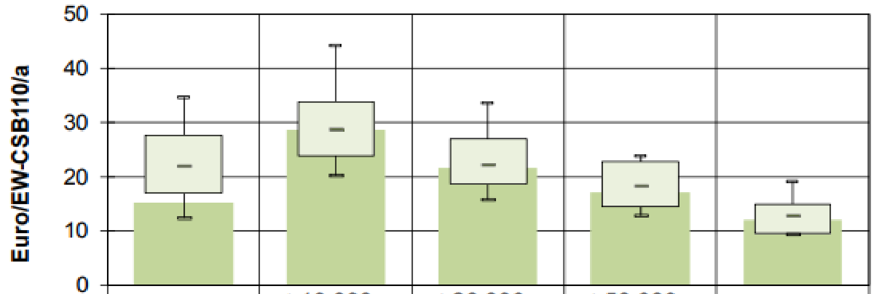
	N_{tot}			P_{tot}		
	Influent [t/a]	effluent [t/a]	reduction rate [%]	Influent [t/a]	effluent [t/a]	reduction rate [%]
Danube	47,674	9,119	81	6,800	647	90
Rhine	2,461	481	80	371	11	97
Elbe	180	33	82	25	3	87

Costs (estimates)

Phosphorus:

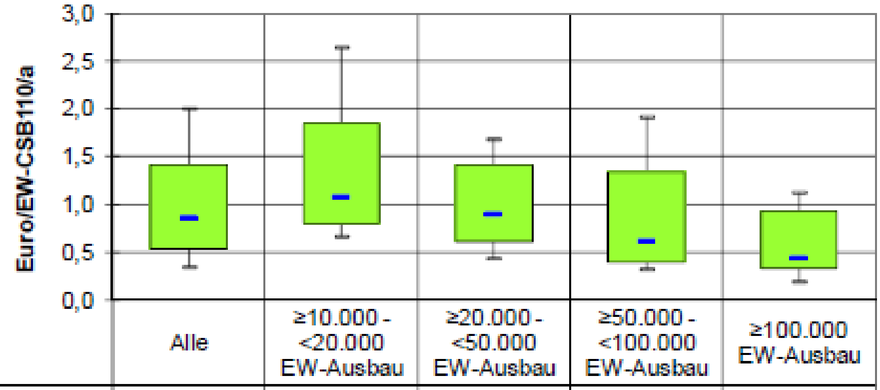
On the basis of data from 90 UWWTPs from the reference years 2003 – 2012, which was collected in the context of a wastewater benchmark, Lindtner and Vohryzka (2013) showed that the average wastewater treatment costs for UWWTPs with P-removal (total costs including e.g. costs for precipitants, energy, man-power and sludge disposal) are 21.8 €/PE/a and that costs vary according to the size of the UWWTP (Figure 7). The costs for precipitants amount to around 5% of the entire wastewater treatment costs (Figure 8). The same authors showed that - contrary to expectations - costs for P-removal do not depend on the P_{tot} effluent concentration achieved (Figure 9). The use of different precipitants with a high price range was considered as explanation for this unexpected result.

Figure 7: Costs for wastewater treatment in UWWTPs with P_{tot}-removal according to the size of the UWWTP (Lindtner and Vohryzka, 2013)



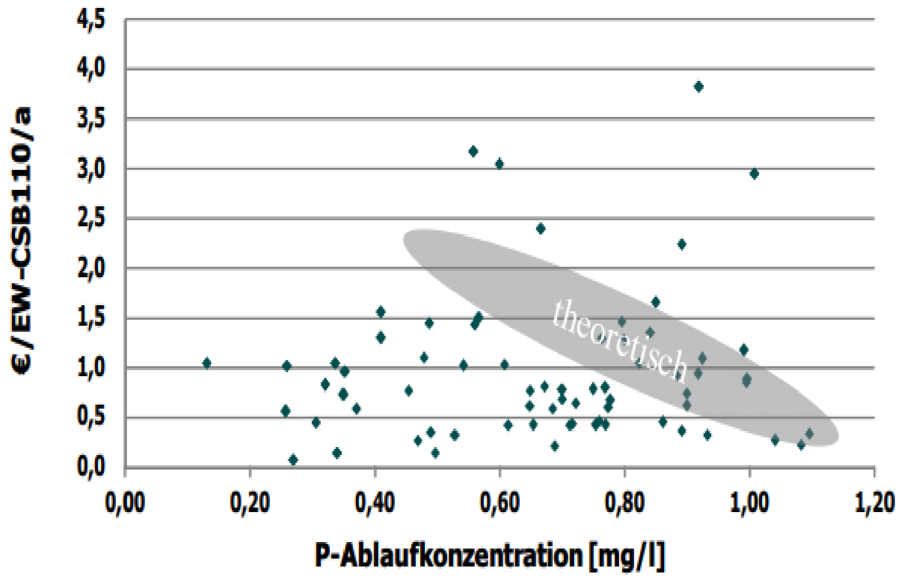
	Alle	≥10.000 - <20.000 EW-Ausbau	≥20.000 - <50.000 EW-Ausbau	≥50.000 - <100.000 EW-Ausbau	≥100.000 EW-Ausbau
Anzahl	90	19	50	6	15
gew. Mittel	15,2	28,5	21,6	17,1	12,0
75-%-Wert	27,6	33,9	26,9	22,7	14,9
90-%-Wert	34,6	44,2	33,5	23,8	19,1
10-%-Wert	12,3	20,2	15,8	12,6	9,3
Median	21,8	28,7	22,1	18,2	12,6
25-%-Wert	16,9	23,9	18,6	14,5	9,6

Figure 8: Specific costs for precipitants according to the size of the UWWTP (Lindtner and Vohryzka, 2013)



	Alle	≥10.000 - <20.000 EW-Ausbau	≥20.000 - <50.000 EW-Ausbau	≥50.000 - <100.000 EW-Ausbau	≥100.000 EW-Ausbau
Anzahl	90	19	50	6	15
75%-Wert	1,4	1,9	1,4	1,3	0,9
90%-Wert	2,0	2,6	1,7	1,9	1,1
10%-Wert	0,3	0,7	0,4	0,3	0,2
Median	0,9	1,1	0,9	0,6	0,4
25%-Wert	0,5	0,8	0,6	0,4	0,3

Figure 9: Costs for precipitants versus P_{tot} concentrations in the effluent (Lindtner and Vohryzka, 2013)



The costs for P_{tot} removal according to the state of the art (1st AEVkA) were also described in Lindtner (2007) (see Table 19).

Table 19: Operating costs for P_{tot}-removal (Lindtner, 2007)

	Operating costs [€/ kg P_{tot} removed]	
Size class [PE]	**min**	**max**
1,000 - 5,000	74	103
5,000 - 20,000	41	59
20,000 - 50,000	26	46
> 50,000	20	34

Nitrogen:

The costs for N_{tot} removal according to the state of the art (1st AEVkA) were described in Lindtner (2007) (see Table 20).

Table 20: Operating costs for N_{tot}-removal (Lindtner, 2007)

	Operating costs [€/ kg N_{tot} removed]	
Size class [PE]	**min**	**max**
1,000 - 5,000	28.6	25.7
5,000 - 20,000	6.4	7.7
20,000 - 50,000	6.0	9.5
> 50,000	4.4	7.7

5.3 Policy options – future possibilities for implementation in Austria

5.3.1 More stringent thresholds for nitrogen & phosphorus for all large UWWTPs

Possible implementation in AT

Phosphorus:

- The AT legislation sets a maximum discharge concentration for phosphorus by 2 mg/L for UWWTPs with a size of 1,001 PE - 5,000 PE and 1 mg/L for UWWTPs > 5,000 PE.
- The national thresholds are already more stringent than those in the UWWTD and they are met by UWWTPs.
- A reduction under 1 mg/L for all large UWWTPs is achievable (see Table 21 and Table 22).
- A possible reduction of the threshold by the EC to 1 mg/L for UWWTPs 10,000 PE - 100,000 PE will not affect the Austrian legislation (see Table 12).
- Table 23 shows an analysis over the Austrian UWWTPs 10,001 PE - 100,000 PE based on the data of EMREG-OW 2017-2019.

Table 21: Data sets (average annual concentrations) without failing thresholds for P_{tot} (1st AEVkA) (EMREG-OW, quality checked data from 2017-2019)

	1st AEVkA Cat. IV (>50,000 PE) **Data sets without failing thresholds for P_{tot}**		
No. of data sets (annual means)	**1.0 mg/L**	**0.8 mg/L**	**0.6 mg/L**
195	195/ 100%	174/ 89%	129/ 66%

Table 22: Data sets (average annual concentrations) without failing thresholds for P_{tot} (>100,000 PE)

	UWWTPs >100,000 PE **Data sets without failing thresholds for P_{tot}**		
No. of data sets (annual means)	**1.0 mg/L**	**0.8 mg/L**	**0.6 mg/L**
102	102/ 100%	91/ 89%	74/ 73%

Table 23: Data sets (average annual concentrations) without failing thresholds for P_{tot} (10,001-100,000 PE)

	UWWTPs 10,001-100,000 PE Data sets without failing thresholds for P_{tot}			
No. of data sets (annual means)	**1.5 mg/L**	**1.0 mg/L**	**0.8 mg/L**	**0.6 mg/L**
690	690/ 100%	687/ 99.6%	609/ 88%	435/ 63%

Nitrogen:

- The AT legislation sets no ELV for the concentration of nitrogen discharge. The reduction rate for size category III and IV has to be at least 70% at a wastewater temperature of 12°C. Table 24 to Table 26 show the concentration for N_{tot} based on the data of EMREG-OW 2017-2019.
- The 1st AEVkA sets values for the concentration of NH_4-N at 5 mg/L for UWWTPs >500 PE at wastewater temperatures of 12°C and 8°C respectively (Table 12). The median values of nitrogen discharge are shown in Table 15.
- The performance of the Austrian UWWTPs regarding the thresholds set by the UWWTD are shown in Table 25 and Table 26. The current UWWTD emission limit values for N_{tot} have not yet been met by several UWWTPs, however, it has to be considered, that the calculation of mean annual concentrations for UWWTPs from EMREG-OW data did not take into account the wastewater temperature.
- The requirements for the minimum percentage of reduction are met (see Chapter 5.3.2).

Table 24: Data sets without failing thresholds for N_{tot} (1st AEVkA) (EMREG-OW, quality-checked data from 2017-2019)

	1st AEVkA Cat. IV >50,000 PE Annual means (without consideration of wastewater temperature) without failing thresholds for N_{tot}			
No. of data sets (annual means)	**12 mg/L**	**10 mg/L**	**8 mg/L**	**6 mg/L**
195	143/ 73%	110/ 56%	85/ 44%	59/ 30%

Table 25: Data sets without failing thresholds for Ntot (> 100,000 PE)

	UWWTPs >100,000 PE Annual means (without consideration of wastewater temperature) without failing thresholds for N_{tot}			
No. of data sets (annual means)	**12 mg/L**	**10 mg/L**	**8 mg/L**	**6 mg/L**
102	73/ 72%	55/ 54%	42/ 41%	29/ 28%

Table 26: Data sets without failing thresholds for N_{tot} (10,001 - 100,000 PE)

	UWWTPs 10,001-100,000 PE Annual means (without consideration of wastewater temperature) without failing thresholds for N_{tot}		
No. of data sets (annual means)	**15 mg/L**	**10 mg/L**	**8 mg/L**
690	639/ 93%	487/ 71%	386/ 56%

- For the purpose of this factsheet one province provided concentrations of daily samples of N_{tot} and the wastewater temperature for the reference year 2020 (Table 27 - Table 29). The data showed that the ELV of the UWWTD are not met by all samples. The cause is partly high fractions of industrial wastewater in the influent to UWWTPs, which however show compliant removal rates for N_{tot}.

Table 27: Daily samples without failing thresholds for N_{tot} (>100,000 PE)

Number of daily samples	**UWWTPs >100,000 PE**		
	without consideration of temperature	**≥ 12°C**	**< 12°C**
total	401	347	54
achieving an ELV ≤ 10 mg/L	219/ 55%	182/ 52%	37/ 69%
achieving an ELV ≤ 20 mg/L	392/ 98%	340/ 98%	52/ 96%

Table 28: Daily samples without failing thresholds for N_{tot} (10,001 - 100,000 PE)

Number of daily samples	UWWTPs >10,000 PE - 100,000 PE		
	without consideration of temperature	**≥ 12°C**	**< 12°C**
total	851	590	261
achieving an ELV ≤ 15 mg/L	732/ 86%	525/ 89%	207/ 79%
achieving an ELV ≤ 20 mg/L	808/ 95%	582/ 99%	226/ 87%

Table 29: Concentrations of N_{tot} in daily effluent wastewater samples in UWWTPs > 10,000 PE of one province

	No samples	**10% Perc.**	25% Perc.	Median	75% Perc.	90% Perc.
				[mg/L]		
Total	1,252	3.4	5.8	9.4	13.0	16.39
< 12°C	315	3.9	5.8	8.5	13.8	21.0
≥ 12°C	937	3.3	5.8	9.6	13.0	15.4

- In 2019 Austrian UWWTPs > 50 PE reported a phosphorus load in the effluent of around 671 t/a via EMREG-OW (Table 34). Assuming that all UWWTPs > 100,000 PE, which showed an effluent concentration > 0.6 mg/L P_{tot} in 2019, reach the effluent concentration of 0.6 mg/L, the effluent loads would decrease to 626 t/a, which would change the entire reduction rate for AT by 0.7%.

Table 30: Total load of P_{tot} in t/a reported from UWWTPs >50 PE in 2019 taking into account a new ELV (concentration) of 0.6 mg/L for UWWTP > 100,000 PE (2019)

	Influent [t/a]	**Effluent [t/a]**	**Reduction [%]**
load reported	7,238	671	90.7
load with max 0.6 mg/L per UWWTP > 100,000 PE	7,238	626	91.4

	• In 2019 Austrian UWWTPs > 50 PE reported a nitrogen load in the effluent of around 9,976 t/a via EMREG-OW (Table 35). Assuming that all UWWTPs > 100,000 PE, which showed an effluent concentration > 9 mg/L N_{tot} in 2019, reach the effluent concentration of 9 mg/L, the effluent loads would decrease to 8,955 t/a, which would change the entire reduction rate for AT by 2.0%.

Table 31: Total load of N_{tot} in t/a reported from UWWTPs >50 PE in 2019 taking into account a new ELV (concentration) of 9 mg/L for UWWTP > 100,000 PE (2019)

	Influent [t/a]	Effluent [t/a]	Reduction [%]
load reported	51,276	9,976	80.5
load with max 9 mg/L per UWWTP > 100,000 PE	51,276	8,955	82.5

Advantages	• EU-level: Lower loads of P_{tot} and N_{tot} discharged into the environment for those MS, which have designated sensitive areas under Art. 5(2,3) and which do not apply Art. 5(4). • Rising P-loads in sewage sludge would be a benefit if P-recovery from sewage sludge is envisaged (see Factsheet Circular economy – sludge reuse Austria). • As long as AT applies Art. 5(4) and as long as the minimum reduction rates under Art. 5(4) are not increased to > 80% for N_{tot} and > 85% for P_{tot}, more stringent thresholds on UWWTP-level have no impact on AT, as these reduction rates are currently achieved at national and river basin district level (see Table 17 and Table 18). • New ELV of 0.6 mg/L P_{tot} and 9 mg/L N_{tot} for UWWTPs > 100,000 PE would result in the following additional loads removed (Table 32).

Table 32: Additionally removed loads of P_{tot} and N_{tot} taking into account new ELV for UWWTPs > 100,000 PE

	Loads additionally removed [t/a]	Increase compared to current removal [%]
Additionally removed loads of P_{tot}	46	0.7
Additionally removed loads of N_{tot}	1,022	2.5

Disadvantages

- High costs to upgrade UWWTPs for N-removal
- Additional sewage sludge due to increased P-removal. The sludge output from P_{tot} elimination varies depending on the type of elimination and ranges from 3 g DS/ g P_{tot} removed (biological removal) to 6.8 g DS/ g P_{tot} removed (precipitation with iron) (DWA-A 131; Beltzung, 2015). The additional amounts of sewage sludge originating from stricter ELV in large UWWTPs is given in Table 33.

Table 33: Additional sewage sludge taking into account a new ELV of 0.6 mg/L for UWWTP > 100,000 PE

	t/a P_{tot} removed	**amount of DS originating from P-removal**		**additional sludge [t DS/a]**	
		3 g DS/ g P_{tot} remov.	**6.8 g DS/ g P_{tot} remov.**	**min**	**max**
current situation (2019)	6,566	19,699	44,651	-	-
new ELV of 0.6 mg/L for UWWTP > 100,000 PE	6,612	19,836	44,961	137	310

Costs

- According to Lindtner and Vohryzka (2013) the costs for operating P-removal in order to obtain an effluent concentration of 0.5 mg/L are between 3.0 – 6.0 €/kg P_{tot} removed for UWWTPs ≤ 50,000 PE and between 1.5 and 4.0 €/kg Ptot removed for UWWTPs > 50,000 PE (additionally to the costs given in Table 19). These figures result in 0.1 - 0.2 €/PE/a for increasing Ptot-reduction from an effluent concentration of 1 mg/L to an effluent concentration of 0.5 mg/L by means of additional precipitation (BMLFUW, 2017).
- Lindtner (2007) has considered the following scenarios when calculating costs for upgrading UWWTPs to the state of the art of nitrogen removal (1st AEVkA):
  - Constructing or enlarging the existing aeration tank. This measure requires that sufficient carbon is available for denitrification, which is not necessarily the case when primary clarifiers are in place. Investment costs for this measure amount to 29.6 € - 78.9 €/ kg Ntot removed. In terms of operating costs, the increased need for aeration energy is offset by the higher denitrification potential and lower sludge production, so that no changes in operating costs are to be expected.
  - If sufficient carbon is not available, further nitrogen removal up to 90 % can only be achieved by means of denitrification and an external carbon source. This can be realized, e.g. with a downstream sand filter with carbon dosing. The investment costs for this measure are between 46 € and 118 €/kg N_{tot} removed, the operation costs between 1.5 € and 3.4 €/kg N_{tot} removed.

- In case of more stringent ELV for UWWTPs > 100,000 PE for P_{tot} (0.6 mg/L) and N_{tot} (9 mg/L) the costs for wastewater treatment would increase by 0.58% (min.) - 0.60% (max.) for P_{tot}.and by 2.0% - 2.2% for N_{tot}.

5.3.2 Stricter nitrogen & phosphorous thresholds in general

Possible implementation in AT

- Currently Austria accomplishes a reduction of approximately 81% nitrogen and 91% phosphorous in relation to the load of the influent (Table 12).
- The reduction rates of phosphorus for UWWTPs >10,000 PE are even slightly better, see Table 34 (EMREG-OW data analysis 2010-2019, all reported entries, without expunging statistical outliers 2010-2012). The performance of the Austrian UWWTPs regarding the thresholds set by the UWWTD is shown in Table 35.

Table 34: Percentage reduction for P_{tot} and N_{tot} for UWWTPs > 10,000 PE

	Requirements 1st AEVkA	Require-ments UWWTD	Numbers of datasets	Reduction rate	
				median	weighted average
P_{tot}	-	80%	2,724	92.1%	94.9
N_{tot}	70% (III u IV)	70-80%	2,684	83.6%	82.3

Table 35: Data sets without failing reduction rates for N_{tot} and P_{tot} (>10,000 PE)

	Annual means* without failing reduction rates for N_{tot}		Data sets without failing reduction rates for P_{tot}	
No. of data sets (annual means)	80%	70%	No. of data sets (annual means)	80%
792	529/ 67%	729/ 92%	792	772/ 98%

*without consideration of wastewater temperature

- In 2019 Austrian UWWTPs >50 PE reported a phosphorus load in the effluent of around 671 t/a via EMREG-OW (Table 36). Assuming that all UWWTPs > 10,000 PE, which showed an effluent concentration > 0.8 mg/L P_{tot} in 2019, reach the effluent concentration of 0.8 mg/L, the effluent loads would decrease to 663 t/a, which would change the entire reduction rate for AT only by 0.1%

Table 36: Total load of P_{tot} in t/a reported from UWWTPs >50 PE in 2019 and under the assumption of a new ELV (concentration) of 0.8 mg/L for UWWTP > 10,000 PE (2019)

	Influent [t/a]	Effluent [t/a]	Reduction [%]
load reported	7,238	671	90.7
load with max 0.8 mg/L per UWWTP >10,000 PE	7,238	664	90.8

- In 2019 Austrian UWWTPs > 50 PE reported a nitrogen load in the effluent of around 9,976 t/a via EMREG-OW (Table 37). Assuming that all UWWTPs > 10,000 PE, which showed an effluent concentration > 10 mg/L N_{tot} in 2019, reach the effluent concentration of 10 mg/L, the effluent loads would decrease to 8,867 t/a, which would change the entire reduction rate for AT by 2.2%

Table 37: Total load of N_{tot} in t/a reported from UWWTPs >50 PE in 2019 and under the assumption of a new ELV (concentration) of 10 mg/L for UWWTP > 10,000 PE (2019)

	Influent [t/a]	Effluent [t/a]	Reduction [%]
load reported	51,276	9,976	80.5
load with max 10 mg/L per UWWTP	51,276	8,867	82.7

Advantages

- see chapter 5.3.1
- New ELV of 0.8 mg/L P_{tot} and 10 mg/L N_{tot} for UWWTP > 10,000 PE would result in the following additional loads removed (Table 38).

Table 38: Additionally removed loads of P_{tot} and N_{tot} taking into account new ELV for UWWTPs > 10,000 PE

	Loads additionally removed [t/a]	Increase compared to current removal [%]
Additionally removed loads of P_{tot}	7	0.1
Additionally removed loads of N_{tot}	1,109	2.7

Disadvantages	• See chapter 5.3.1 • Additional sewage sludge due to increase P-removal (see chapter 5.3.1) and Table 39.

Table 39: Additional sewage sludge under the assumption of a new ELV of 0.8 mg/L for UWWTP > 10,000 PE

	t/a P_{tot} removed	amount of DS originating from P-removal		additional sludge [t DS/a]	
		3 g DS/ g P_{tot} remov.	6.8 g DS/ g P_{tot} remov.	min	max
current situation (2019)	6,566	19,699	44,651	-	-
new ELV of 0.8 mg/L for UWWTP > 10,000 PE	6,574	19,721	44,700	22	50

Costs	• See chapter 5.3.1 • In case of more stringent ELV for UWWTPs > 10,000 PE for P_{tot} (0.8 mg/L) and N_{tot} (10 mg/L) the costs for wastewater treatment would increase by 0.1% for P_{tot}. and by 2.4% - 2.5% for N_{tot}.

5.3.3 Risk based approach via derogations where there is evidence that water quality of the recipient body is not affected

Possible implementation in AT	• AT applies the combined approach based on the emission-immission-principle (in line with Art. 10 of the WFD). • While the emission limit values are covered by the UWWTD, the AAEV, the 1st AEVkA and the 65 specific wastewater treatment ordinances for domestic and industrial discharges in AT stipulate that, stricter ELV must be applied if e.g. the water body status assessment according to the WFD shows bad or moderate status. Water permits are required for all discharges of UWWTPs into receiving waters. E.g. lake Mondsee showed no good status in the assessment for the 2nd WFD water management plan. Measures were set to reduce point source and diffuse pollution. At the UWWTP Mondsee the ELV was adapted to 0.35 mg/L P_{tot} as annual mean (BMLFUW, 2017). • A risk based approach allowing less stringent requirements if the recipient water body is not affected is not applied in AT except for very specific cases, where a stringent permitting procedure is in place including the possibility of the Federal Ministry to file a complaint. Stringent emission-based effluent requirements apply in the whole country independent of the recipient water body. A more usual situation in AT is the prescription of stricter ELV and more stringent treatment if required (e.g. while the ELV for P_{tot} for UWWTPs

	> 10,000 PE is 1 mg/L (Table 12), it is 0.5 mg/L in the catchment area of a national or international lake). • It is assumed that this policy option means less stringent treatment requirements under the UWWTD in areas where there is evidence, that the water quality of the recipient body is not affected. • As AT provides clear standards for wastewater treatment in UWWTPs >50 PE , this policy option does not affect AT.
Advantages	• AT applies the combined approach with emission-oriented minimum requirements for all UWWTPs laid down in ordinances. For AT this approach would not bear advantages.
Disadvantages	• Possibility to individually weaken the treatment requirements of the Directive • Less comparability between MS as derogations may be granted in different ways in different MS • Difficult evaluation of data across Europe • Pressure of certain stakeholders to change Austrian national law and to generally allow derogations if water quality is not affected (resulting in lowering of existing national standards)
Costs	• Costs for this policy option could not be evaluated

5.4 Further data collection/ data evaluation

- N_{tot}: Reliable assessments whether N_{tot}-thresholds according to the UWWTD (annual mean concentration in the effluent at a wastewater temperature of > 12°C) are achieved are only possible if data on N_{tot} –concentrations and wastewater temperature in individual samples is available.

5.5 References

5.5.1 Legislation Austria

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5.5.3 Guidance documents/ Codes of practice

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5.5.4 Reports and publications

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6 Factsheet – Pollutants of emerging concern

Authors:

Norbert Kreuzinger[1]
Heidemarie Schaar[1]

[1]Institut für Wassergüte und Ressourcenmanagement (IWR), Technische Universität Wien, Karlsplatz 12/226, 1040 Wien, Mail: sekretariat@iwag.tuwien.ac.at

6.1 Background

Currently, target compounds in the UWWTD are limited to traditional wastewater parameters. Secondary treatment of all discharges from agglomerations of > 2,000 PE and more advanced treatment for agglomerations > 10,000 PE in designated sensitive areas and their catchments is required.

For the last 20 years the sensitivity of analytical methods has improved. This resulted in an advanced knowledge of the occurrence and effects of synthetic chemicals in the aquatic environment and urban wastewater as entry pathway for these substances. As a result of this development, measures at UWWTPs have been identified as one possible strategy to minimize emissions (Frauenhofer, 2017; IKSR, 2019) and also the EC has emphasized the role of the UWWTD with regard to pollutants of emerging concern in the aquatic environment (e.g. strategy papers on plastics[3] and on pharmaceuticals[4]). In 2020 the JRC was commissioned to set up expert groups dealing with the potential inclusion of selected pollutants of emerging concern in the Directive (e.g. identification of representative pollutants in urban wastewater and identification of treatment technologies for their removal from wastewater).

Pollutants/ contaminants of emerging concern (CECs) cover substances that are present in the aquatic environment in a low concentration range (ng/L to µg/L), may cause ecological or human health impacts and are typically not regulated by current water legislation. CECs comprise a variety of different substance groups like pharmaceuticals and personal care products, industrial chemicals, biocides and pesticides, but also microplastics and antibiotic resistance. The implementation of the latter two is currently not under discussion and will therefore not be part of the factsheet. Before their regulation in the WFD and the EQSD, priority substances were also regarded as CEC (e.g. nonylphenols), but it could be shown that for most of these substances, UWWTP effluents are not their main pathway into the aquatic environment (Umweltbundesamt, 2009; BMLFUW, 2017). There are ongoing efforts to prioritize chemicals of major concern for European waters (e.g. EU Watch List (C(2015) 1756), Norman network[5]) and to identify those, which are predominantly entering the aquatic environment via UWWTPs.

[3] https://ec.europa.eu/environment/strategy/plastics-strategy_en
[4] https://ec.europa.eu/health/human-use/strategy_en
[5] https://www.norman-network.com/nds/prioritisation/

A current topic discussed in the context of the WFD is the implementation of effect-based monitoring (EBM) and assessment (EC, 2019) applying in vitro biotests. This can be considered a comprehensive and complementary approach to single substance analysis, also taking into account unknown substances and mixture effects. Effect-based trigger values (EBTs) for various modes of action, which are under development and partly already established (Escher et al., 2018; NORMAN and Water Europe, 2019), are considered a feasible tool for quality assessment within the UWWTD, too.

The three policy options proposed by the EC are:

a) EU thresholds to be met on a number of proxy substances to be applied in large and/or medium and/or small agglomerations
b) Obligation to upgrade treatment plants to deal with CECs if
   1. the UWWTP is > 100,000 PE;
   2. discharges into vulnerable areas (drinking water supply zones, bathing water areas),
   3. WWTPs that discharge into rivers with low dilution
a) Make use of a risk-based approach: require the establishment of a new sort of sensitive areas and take action based on which substances are found in the water.

6.2 Current situation in Austria

Legal basis	• Austrian Water Act (BGBl. Nr. 215/1959) • General Waste Water Ordinance (AAEV, BGBl. Nr. 186/1996) • First wastewater emission ordinance for UWWTPs > 50 PE (1st AEVka , BGBl. Nr. 210/1996) • Quality Target Ordinance/Chemical Condition of Surface Water (QZV Chemie OG, BGBl. II Nr. 96/2006) • Quality Target Ordinance/Chemical Condition of Groundwater (QZV Chemie GW, BGBl. II Nr. 98/2010) • National ordinance on an emission register for point sources (EmRegV-OW 2017, BGBl. II Nr. 207/2017) • Urban Waste Water Treatment Directive (UWWTD, 91/271/EEC) • Water Framework Directive (WFD, 2000/60/EC) • Environmental Quality Standards Directive (EQSD, 2013/39/EU)
Current situation	• **Pollutants of emerging concern in UWWTPs – current data in Austria** The national ordinance EmRegV-OW 2017 covers the electronic register for the determination of essential surface water body pollutants emitted by specified

point sources. Approximately 640 UWWTPs (≥ 2,000 PE) belong to the monitored point sources. Substances that have to be measured are listed in the Annex of the ordinance. Before EmRegV-OW came into force, a monitoring campaign had been conducted to evaluate the relevant pollutants in the effluents of representative Austrian UWWTPs with conventional biological treatment (high sludge retention time with nitrification and denitrification). In case of exceedance of EQS in the effluents of the UWWTPs, the substances were classified as relevant for UWWTP discharges (Umweltbundesamt, 2009). The selection of substances for regular monitoring at UWWTPs was based on availability of standard analytical methods with sufficient sensitivity for specific pollutants. As a consequence of this study, cadmium, diuron and nonylphenols have to be measured by UWWTPs > 10,000 PE once every six years from 2010 to 2022. A second study analyzing relevant pollutants in UWWTP effluents was conducted in 2017 covering priority substances from the EQSD, substances from the EU Watch List (C(2015) 1756) and further candidate substances for revision of these legal frameworks. The study in 2017 showed that eleven substances are relevant for UWWTP effluents (nickel, mercury, PFOS, dioxins and dioxin-like PCB, PBDE, 17α-ethinylestradiol (EE2), estrone (E1), 17β-estradiol (E2), diclofenac, copper and zinc (BMLFUW, 2017). In accordance with the selection of pollutants elaborated in 2009, the substances nominated for regular monitoring at UWWTPs > 10,000 PE from 2023 onwards will be nickel, nonylphenols and mercury. According to the draft of the 3rd WFD River Basin Management Plan, PFOS could soon be added.

- **Pollutants of emerging concern – abatement in UWWTPs**
  Austria's UWWTPs > 5,000 PE are typically operated as low-loaded activated sludge treatment plants with a high sludge retention time (SRT) to comply with the nitrogen removal requirements of >70 %. In addition to nitrogen removal, a high SRT has a positive impact on the biotransformation of a broad variety of CECs (Achermann et al., 2018, Clara et al., 2005). Independent of the high SRT, however, recalcitrant substances, as for example carbamazepine or diclofenac are characterized by low removal and high effluent concentrations. To gain experience on the potential of technologies for advanced treatment (CEC abatement) and on operational conditions, several pilot studies on ozonation, activated carbon and the combination of both were conducted in Austria, funded by the Ministry of Agriculture, Regions and Tourism (KomOzon - project no. GZ A601819; KomOzAk I - project no. B202770 and 100927; KomOzAk II – project no. B601389).
- **Pollutants of emerging concern in surface waters – current data in Austria**
  Pollutants, which are already regulated by water legislation, are periodically assessed in surface waters in the context of the WFD. The draft of the 3rd WFD River Basin Management Plan shows that except for ubiquitous pollutants (e.g. PFOS), only a very small number of water bodies (< 1% of 8,100) fails good chemical status and good ecological status due to synthetic and non-synthetic pollutants from point source wastewater discharges. For the category of EU pollutants (priority substances), a few failures to meet the target due to emissions from point sources were identified for nickel, nonylphenols and tributyltin (BMLRT, 2021).
  Measurements of CECs originating from UWWTP effluents in surface waters in

recent years focused on pharmaceuticals and hormones. It could be shown that carbamazepine or diclofenac belonged to the pharmaceuticals present in 100 % of the selected surface waters at concentrations between 0.02 and 0.08 µg/L (BMNT, 2019). Higher concentrations generally occurred at sampling sites with higher wastewater shares confirming the relevant role of UWWTPs for pharmaceuticals in the aquatic environment. As EQS for CECs do not exist, the concentrations in surface water were compared to other assessment criteria than EQS, e.g. chronic quality criteria (QK-chron). Diclofenac and ibuprofen were the pharmaceuticals with the highest frequency of exceedance. Carbamazepine did not exceed the PNEC, applied as quality criterion.

- **Combined emission-immission-principle based approach**
  The emission-immission-based approach foresees additional requirements for UWWTPs in case of immission-related restrictions. This is based on a case-by-case assessment. If immission standards (laid down in the QZV Chemie OG and the QZV Ökologie OG) are exceeded or close to exceedance in a water body, emissions of the substance of concern can be limited, even for substances without emission standards. This principle only applies to chemicals, which are already regulated in water legislation, but not for CECs.

6.3 Policy options – future possibilities for implementation in Austria

6.3.1 EU thresholds to be met on a number of proxy substances to be applied in large and/or medium and/or small agglomerations

Possible implementation in AT

- Basically, the option of implementing a set of proxy substances represents a feasible approach. However, it is necessary to specify the nature of the threshold, i.e. whether compliance with specific effluent concentrations or a minimum removal efficiency is targeted by this policy option. European states where UWWTPs have been upgraded for CEC abatement (Switzerland and partly the German federal states North Rhine-Westphalia (NRW) and Baden Württemberg (BW)) require 80 % removal efficiency of certain proxy substances in the UWWTPs (sum of conventional and advanced treatment).
- There are different types of proxy substances. Performance indicators are technology/process-based proxy substances that focus on the performance of the applied treatment process irrespective of the risks associated with these substances. Toxicology-based proxy substances are selected based on their toxicity and thus their biological effects. Taking planning reliability for UWWTPs into account, only technology-based substances can provide a reliable basis. A combination of both approaches is applied, e.g. in the case of diclofenac.
- Approx. 290 substances are on the proxy substance list that is currently discussed by the JRC expert group dealing with the identification of

representative CECs. For practical implementation the number of the substances should be limited to a maximum of 10-15. Table 40 shows a list of several proxy substances published in a DWA-working report of FA KA-8 on analytics and plant documentation for targeted micropollutant removal methods (DWA-KA-8, 2020), including a set suggested in the EU expert groups by TU Wien.

Table 40: Comparison of proxy substance lists (DWA-KA-8, 2020, modified)

CEC	frequ.	CH)1	NRW)2	BW)3	Berlin)4	D)5	TUW
Benzotriazole)*	6	x	x	x	x	x	x
Carbamazepine	6	x	x	x	x	x	x
Diclofenac	6	x	x	x	x	x	x
Metoprolol	5	x	x	x	x	x	
Clarithromycin	4	x	x		x	x	
Hydrochlorothiazid	4	x		x	x	x	
Irbesartan	3	x		x		x	
Sulfamethoxazole	3		x			x	x
Σ 4+5-Methyl-benzotriazole)*	3	x		x		x	
Candesartan	2	x			x		
Acesulfame K)*	1						x
Amisulprid	1	x					
Bisphenol A)*	1						x
Chlorothiazid (TP)	1				x		
Citalopram	1	x					
Estrogenicity)+	1						x
Formylamino-antipyrin (TP)	1				x		
Gabapentin	1				x		
Ibuprofen	1						x
Olmesartan	1				x		
Oxipurinol (TP)	1				x		
Tramadol	1				x		
Tramadol-N-oxid	1				x		
Valsartan	1				x		
Valsartanic acid (TP)	1				x		
Venlafaxine	1	x					

* no pharmaceutical; + in vitro bioassay; 1) UVEK: Schweizer Verordnung zur Überprüfung des Reinigungseffekts von Maßnahmen zur Elimination von organischen Spurenstoffen bei Abwasserreinigungsanlagen (Min. 6, Max. 12 Subs.); 2) Anleitung zur Planung und Dimensionierung von Anlagen zur Mikroschadstoffelimination; 3) Arbeitspapier Spurenstoffelimination auf kommunalen Kläranlagen in Baden-Württemberg; 4) Entwurf Arbeitsgruppe Spurenstoffe, Berlin; 5) Referentenentwurf zur Aktualisierung des Deutschen Abwasserabgabegesetzes (2019); 6) Recommendation to JRC expert group on the identification of representative indicator substances by expert group member Norbert Kreuzinger

Table 41: Behavior of the indicator substances suggested to the JRC expert group by TU Wien during conventional and advanced WWT

Process indicator substance	Abatement: > 80 % (+), 50-80 % (o), < 50 % (-)			
	low SRT	high SRT	Ozonation	Activated carbon
Acesulfame	-	o	o	-
Benzotriazole	o	o	o	+
Bisphenol A	-	+	+	+
Carbamazepine	-	-	+	+
Diclofenac	-	o	+	+
Estrogenicity	-	o	+	+
Ibuprofen	+	+	-	o
Sulfamethoxazole	o	o	+	o

- Selection criteria for process indicators are suggested by Jekel et al. (2015):
  - substances are representative for a group of compounds with similar characteristics as to physicochemical properties or reactivity
  - high detection frequency and occurrence in concentrations significantly above the limit of quantification of commonly applied analytical methods
  - detectable at low concentrations by widely available methods with comparably low effort
  - behavior (fate) of the substances in both the urban water cycle and the applied treatment processes should be well understood and the removal in the treatment processes should be known
- In case of an upgrade to advanced treatment, the design water flow has to be defined (full-stream versus partial-stream treatment, percentile of hydraulic design criteria of UWWTPs, compare Stapf et al., 2020). For the UWWTPs upgraded so far, there was no joint approach. The German federal states BW and NRW have the following design guidance for separate and combined sewer systems:
  - separate sewer system (100 %): full-stream treatment, i.e. 100 % of annual wastewater flow
  - combined sewer system without immission-based requirements: partial-stream treatment with design flow for CEC abatement ≥ $Q_{T,max}$ (peak hour dry weather flow as mean over last three years) and at least 70 % of the annual wastewater flow.

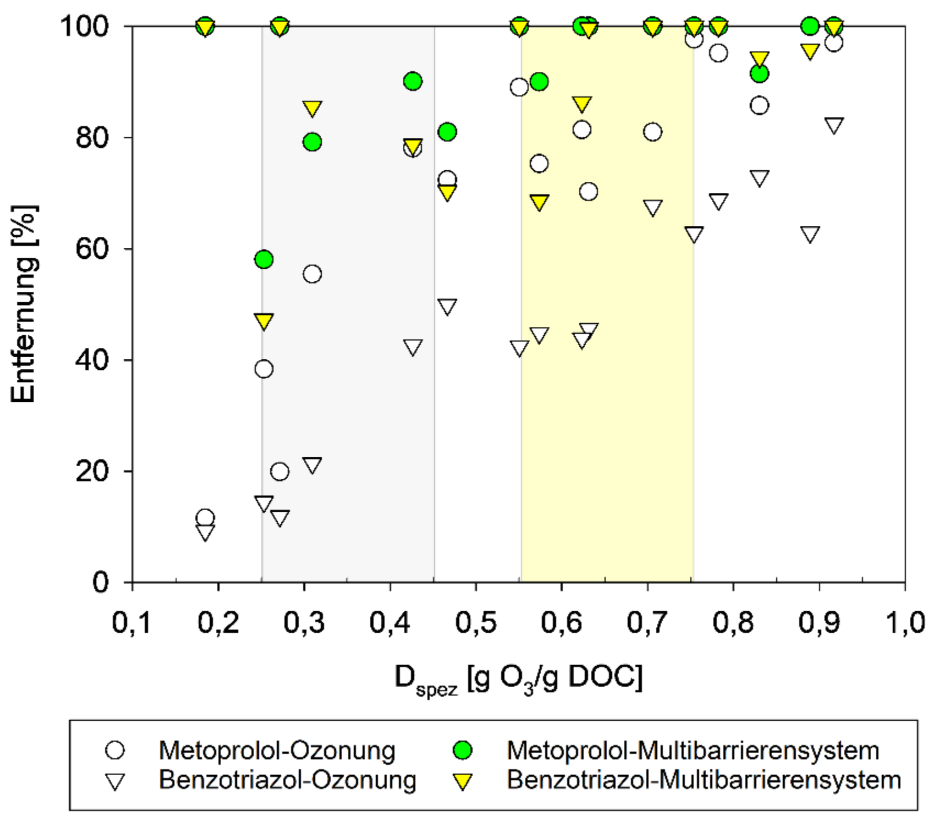
Advantages	• No major obstacles for implementation and surveillance expected once the boundary conditions for the thresholds are defined (max. concentration or minimum abatement) • Implementation delivers a basis for policy option b) and can be considered a pre-condition • Provides a level playing field
Disadvantages	• Policy option a) alone will not tackle the challenge of pollutants of emerging concern in the aquatic environment • No consideration of hot spots as vulnerable areas (see opt. b2-3)
Costs	• As an example, costs for proxy substance analysis were estimated based on an offer from Umweltbundesamt (price list 2021) for the seven chemical compounds recommended to the JRC-expert group by TU Wien (Table 40) and the costs for the estrogenicity in vitro bioassay ERα Calux® from BioDetectionSystems (price 2019) summing up to a total of approx. 1,000 € per sample. In case of upgrading, see policy option b)

6.3.2 Obligation to upgrade treatment plants to deal with CECs if 1) the UWWTP is > 100,000 PE; 2) discharges into vulnerable areas (drinking water supply zones, bathing water areas), 3) WWTPs that discharge into rivers with low dilution

Possible implementation in AT	• Under this policy option, there are two conceivable approaches to decide which UWWTPs to upgrade: – size-based (independent of immission situation): high impact with regard to load-reduction for upgrade of large UWWTPs – immission-based (independent of UWWTP size) • The policy option resembles the basic idea of the new Swiss Water Protection Act (FOEN, 2015) which was implemented in 2016. This Act foresees a reduction of selected CECs by 80% in – plants with > 80,000 connected inhabitants; – plants with > 24,000 connected inhabitants in the catchment area of lakes; – plants with > 8,000 connected inhabitants that discharge untreated wastewater containing more than 10% conventionally treated wastewater into a watercourse; – other plants with ≥ 8,000 connected inhabitants, if treatment is required due to special hydrogeological conditions. • A possible way of financing the upgrade of UWWTPs is the Swiss funding approach, i.e. to involve every inhabitant connected to an UWWTP in financing the upgrade. • Based on the outcomes of the related Austrian research projects KomOzAk I and II, the complementary application of ozonation and a subsequent

biologically activated granular activated carbon (BAC) represents a multibarrier-approach, that proved to tackle CECs better than one single technology. For substances with moderate removal during ozonation (depending on the specific ozone dose), such as benzotriazole or metoprolol, a substantial further removal could be achieved by a combination of ozonation and granular activated carbon (seeFigure 10).

Figure 10: Metoprolol and benzotriazole abatement in ozonation and in a multibarrier-system combining ozonation and granular activated carbon (Krampe et al., 2020)



- Based on the EMREG-OW database (2018) the number of large UWWTPs to be upgraded according to option b1 is listed in Table 42. The threshold of 100,000 PE was applied in three different ways, namely for organic design capacity (PE), actual load (PE) and connected inhabitants (E).

Table 42: Number (n) of UWWTPs to be upgraded according to option b1

WWTP > 100,000	unit	n	Σ EW design [mio PE]	Σ EW_{load} [mio PE]	Σ E [mio E]	Water treated [mio m^3/a]
Organic design capacity	PE	34	11.6	8.7	4.9	566.0
Actual load	PE	19	9.7	7.6	4.2	476.4
Connected inhabitants	E.	7	7.0	5.7	3.6	354.3

- For option b2), defining CEC-sensitive areas and possible criteria for this definition are a prerequisite. Therefore, this policy option is not examined in detail in this factsheet. The analysis of areas at risk for failing EQS for priority substances is regularly done for surface water bodies in the context of the WFD (BMRT, 2021) and was additionally done for 754 sub-basins in a study by BMNT (2019b). For benzo(a)pyrene, a high or very high risk of non-compliance with the EQS was calculated for all sub-basins, whereas for cadmium and zinc this risk was calculated for only one sub-basin each. For fluoranthene the respective number is 80 (sub-basins), for copper 95, for PFOS 115 and for tributyltin compounds two.
- In the context of the risk analysis elaborated regularly under the WFD, surface water bodies with a wastewater share of > 10 % were determined for i) mean annual discharge (MQ) and ii) mean annual low discharge (MNQ = Q_{95}) (BMLRT, 2021). This assessment under the WFD was restricted to water bodies with a discharge from point sources (UWWTPs ≥ 2,000 PE and industrial discharges). Out of a total of 8,119 water bodies in Austria 544 water bodies receive discharges from UWWTPs. Flow data for MQ was available for all 544 water bodies, flow data for MNQ for 542 out of 544 water bodies.

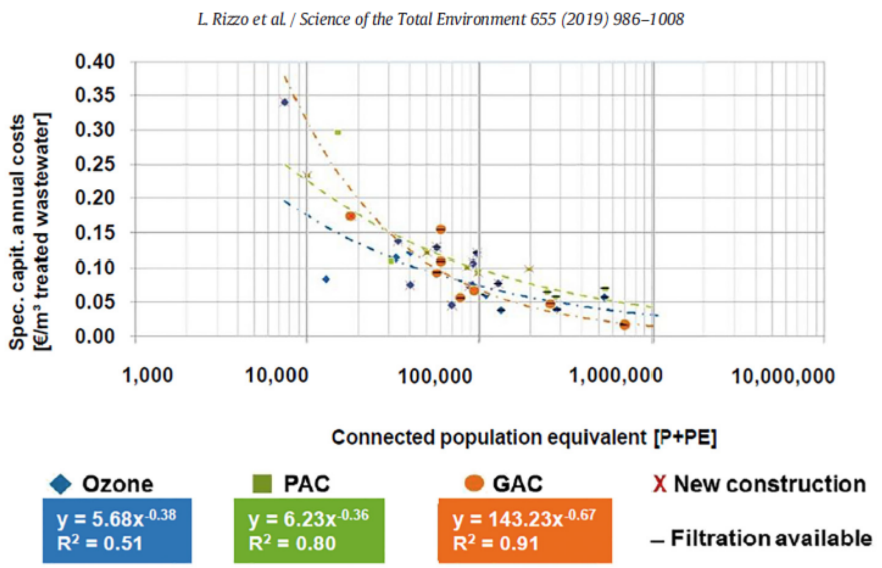
Table 43: Water bodies with > 10 % share of wastewater (MQ and MNQ-scenario)

Scenario	Water bodies with > 10 % WW	Σ m^3 wastewater	Σ km^2 catchment area
MQ	74 out of 544	2.4×10^9	36,879
MNQ	205 out of 542	3.0×10^9	711,147

- In Switzerland the upgrade of WWTPs is restricted to > 8,000 connected inhabitants unless there are very specific requirements for drinking water supply or ecological sensitive areas if the wastewater share in the receiving

	water body exceeds 5 %. In Baden-Württemberg (Germany) the threshold for dilution (50 % wastewater share in case of MNQ) is restricted to WWTPs > 10,000 PE. • For monitoring and surveillance, a combination with policy option a) is required.
Advantages	• Obligation for large UWWTPs – targets "high-load" emissions – takes the additive impact of a collective (in the sense of shared) receiving water body for several large UWWTPs' discharges (reducing the impact on downstream water use) • Taking vulnerable areas into account – targets human health (drinking and bathing water areas) and – targets ecological health (rivers with low dilution)).
Disadvantages	• Immission-based options (b2-3) require great efforts and expertise for case-by-case assessment as a basis for legal issuing/permissions if "simple" and well-defined criteria are not provided • Regarding pollution in the context of international river basins, immission-based options (b2-3) are of limited effectiveness if water bodies with small WWTPs are affected • Emission-based options (b1) might be difficult to explain to taxpayers, if the implementation occurs on large water bodies and their positive effects are not obvious at local, but only at international scale • Financial burden for small municipalities with low-dilution rivers or in vulnerable areas
Costs	• Impact-based approaches follow the polluter-pays principle

Figure 11: Specific annual costs (capital costs and operating costs) for different treatments and WWTP sizes



- The definition of the treatment goals, i.e. the required CEC removal efficiency is a prerequisite for cost calculations. Without it the costs can only be estimated based on experiences from full-scale plants and the operational conditions. Figure 11 shows a cost curve for annual costs per m³ treated wastewater (comprising capital and operating costs), which was generated based on full-scale and pilot-scale experiments in Switzerland and Germany (Rizzo et al., 2019) for various treatment technologies.
- In addition to the treatment goals, the effluent matrix (dissolved organic carbon and nitrite) and the amount of wastewater to be treated (full- vs. partial stream) play a decisive role for both capital costs (CAPEX, regarding treatment capacity) and operational costs (OPEX).
- CAPEX are to be calculated for civil works, machinery, automation & control and other costs incl. e.g. space requirements
- OPEX can be subdivided in variable costs and fixed costs.
- Variable costs comprise:
  - Material: oxygen (ozonation), activated carbon (1st approach: approx. 1,600 €/t granulated active carbon (GAC) and 1,800 €/t powder activated carbon (PAC))
  - Energy: pumping (site-specific), ozone production
- Fixed costs comprise:
  - Operation and maintenance (1st approach: civil works 0.5 %/a, machinery 2.0 %/a, electrical engineering 2.5 %/a)
  - Personnel (1st approach: approx. 55,000 €/person/a, depending on national salary levels), administration
  - Costs for monitoring (analytical costs), depending on monitoring program (substances and frequency)
- Depending on the size of the treatment plan, the dominant part of OPEX can be material costs, but site-specific energy demand for pumping can be in the same range as e.g. the energy demand for ozone generation.

Table 44: Estimated costs for large WWTPs to be upgraded with full-stream treatment

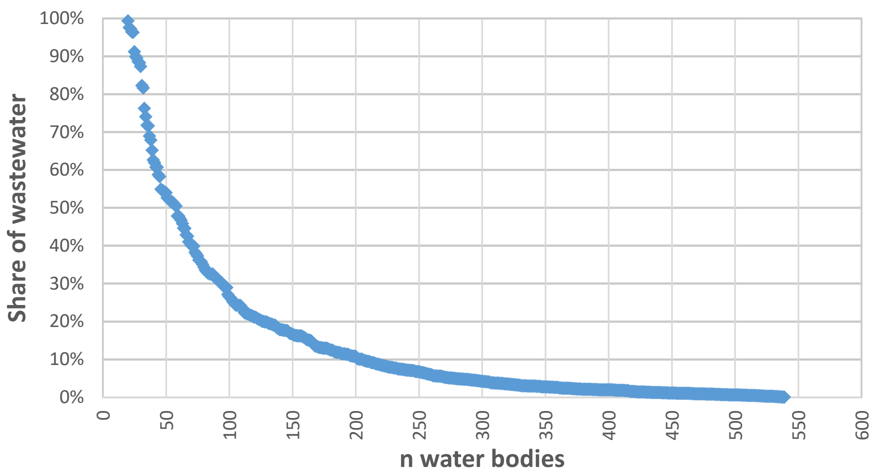
WWTP > 100,000	**n**	**Σ EW_{design} [mio PE]**	**Σ EW_{load} [mio PE]**	**Σ E [mio E]**	**Water treated [mio m³/a]**	**Annual costs [mio €]**
Organic design capacity	34	11.6	8.7	4.9	566.0	56.6
Actual load	19	9.7	7.6	4.2	476.4	47.6
Connected inhabitants	7	7.0	5.7	3.6	354.3	35.4

- Costs for upgrading large WWTPs were estimated with annual costs of 10 cent/m³ (Figure 2) and full-stream treatment, even though - in case of combined sewer systems - the design flow can vary between 70-90 % of the annual wastewater flow (depending on the peak hour dry weather flow), see Table 44.
- Costs for upgrading WWTPs discharging into water bodies with > 10 % share of wastewater were calculated for a worst-case-scenario by summing up the amount of discharged wastewater and applying higher annual costs of 20 cents per m³ (due to the lack of knowledge on the UWWTP sizes that discharge to the water bodies). This worst-case-scenario neither takes the UWWTP size nor further planning on the UWWTPs to be upgraded on a water body level into account. Moreover, as for option b1, full-stream treatment was assumed. Costs were calculated by multiplying the amount of wastewater discharged to these low dilution water bodies with an annual cost of 20 cent/m³. Higher costs than for option b1 were applied due to the lack of information on the size of the WWTPs.

Table 45: Annual costs for upgrading WWTPs at water bodies with > 10 % share of wastewater (MQ and MNQ-scenario, see Table 43))

Flow	Water bodies >10 % WW	Σ m³ wastewater (> 10 % WW)	Annual costs mio €
MQ	74	2.4×10^9	477.6
MNQ	205	3.0×10^9	603.9

Figure 12: Share of wastewater in water bodies (MNQ scenario). Data points above 100 % are cut off for reasons of scaling.



- For specific information on costs see Rizzo et al. (2019) and, project reports for KomOzon, KomOzAk I, KomOzAk II, Sehlen et al. (2020), Stapf et al. (2020).

6.3.3 Make use of a risk-based approach: require the establishment of a new sort of sensitive areas and take action based on which substances are found in the water

Possible implementation in AT	• Sensitive areas can be defined based on environmental / ecological criteria; on criteria for human water use; water availability; higher ranking interests or downstream interests; • Under this policy option, criteria for the definition of sensitive areas would be needed. A possible approach to establish such criteria could be that the EC defines the general framework for these criteria, whereas the MS define the details.
Advantages	• “tailor-made” solutions can be implemented for individual cases • A clear and unambiguous definition of sensitive areas (see policy option b2) could help to have obvious criteria as framing conditions and as a basis for decision-making.
Disadvantages	• Great effort and background information needed (for both definition of areas and regular review); • As scientific knowledge on risk assessment is continuously increasing, approaches / targets could change and get more stringent rapidly, compromising investments due to potentially even more stringent requirements.
Costs	• See policy action a & b

6.4 Further data collection/ data evaluation

- Calculation of the CH-approach for AT (cost-benefit analysis)
- Increase knowledge and database as regards effect-based methods for the assessment of wastewater and surface waters (in sensitive areas) and in the light of EBM as potential tools of assessing treatment efficiencies.

6.5 References

6.5.1 Legislation Austria

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7 Factsheet – Energy consumption and renewable energy production

Authors:

Clemens Steidl[1]
Katharina Lenz[1]
Florian Kretschmer[2]
Stefan Lindtner[3]

[1]Umweltbundesamt, Spittelauer Lände 5, 1090 Wien, Mail: office@umweltbundesamt.at

[2]Institut für Siedlungswasserbau, Industriewasserwirtschaft und Gewässerschutz (SIG), Universität für Bodenkultur Wien (BOKU), Muthgasse 18, 1190 Wien, Mail: sig-office@boku.ac.at

[3]Ingenieurbüro kaltesklareswasser, Obere Augartenstraße 18/8/20, 1020 Wien, Mail: office@k2w.at

7.1 Background

For decades, wastewater has been seen as (end-of-pipe) waste, and its collection and treatment as an energy consuming and thus expensive task (though recognized as important issue in terms of water pollution control). Estimates show that the EU WWTPs, which are subject to the UWWTD, use 0.8% of all electric energy consumed (European Commission, 2019). In AT the UWWTPs > 50 PE use 0.4% of the total energy consumed. The annual voluntary performance statement for UWWTPs that is organized by the Austrian Water and Waste Association (ÖWAV-Kläranlagen-Leistungsnachweis, “KAN survey”) of the year 2019 shows, that UWWTPs use 410 GWh/a, of which 150 GWh/a are self-produced (788 KAN-UWWTPs > 50 PE including South-Tyrol). The entire energy production in AT was 65,270 GWh/a ($235*10^{15}$ Joule) in 2016 (ÖWAV, 2020b, Statistik Austria 2017).

The current UWWTD does not include requirements on electric and thermal energy consumption, efficiency and/or production.

The most important EU energy policies, which are already referring to wastewater treatment, are:

- Directive 2012/27/EU (Energy Efficiency Directive, amended by Directive 2018/2002) establishes energy consumption targets for primary and final energy consumption. Directive 2018/2002 mentions that the potential for energy savings in the water sector needs to be explored by the use of smart technologies and processes. Commission Recommendation (EU) 2019/1658 of 25 September 2019 on transposing the energy savings obligations under the Energy Efficiency Directive mentions the wastewater sector.
- Regulation (EU) 2021/241 of the European Parliament and of the Council of 12 February 2021 establishing the Recovery and Resilience Facility
- The EU Strategy for Energy System Integration (European Commission, 2020), which forms part of the European Green Deal, mentions the use of wastewater for bioenergy production, including biogas.
- The EU Strategy on Heating and Cooling (European Commission, 2016) highlights the importance of this sector in the fight against climate change. Wastewater contains significant amounts of thermal energy (warm/hot wastewater from households, commercials, and industry) which have remained widely unused so far. However, this might change in the near future, as the recast of Directive (EU) 2018/2001 on the

promotion of the use of energy from renewable sources now acknowledges wastewater as renewable energy source.

- Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088 (Text with EEA relevance).

The policy options proposed by the EC are the following:

a) UWWTPs and their network need to carry out energy efficiency audits. Cover all or only large agglomerations
b) EU fixed energy use reduction targets
c) EU level energy labels/eco labels (mandatory or voluntary)
d) Energy generation from wastewater treatment (see Factsheet Circular economy – sludge reuse, option b)

This factsheet describes two main aspects (focusing on UWWTPs): (1) **efficient use** of electric and thermal energy and (2) electric and thermal energy **generation** primarily based on digester gas combustion and wastewater heat recovery. Beside the coverage of UWWTP-internal electricity and heat demand the option to use available excess energy (mainly heat) in WWTP-external infrastructure (settlements) is also briefly addressed.

7.2 Current situation in Austria

7.2.1 Current situation for electric energy

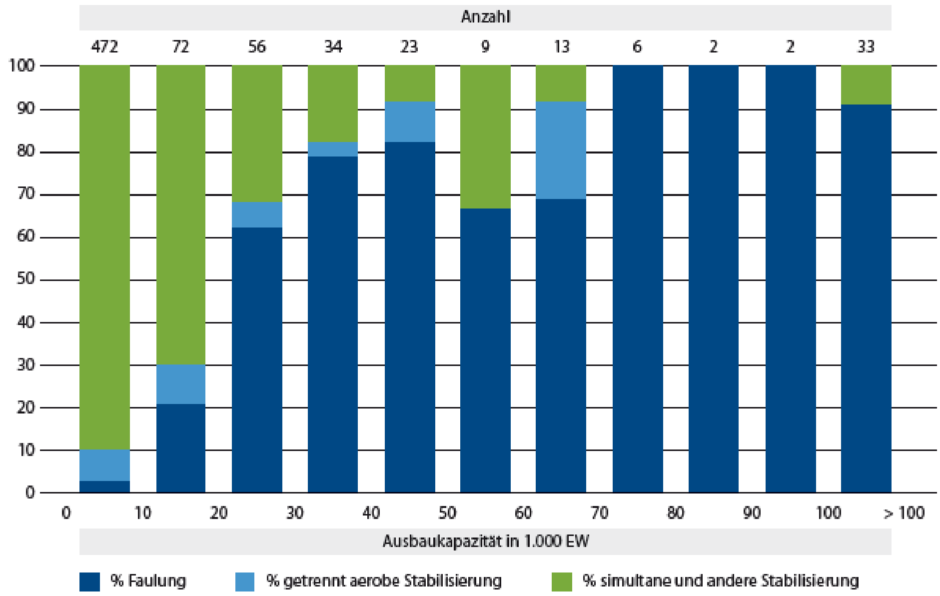
Legal basis	• In 2021 an Act on developing renewable energy sources (Erneuerbaren Ausbau Gesetz (EAG)) will come into force, which may have an impact on energy production at UWWTPs. • Neither the AAEV (General Waste Water Ordinance) nor the 1st AEVkA (First wastewater emission ordinance for UWWTPs > 50 PE) foresee standards for energy consumption/generation.
Current situation	• Energy costs in AT constitute 16% of an UWWTP's operation costs (consideration of mainly UWWTPs > 10,000 PE, ÖWAV, 2019). To minimize costs, Austrian wastewater utilities have a long history of optimizing energy consumption. • UWWTPs in AT have the option to participate in a voluntary efficiency audit/ benchmarking (https://www.abwasserbenchmarking.at/public/home). In the last 10 years this benchmarking was completed by 103 UWWTPs (6 out of 33

UWWTPs with a size 50,000 PE - 100,000 PE and 21 out of 42 UWWTPs > 100,000 PE (ÖWAV, 2018)). The participation fee depends on the size of the UWWTP, the fee is sponsored by the Federal Ministry for Agriculture, Regions and Tourism by 50 %, in some provinces, there is an additional funding.

Efficient use of energy

- Energy consumption depends on the size of the UWWTP, on the treatment goal (in AT typically tertiary treatment), and on the sludge stabilization. In AT there are 888 UWWTPs > 500 PE (reference year 2018, ÖWAV, 2019 and BMLRT, 2020). For 722 of these UWWTPs information about the type of sludge stabilization was available (see Figure 13). In the size class < 20,000 PE only 20 % of the UWWTPs have anaerobic sludge stabilization. In the size class 20,000 PE - 30,000 PE it is > 60 % and in the size class > 40,000 PE more than 80 %. In the size class > 50,000 PE information on sludge stabilization was available for a total of 65 UWWTPs (out of 75 UWWTPs in total), 56 of which were reported with anaerobic sludge stabilization and only 9 with aerobic stabilization.

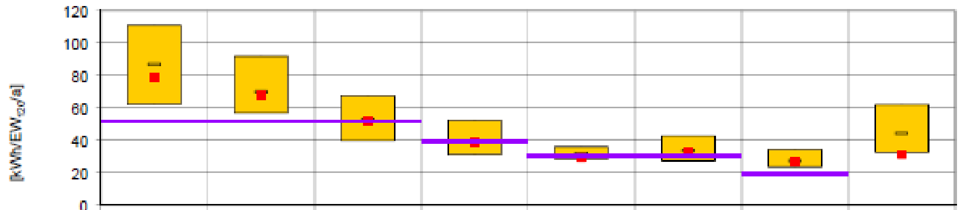
Figure 13: Percentage of UWWTPs with aerobic and anaerobic sludge stabilization (ÖWAV, 2019)



- For UWWTPs < 20,000 PE the construction and operation of anaerobic sludge stabilization is not economical. Several challenges occur because of the emerging amount of digester gas, the complexity of the plant management and safety regulations, higher greenhouse gas emissions (efficiency, leakages, etc.).
- Figure 14 shows the energy consumption per size category (excluding the Viennese UWWTP with 4 mio PE) in AT. UWWTPs > 50,000 PE with anaerobic sludge stabilization show an average energy consumption of 27 kWh/PE/a, UWWTPs > 50,000 PE with aerobic sludge stabilization 32 kWh/PE/a. The energy

demand required by aerobic sludge stabilization is at least 10 kWh/PE/a higher than that of anaerobic stabilization. The potential energy savings for different size classes and different types of sludge stabilization were evaluated in ÖWAV (2020c) and are presented in Figure 14.
Modelling results combined with best practice examples show that 20 kWh/PE/a is considered as minimum energy requirement for the operation of an UWWTP and a further reduction is considered impossible.

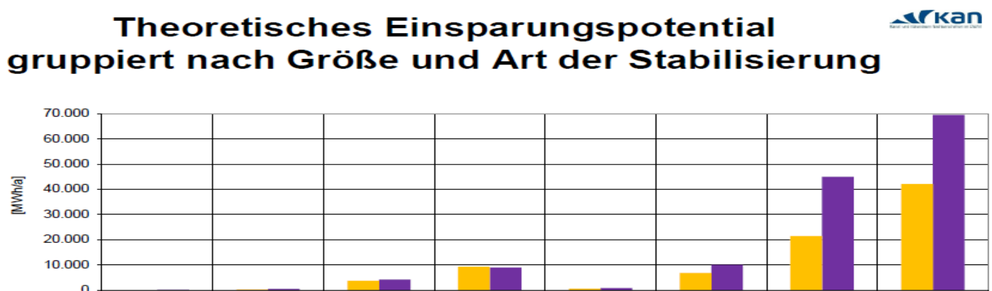
Figure 14: Specific energy consumption [kWh/PE/a] per size class and type of sludge stabilization and potential for energy savings (ÖWAV-KAN survey 2019 in ÖWAV, 2020c))



	andere Stabil. ≤500	andere Stabil. > 500 EW	andere Stabil. >1.000 EW	andere Stabil. >5.000 EW	andere Stabil. >50.000 EW	Faulung ≤50.000 EW	Faulung >50.000 EW	ALLE ARAs
75%-Wert	111	92	67	52	36	43	34	62
Median	87	70	53	40	32	33	27	44
gew. Mittel	79	68	51	39	29	32	27	31
25%-Wert	62	57	40	31	28	27	23	32
Zielwert	50	50	50	40	30	30	20	

- There is a distinct gap between aerobic and anaerobic sludge stabilization (higher energy consumption with aerobic digestion and no energy production). For UWWTPs > 50,000 PE with aerobic sludge treatment there is only little savings potential, as they already have a very low energy consumption. UWWTPs > 50,000 PE with anaerobic sludge treatment have a small energy savings potential each (already very efficient operation), but as these UWWTPs represent 70% of the organic design capacity of all UWWTPs in AT, the absolute energy savings potential is high (see Figure 15).

Figure 15: Potential energy savings grouped according to size classes and type of sludge stabilization (Lindtner 2019 in ÖWAV, 2020c))



	aerobe Stabilisierung ≤500 EW	aerobe Stabilisierung >500 EW	aerobe Stabilisierung >1000 EW	aerobe Stabilisierung >5.000 EW	aerobe Stabilisierung >50.000 EW	Faulungs-anlagen ≤50.000 EW	Faulungs-anlagen >50.000 EW	ALLE ARAs
auf Zielwert	150	525	4.240	8.985	845	9.911	44.909	69.565
auf Median	46	256	3.680	9.268	544	6.830	21.431	42.053

Kommunale ARAs ohne Wien und ohne Ausreißer

- At present, many UWWTPs are implementing further possibilities for energy generation (mainly photovoltaics). Data about the energy generation from this measure is not yet available, but will be collected next year, though these possibilities for energy generation must be seen separately from wastewater treatment.

- Concerning sewer systems, recent investigations on energy consumption and energy efficiency have primarily concerned the operational optimization of pumping stations. Energy generation in sewer systems has not been an issue so far.
- In the discussion about advanced wastewater treatment (e.g. ozonation) the additionally required electric energy for this treatment step is relevant. Schaar (2015) summarized additional energy requirements from different projects and showed that the additional need for electric energy for ozonation mainly depends on the content of DOC (dissolved organic carbon) in wastewater and the structural, site-specific conditions at the UWWTP (pumping of wastewater required or not). Excluding the energy requirements for pumping the additional energy required for ozonation by an UWWTP with 30,000 PE is in the range of 6.3 – 7.2 kWh/EW/a.

Digester gas-based energy generation in combined heat and power (CHP) units to cover own demands

- For the KAN survey 2019 (ÖWAV, 2020c)) 161 UWWTPs reported their excess of digester gas (average 25 L/PE/day). Depending on the degree of efficiency of the CHP-unit, the electric energy (GWh/a) was calculated, extrapolated to all UWWTPs, which were participating, and opposed to the total energy consumption. According to this calculation around 36 % of the total energy consumption was covered by self supply of energy from digester gas.
- Table 46 shows, that a main potential for the production of electric energy can be attributed to the degree of efficiency of the CHP-unit. An efficiency degree of the CHP-unit of 30 % results in around 50 % of the total energy consumption covered by self supply of energy from digester gas. This increase of self-supply (from currently around 36 % to around 50 %) could be reached without the need to reduce energy consumption at UWWTPs.

Table 46: Production and use of digester gas (Lindtner 2019 in ÖWAV, 2020c))

UWWTPs reporting data for digester gas production (2019)	161
Digester gas reported [m³/a]	82,239,627
Electric energy content of reported digester gas [GWh/a]	775
Electric energy for degree of efficiency of the CHP-unit 25% [GWh/a]	194
Electric energy for degree of efficiency of the CHP-unit 30% [GWh/a]	233
Electric energy for degree of efficiency of the CHP-unit 35% [GWh/a]	271

	• Lindtner (2008) provides standard ranges of electric and thermal energy consumption and (digester gas-based) generation potentials for Austrian WWTPs (also subclassifying different treatment steps/technologies).
Costs (estimates)	• Costs for execution of benchmarking: – UWWTPs ≤ 5,000 PE – 10,000 PE: 2,800 € - 10,300 € (initial survey), 1,100 € – 4,100 € (subsequent years); – UWWTPs 10,001 PE – 100,000 PE: 4,100 € - 11,800 € (initial survey), 1,500 € – 7,000 € (subsequent years); – UWWTPs 100,001 PE – 500,000 PE: 6,700 € - 19,600 € (initial survey), 2,500 € – 10,200 € (subsequent years) • Costs for electric energy at UWWTPs: 1 kWh = 0,10 € (source: personal communication Lindtner)

7.2.2 Current situation for thermic energy

Legal basis	• The Energy Efficiency Act (Bundes-Energieeffizienzgesetz, BGBl. I Nr. 72/2014 i.d.g.F.) implements Directive 2012/27/EU into national law and mentions recovery of wastewater heat. • In 2021 a technical guidance on the use of thermic energy from wastewater will be published (ÖWAV-Arbeitsbehelf 65 „Energetische Nutzung des thermischen Potenzials von Abwasser“). This document includes a decision guidance, whether heat recovery is useful in a specific sewer network from the perspective of water management.
Current situation	• Today, heat generation at WWTPs is still widely reduced to digester gas application in combined heat and power (CHP) units. • Wastewater heat recovery is being investigated at several WWTPs (e.g. Vienna), one installation is already under operation (for years) at the Weiz WWTP. • Bigger cities like Vienna and Graz are working on “wastewater heat maps” for their sewer network, e.g. Abwasserwärme Wien Energie (https://www.wien.gv.at/umwelt/kanal/abwasser-energiegewinnung.html), Graz Wärmemodell (http://docplayer.org/25041851-Grazer-energie-agentur-abwasserwaermenutzung-leitfaden-zur-projektentwicklung.html), to display in-sewer wastewater heat recovery options. One obvious issue for the development of wastewater heat maps is that too extensive wastewater heat recovery in the sewer network could lower the wastewater temperature to an extent where it jeopardizes the efficiency of treatment in the WWTP. Today, at least three related installations are under operation in Austria (Amstetten, Innsbruck, Vienna (one in operation, several under construction). • In a study from Neugebauer et al. (2015) the heat recovery potential in the effluent of 630 WWTPs > 2,000 PE was estimated to be almost 3,200 GWh/a, about another 230 GWh/a can be provided by digester gas-based CHP generation. 420 of the investigated UWWTPs are located in close vicinity or even within existing settlements (categories: 0 - 150 m equals within the settlement, 150 – 1,000 m describes UWWTPs near to the settlement and

	farther than 1,000 m) and thus very promising for heat supply (simplified method: specific heat capacity of water is 4.2 kJ/kg*K or 1.16 kWh/m³*K, in other words, 1.16 kWh when cooling down 1 m³ wastewater by 1 K). • Case study Kapfenberg: This study is not only about wastewater heat recovery but also about adapting the common practice of WWTP-internal heat supply. Excess (high-temperature) heat from digester gas-based CHP generation is fed into the municipal (high-temperature) district heating network. In 2021 and 2022 modifications in the WWTP's internal heat supply system will be applied for future covering of its own (low-temperature) heat demand primarily by (low-temperature) wastewater heat recovery from the effluent. This makes additional CHP heat available for use in the municipal district heating network.[6] The UWWTP is no longer seen as a separate utility, but is now operated with an integrated energy concept (warm water supply for 139 residential units covered by 100% in summer and up to 50% in winter, warm water supply for the UWWTP itself). • Wastewater heat recovery applications can also be used to provide cooling. This option is expected to be very viable in the near future.
Costs	• Costs could not be evaluated

[6] Project report under preparation

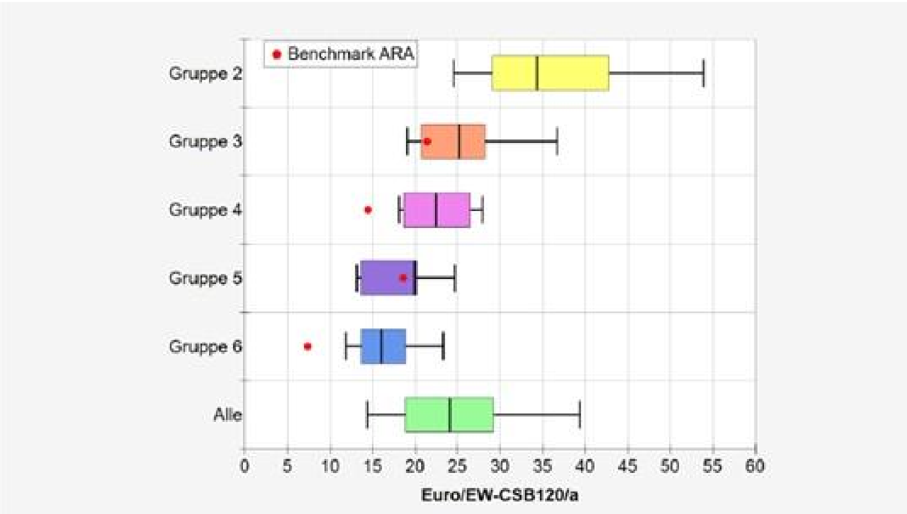
7.3 Policy options – future possibilities for implementation in Austria

7.3.1 UWWTPs and their network need to carry out energy efficiency audits. Cover all or only large agglomerations

Possible implementation in AT

- Electric energy efficiency audits/ benchmarking is already done on voluntary basis (special focus on energy possible).
- Evaluations of operating costs, expenses and energy consumption are shown in the yearly reports by the Austrian Water and Waste Management Association (ÖWAV). The used benchmarking method is based on the comparison of UWWTPs within a group; the benchmarks are set by one existing benchmark plant per group. Figure 16 shows an example of an evaluation of the operating costs (ÖWAV, 2018).

Figure 16: Evaluation of the operating costs (ÖWAV, 2018)



Euro/EW-CSB120/a		25-%-Perzentil	Median	75-%-Perzentil	Anzahl
Gruppe 2	≥ 5.000 bis ≤ 20.000 EW Ausbau	29,12	34,34	42,83	26
Gruppe 3	≥ 20.000 bis ≤ 35.000 EW Ausbau	20,79	25,17	28,23	31
Gruppe 4	≥ 35.000 bis ≤ 50.000 EW Ausbau	18,65	22,46	26,50	19
Gruppe 5	≥ 50.000 bis < 100.000 EW Ausbau	13,64	19,98	20,15	6
Gruppe 6	≥ 100.000 EW Ausbau	13,66	16,04	18,87	21
Alle Teilnehmer		**18,90**	**24,10**	**29,26**	**103**

- UWWTPs ≤ 50,000 PE contribute 40% of the energy consumption of all UWWTPs in AT. Although they show a high potential for saving electric energy (see Figure 14) they provide a minor absolute energy savings potential compared to UWWTPs > 50,000 PE (see Figure 15).
- If energy efficiency audits become mandatory for large agglomerations (e.g. for agglomerations/UWWTPs > 50,000 PE), 75 UWWTPs will be concerned (of which 27 already participated in the voluntary benchmark in the last 10 years)

Advantages or benefits	• Options for improving electrical and thermal energy efficiency at UWWTPs are highlighted • Decrease of energy consumption while at the same time maintaining the state of the art of wastewater treatment (energy reduction targets must not affect the cleaning performance) • Information on available excess energy (electric and thermal) to be used for local/municipal energy supply planning.
Disadvantages or barriers	• Additional costs for benchmarking • Missing willingness to participate in the benchmarking from those UWWTPs, which have not participated yet
Costs	• UWWTPs > 50,000 PE: 48 UWWTPs have not yet participated in the voluntary benchmarking. For these UWWTPs the costs for an initial benchmarking would be between 4,140 € - 11,820 € (UWWTPs > 50,000 PE - 100,000 PE, 27 UWWTPs concerned) and between 6,720 € - 19,600 € (UWWTPs > 100,000 PE, 21 UWWTPs concerned)

7.3.2 EU fixed energy use reduction targets

Possible implementation in AT	• The data from AT show that the energy reduction potential (in % and absolute figures) differs considerably depending on the size of UWWTP and type of sludge stabilization. EU fixed energy use reduction targets (e.g. % - reduction) at UWWTP-level might therefore be problematic for AT, while a reduction target at national level would be easier to implement. • In AT 50 kWh/PE/a – 20 kWh/PE/a are regarded as minimum electric energy requirement (depending on the size and type of sludge stabilization). • In AT, UWWTPs with highest treatment efficiencies are also those with lowest energy consumption. A slight reduction of wastewater treatment efficiency for saving energy consumption by UWWTPs would reduce the treatment efficiency and result in the abandoning of nitrogen-removal by means of denitrification.
Advantages or benefits	• In case of reduction targets at national level: Reduction of total electric energy consumption by UWWTPs
Disadvantages	• Fixed reduction targets (e.g. %-rates) could affect the treatment efficiency of highly functional UWWTPs, while at the same time not influencing the energy consumption in the intended way • Fixed reduction targets will not be viable for UWWTPs, which have already a good performance. A further reduction might be possible at the expense of wastewater treatment and is therefore not feasible. For such UWWTPs benchmarks (e.g. xy kWh/PE/a) might be a better approach. • Fixed reduction targets from the EC might foresee the recommendation to install anaerobic stabilization in larger UWWTPs. There are currently nine UWWTPs > 50,000 PE with aerobic sludge stabilization in AT, which already

	have very low energy consumption. A reconstruction of these UWWTPs into UWWTPs with anaerobic sludge stabilization would have to be decided on a case-by-case basis and under consideration of costs and benefits (reconstructions are costly and benefits as regards energy savings might be low).
Costs	• There are many possibilities, how this policy option could be defined. Therefore costs could not be estimated

7.3.3 EU level energy labels/eco labels (mandatory or voluntary)

EU level energy labels are obtained from energy efficiency audits. They can only be achieved by those UWWTPs, which have optimized their energy consumption while at the same time maintaining the state of the art of wastewater treatment without reduction of wastewater treatment standards.

Therefore, the description of policy option 3.1 also applies for this policy option. Energy labels can address both, electrical and thermal energy.

7.3.4 Energy generation from wastewater treatment (see factsheet Circular economy – sludge reuse, option b)

Possible implementation in AT	• In AT there are already many voluntary measures at UWWTPs (sporadically also in sewer systems) to generate energy at the UWWTP (use of digester gas, wastewater heat recovery) to reduce the dependency on external energy supply (energy consumption is an important driver of the costs of wastewater treatment. • Incentive system to voluntarily increase energy generation at the treatment plant (no fixed targets) (e.g. state subsidies, fixed feed-in tariffs for electrical energy or gas). • Invest in highly efficient CHP-units at big UWWTPs • EU Powerstep-Project: the projects aims to plan and operate UWWTPs to produce a maximum of energetic energy to feed the local power supply (www.powerstep.eu) • Projects on micro-sieving: The project describes the application of micro-sieving as an alternative to primary sedimentation (for small UWWTPs). The separated solids and organic material shall be used in anaerobic digesters.
Advantages	• Step towards electrical and thermal energy autarky of a UWWTP • UWWTP excess energy (mainly heat) can be used to supply adjacent settlement structures (thermal energy supply for households, greenhouses, etc.), which will generate an additional income for the wastewater utility.

	Use of local, renewable and climate friendly energy sources will furthermore increase local independence from energy imports • Improve the public image and perception of wastewater (from waste to resource)
Disadvantages	• In-sewer heat recovery must not adversely affect temperature-sensitive wastewater treatment processes • Energy generation beyond the internal needs may imply additional efforts for the wastewater utility
Costs	• Costs could not be evaluated

7.4 Further data collection/ data evaluation

- There is currently no data collection as regards energy consumption and/ or production from UWWTPs at national level (therefore, also no data on which technologies for energy recovery are already implemented). At the level of the provinces the situation differs, with some provinces having data collections and others not. On a voluntary basis data on energy consumption and/ or production is collected by the KAN survey or via benchmarking (the data collected by the KAN survey is not open to the public, and therefore could not be fully used in this factsheet).

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8 Factsheet – Methane emissions

Authors:

Joseph Tauber[1]
Vanessa Parravicini[1]
Karl Svardal[1]

[1]Institut für Wassergüte und Ressourcenmanagement (IWR), Technische Universität Wien, Karlsplatz 12/226, 1040 Wien, Mail: sekretariat@iwag.tuwien.ac.at

8.1 Background

Sewer systems and wastewater treatment can be sources of carbon dioxide, nitrous oxide and methane (Doorn et al. 1997; Daelman et al. 2012). Direct carbon dioxide emissions are climate-neutral because the organic matter in wastewater is mostly of biological origin, but direct emissions of methane and nitrous oxide have a significant impact on climate.

The UWWTD does not foresee any requirements for methane emissions from UWWTPs. In AT, methane emissions from wastewater treatment are estimated annually in the frame of the National Greenhouse Gas Inventories.

The policy option proposed by the EC is the following:

a) Establish a baseline of methane emissions for large facilities and reduction targets

8.2 Current situation in Austria

Legal basis	• As a Party to the United Nations Framework Convention on Climate Change (UNFCCC), Austria is required to produce and regularly update National Greenhouse Gas Inventories (National Inventory Reports, NIR). • Regulation (EU) No 525/20131 relating to a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol.
Current situation	• In Austria, wastewater treatment processes contribute 0.2% (189,978 t/a CO_2-eq) of the total greenhouse gas (GHG) emissions, in total 82,261,000 t/a CO_2-eq (without land use, land use change and forestry (LULUCF)) (Umweltbundesamt, 2019). According to the current estimations based on the IPCC Guidelines (IPCC, 2006), nitrous oxide (N_2O) contributed 166,232 t/a CO_2-eq (88%), while methane (CH_4) contributed 23,746 t/a CO_2-eq (12%) of the GHG emissions from wastewater treatment (reference year 2017). • The Austrian NIR currently considers direct CH_4-emissions from septic tanks, but no emissions deriving from UWWTPs via the activated sludge process or sewage sludge treatment using anaerobic digestion or aerobic stabilization. A Tier 2 method according to the IPCC guidelines (IPCC, 2006) is applied to calculate CH_4- loads referred to population equivalents (PE) connected to septic tanks. Tier 2 is a *"good practice"* calculation method using partly default values of the IPCC guidelines, partly country-specific emission factors, whereas Tier 3 uses a country-specific method based on emission values measured on-site and bottom-up data. The latter method is more accurate, but requires more effort

	to provide good data and advanced methodologies. Since 1991 the connection rate to septic systems decreased from 17.8% to 3.0% in 2016 (Umweltbundesamt, 2019). This caused a reduction in the reported methane emissions from wastewater treatment in Austria from 4,850 t/a CH_4 in 1990 to 897 t/a CH_4 in 2018. In the same period the connection rate to sewer systems and UWWTPs increased to 95.2% (2016). Also, the number of UWWTPs including anaerobic digestion (AD) has increased in Austria. • Besides the estimation of CH_4-emissions in the NIR, no regular assessment of these emissions from UWWTPs and sewer networks exists in AT. For the first time therefore, an estimation was made for this factsheet (detailed methodology see Annex). • In 2019 approx. 1,900 UWWTPs with a design capacity of 21.5 mio PE and industrial WWTPs with a capacity of 10.2 mio PE were operated in Austria (ÖWAV, 2019). Austria's municipal anaerobic sludge digestors have an estimated design capacity of 10.5 mio PE. This includes Vienna's main UWWTP, featuring a design capacity of 4 mio PE, which started the operation of the newly built anaerobic digesters in 2020. • For Austria total methane emissions (E) from sewers and municipal wastewater treatment can be estimated (detailed methodology see Annex): $E = E_{sewer} + E_{WWTPs} = 4{,}440 + 4{,}280 = 8{,}720$ t/a CH_4 Considering, that the global warming potential of 1 kg CH_4 is equal to 25 kg CO_2 for a timeframe of 100 years (IPCC, 2007), the methane emissions can be estimated as CO_2 equivalent as follows: 8,720 t/a CH_4* 25 kg CO_2-eq/kg CH_4 = 218,000 t/a CO_2-eq This emitted load is estimated without considering methane emissions from aerobic and anaerobic industrial wastewater treatment and anaerobic sludge digestion. The estimated emissions of 218,000 t CO2-eq/a is of the same order of magnitude as the CO2-eq emissions calculated in the current NIR for nitrous oxide emissions from centralized wastewater treatment plants (166,232 t CO2-eq/a) (Umweltbundesamt, 2019).
Costs (estimates)	• Estimation of costs was not made.

8.3 Policy options – future possibilities for implementation in Austria

8.3.1 Establish a baseline of methane emissions for large facilities and a benchmark for reduction targets

Possible implementation in AT	
	• The estimation of methane emissions for AT clearly indicates that these emissions from UWWTPs and sewer systems can be significant (0,5% of the total GHG emissions in AT). • CH_4-emissions from UWWTPs are assumed to vary strongly depending on size, age, condition, design, construction and a few operational aspects (i.e. hydraulic and/ or organic loading) of the plants. • A first baseline of methane emissions from large facilities could be estimated for the approximately 65 UWWTPs > 50,000 PE (BMLRT, 2020) in AT depending on the availability of required data (see estimation in the Annex). • More detailed measurements/ research at UWWTPs and in sewer systems is required for a sound baseline of methane emissions from large facilities. Emission measurements from different treatment systems, (aerobic versus anaerobic) as well as from different sewers applying the same measuring method, same system boundaries and same reference variables (e.g. rate of capacity utilization, design capacity (PE) and organic load), are required to establish a reliable baseline. • Based on UKWIR 2009 and STOWA 2010 it is estimated that methane emissions from AD could be reduced by approx. 2/3 at optimal conditions, if all Austrian sludge digestors were brought to the highest operational and technical standards to minimize CH_4 emissions. • Best practices to reduce methane emissions are: – Well stabilized sludge (aerobic and anaerobic) leads to a low residual gas potential, which leads to lower methane emissions in the following treatment steps – Reduce sludge retention time in thickeners and buffer tanks to a minimum – Incinerate stabilized sludge (aerobic and anaerobic treated sludge) as fast as possible to reduce emissions related to storage – this applies especially to larger WWTPs – Cover sludge thickeners and buffer tanks – Install suction devices to vacuum up gas from covered thickeners, buffer tanks and sludge shafts placed on the top of digesters – Treat the gas by using it as combustion air in combined heat and power plants (CHPs), or for aeration in the biological step of the WWTP, were the CH_4 can be biologically removed in the aeration tank – Renew existing CHPs to reduce methane slip, beginning with the biggest WWTPs

	• As regards the calculation of methane emissions in the NIR, methane emissions from UWWTPs and sewers would need to be added to those of septic systems, in order to obtain a more complete picture of GHG emissions in the wastewater sector. In a first step a Tier 2 method could be implemented. After on-site measurements, the methodology could change towards Tier 3. Applying this approach, 189,987 t/a CO_2-eq in the current NIR (N_2O and methane emissions from septic systems) plus additional 218,000 t/a CO_2-eq for methane emissions from sewers and UWWTPs would result in 408,000 t/a CO_2-eq or 0,5% of Austria's GHG emissions.
Advantages	• Generation of a comprehensive data pool about methane emissions from UWWTPs and sewer systems in AT, which is the prerequisite to define possible reduction goals and effective measures. • NIR: Data quality reported in the NIR would significantly improve, the estimations would show a more realistic picture
Disadvantages	• Costs for research and measurements in case of a Tier 3 method • Future reduction requirements of methane emissions must not lower the treatment efficiencies of UWWTPs
Costs	• Estimation of costs could not be made

8.4 Further data collection / data evaluation

Not identified.

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8.6 Annex: Calculation of CH_4-emissions from UWWTPs and sewer systems in AT

8.6.1 Scientific background: Methane emissions from UWWTPs

Methane emissions from wastewater treatment arise mainly from processes exhibiting full or partial anaerobic conditions, as primary sedimentation tanks, sludge thickeners, anaerobic digesters and sludge storage tanks. Long-term storage of aerobically stabilized sludge can also lead to methane emissions, depending on the operating conditions and storage duration (Wang et al. 2011; Parravicini et al. 2016). Anaerobic digestion of sewage sludge targets methane production and its energetic valorization, thus a part of it can be emitted at leaking points or leave the digester with the withdrawn sludge, dissolved or as bubbles (Tauber et al., 2019). Dissolved methane generated in sewers or in the mechanical pre-treatment steps can be emitted further downwards in aerated grit chambers and the activated sludge tanks. Given that methane can be partially oxidized by bacteria under aerobic conditions (Daelman et al., 2012), emissions from aerated tanks could be reduced by optimizing aeration conditions.

Methane emission data for WWTPs are currently available from eleven scientific publications. The reported methane emissions vary considerably between 11 g CH_4/PE/a (Wang et al. 2011) and 390 g CH_4/PE/a (Daelman et al., 2013; Daelman et al., 2014, cited in Schaum et al., 2016). Becker et al. (2012) report an average methane emission for WWTPs of 162 ± 87 g CH_4/PE/a. Most of the values for whole WWTPs reported in literature are between 165 g CH_4/PE/a (Gärtner and Hirschberger, 2011) and

372 g CH_4/PE/a (STOWA, 2010). Furthermore, STOWA (2010) compared CH_4-emissions from three WWTPs in the Netherlands with anaerobic digestion and three WWTPs with aerobic sludge stabilization. WWTPs with aerobic sludge treatment emitted on average 307 g CH_4/PE/a, whereas WWTPs including anaerobic digestion emitted 372 g CH_4/PE/a, this leads to emissions of 65 g CH_4/PE/a caused by AD.

Also, the age of the WWTP infrastructure impacts the magnitude of methane emissions. UKWIR (2009) reported 200 g CH_4/PE/a for existing (older) AD systems and 65 g CH_4/PE/a for newly built WWTPs including AD.

In summary, literature data accounts for 11 to 307 g CH_4/PE/a for WWTPs without AD and additional 65 to 281 g CH_4/PE/a for the digestion process. Table 47 gives an overview of methane emission values measured at WWTPs.

Table 47: Overview on methane emission values measured at WWTPs, adapted from Schaum et al. (2016)

CH_4 emissions [g CH_4/(PE·a)]	Technical description	Literature
31[a]	Municipal WWTP (without sewage sludge treatment, 210,000 PE, UK)	Aboobakar et al. (2011)
280	WWTP >10,000 PE and >100,000 PE in North Rhine Westphalia (Germany); emissions 90% from sludge treatment[b]	Becker et al. (2012)
39	WWTP Durham (UK), wastewater treatment, aerobic sewage sludge stabilization	Czepiel et al. (1993)
390[c]	WWTP Kralingseveer (The Netherlands); wastewater treatment (activated sludge process), sewage sludge treatment via digestion	Daelman et al. (2013); Daelman (2014)
300	Municipal WWTP (without sewage sludge treatment) (data from the Netherlands from 1991)	EEA (2013)
<4–18[a]	WWTPs (France, details not published) <0.1–0.4 g CH4/kg CODinfluent	Foley et al. (2015)
165	WWTP (320,000 PE) including digestiond; emissions >98% from digestion	Gärtner & Hirschberger (2011)
110[a]	Methane emissions (measurement) Swedish WWTP with digestion (0.25% CODinfluent)	Gustavsson & Tumlin (2013)
106	Digestion at municipal WWTP degassing of digested sludge: 30 g CH4/(PE·a) gas generation in stack container with 1 day retention time: 76 g CH4/(PE·a)	Leal Verduguo (2014)
0.09–0.18	WWTP Simmering (Austria), only activated sludge tank	Schmid & Puxbaum (2000)
307 resp. 372[e]	3 Dutch WWTPs without and, respectively, with digestion (by digestion 65 g CH4/(PE·a))	STOWA (2010)
A: 251[f] B: 71[f]	Methane losses during digestion operation volatile emissions, residual gas, methane slip A = stock; B = new construction	UKWIR (2009)
11	WWTP Jinan (China), wastewater treatment incl. sewage sludge thickening and drying bed (no digestion)	Wang et al. (2011)

[a] Assuming a chemical oxygen demand (COD) inflow load into the WWTP of 120 g COD/(PE·d).

[b] Denitrification 20 g CH4/(PE·a), sand trap, Bio-P, nitrification 8 g CH4/(PE·a), static sludge thickening 16 g CH4/(PE·a), digested sludge stacking 64 g CH4/(PE·a), sludge digestion 172 g CH4/(PE·a) – measurement of sludge digestion above the digester tanks (digester head), that means methane losses due to leakages (Becker et al. 2012).

[c] 11 g CH4/(kg CODinfluent), respectively, 1.1% relating to the COD inflow load into the WWP; approximately 72 ±23% of the overall methane emissions originate from the sludge treatment units; primary sludge thickener, digested sludge storage, dewatering, sludge storage, methane slip combined heat and power unit (CHP) (Daelman et al. 2012).

[d] Calculation of specific emissions of 145 kg CH4/d with 320,000 PE; distribution of methane emissions: <1% from biological wastewater treatment, <0.5% from sludge thickeners, >98% from digested sludge tanks (digested sludge thickener and stack container) (Gärtner & Hirschberger 2011).

[e] 7 g CH4/(kg CODinfluent) without digestion and 8.5 g CH4/(kg CODinluent) with digestion; conversion assuming a specific COD load of 120 g COD/(PE·d); individual data: WWTP Papendrecht 212 g CH4/(PE·a), WWTP Kortenoord 153 g CH4/(PE·a), WWTP Kralingseveer (with digestion) 438 (Oct. 2008) and, respectively, 230 (Feb. 2009) g CH4/(PE·a), cited in Daelman et al. (2013); Daelman (2014).

[f] A: 10.7 and B: 3.5% of the total gas amount; A: 14.6 and B: 4.8 kg CH4/(Mg TS) (UKWIR 2009); conversion assuming 38 g TS/(PE·d).

Becker et al. (2012) attempted to distinguish among the different CH_4 emission sources at WWTPs:

Sand trap, primary settling, biological P removal, nitrification	8 g CH4/PE/a	3%
Denitrification	20 g CH_4/PE/a	7%
Static sludge thickeners	16 g CH_4/PE/a	6%
Static sludge thickeners	64 g CH_4/PE/a	23%
Anaerobic digestion (leakages, dissolved CH4, CHP slip)	172 g CH4/PE/a	61%
Sum	**280 g CH4/PE/a**	**100%**

AD was identified as the main source of methane emissions by different authors. Becker et al. (2012) showed that approx. 50% of the methane is emitted from AD and the emitted methane load strongly depends on the organic loading of the digester. Tauber et al. (2019) applied measurements at large scale digesters and showed, that doubling the organic loading rate from 1.7 to 3.4 kg COD/(m^3·d) increased the methane emissions occurring with the digested sludge withdrawn, disproportionately from 1.0 to 9.7 g CH_4/PE/a.

A comprehensive survey covering all the methane sources at WWTPs is not available, the differentiation among the single emission sources is difficult, also because methane production and emissions often do not take place at the same spot. Nevertheless, using data from different authors the following overview on methane sources can be given:

1. Inflow and mechanical treatment (8 g CH_4/PE/a) (Becker et al., 2012):
   - Inflow pumping station (emissions from methane produced in the sewer)
   - Aerated or unaerated sand trap (emissions from methane produced in the sewer, and produced in anaerobic pockets of unaerated sand traps)
   - Primary settling tanks (emissions depending on sludge residence time, temperature and anaerobic conditions)
2. Biological wastewater treatment (20-307 g CH4/PE/a) (STOWA, 2010; Becker et al., 2012):
   - Nitrification tanks/zones (methane generated in the sewers is emitted during aeration or partially removed by bacteria)
   - Denitrification (emissions generated during long anoxic/anaerobic phases, mainly emitted during aerated phases/ from aerated zones through stripping of dissolved methane)

- Secondary settling tanks, can emit depending on the sludge residence time methane, but they are of minor relevance
- Effluent (depending on turbulence, methane can leave the WWTP dissolved in the effluent)

3. Sludge handling and anaerobic digestion (65-281 g CH_4/PE/a) (Schaum et al., 2016):
   - Static sludge thickeners were identified as one of the largest point methane sources at WWTPs
     The emission depends on the thickening time (165 g CH_4/PE/a); Gärtner and Hirschberger, 2011)
   - Anaerobic digestion: methane emissions from the digester itself vary strongly, depending on the organic loading rate, constructive details of the digesters (open or closed sludge shaft), age of the infrastructure and leaks. Additional emissions arise from digested sludge and dissolved methane.
   - Digester sludge storage tanks: depending on the residence time and temperature in the storage tanks and if the tanks are open or covered, this source was identified as the largest point source of methane (76 g CH_4/PE/a) (Leal Verduguo, 2014)
   - Combined heat and power plant: methane emissions vary with the age and efficiency of the CHP engines (1-2% of the CH_4 burned)
   - Safety flares, depending on size and type (1-2% of the CH_4 burned); Woess-Gallasch et al. (2010) reported for Austrian CHPs an average of 1.73%.
   - Dewatered digester sludge: no data available.

Taking into account all methane emission sources at WWTPs, this leads to total estimated emissions of 115 - 230 g CH_4/PE/a, which represent 4 - 8% of the average targeted methane production in AD (only for plants including AD; while in contrast, emissions from plants with aerobic stabilization are expressed as PE-specific loads). The most significant point sources identified are open static sludge thickeners and open digester sludge storage tanks with long retention times as well as overloaded, poorly operated digesters. Therefore, the minimization of these emissions is of big concern when the improvement of the carbon footprint as well as the energy balance of WWTPs is targeted. Moreover, due to the high share of renewable energy in Austria, already minor methane emissions can off-set the CO_2-credits resulting from the valorization of the produced biogas. This is described in the following example, assuming overall CH_4 emissions of 4% and 8% respectively.

Calculation of PE-specific methane emissions expressed as CO_2 Equivalents (CO_2-eq) for two scenarios

Population equivalent specific CH_4 emissions (hypothesis 4% of produced methane is emitted):

$$0.175\ m^3\ CH_4/PE/a * 0.657\ kg\ CH_4/m^3 * 25\ kg\ CO_2\text{-eq}/kg\ CH_4 = 2.87\ kg\ CO_2\text{-eq}/PE/a$$

Population equivalent specific energy production with electricity recovery from biogas:

$$(4.380 – 0.175\ m^3\ CH_4/PE/a) * 9.97\ kWh/m^3 * 0.35 = 14.67\ kWh/PE/a$$

4% methane emissions (optimistic scenario) leads to:

$$2{,}870\ g\ CO_2\text{-eq}/PE/a\ /\ 14.67\ kWh/PE/a = 196\ g\ CO_2\text{-eq}/kWh$$

8% methane emissions (pessimistic scenario) leads to:

$$5{,}740\ CO_2\text{-eq}/PE/a\ /\ 14.06\ kWh/PE/a = 408\ g\ CO_2\text{-eq}/kWh$$

These calculations are based on a daily biogas production of 20 L/PE/d, which is equal to 4,380 L/PE/a. Lindtner (2008) reported 15-24 L/PE/d as specific gas production for Austria WWTPs including AD. A methane content of 60% in the biogas, a calorific value of 50 MJ/kg = 9.97 kWh/m^3 and a CHP efficiency of η_{el} = 0.35 were assumed.

For comparison, a modern natural gas power plant with combined heat and power coupling emits 312–347 g CO_2-eq per kWh (based on produced electrical and thermal energy) depending on its operation condition, for normal use (e.g. gas boilers) the natural gas emission factor is 440 g CO_2-eq/kWh (e-control, 2014). Also, the electricity mix for electric power generation, transmission and distribution for the EU is estimated to be 406 g CO_2-eq per kWh (EcoInvent, 2020). These values clearly show that in the calculation above 8% methane emissions already - off-set the CO_2-credit resulting from biogas valorization at WWTPs.

It is assumed that methane emissions vary considerably between single WWTPs, depending on their size, age, condition, design, construction and a few operational aspects for example hydraulic and organic loading. Exact methane emission values for single Austrian UWWTPs cannot be given at present and need more detailed measurements and research.

8.6.2 Scientific background: Methane emissions from sewers

Direct methane emissions from closed sewers are mainly caused by methanogens growing in the deeper layer of wetted biofilms and sediments, where anaerobic conditions prevail. The methane production shows highly dynamic temporal and spatial variations and is influenced by several parameters such as sewer type, slope, hydraulic retention time, surface to volume ratio as well as sewage temperature and COD load (Liu et al., 2015). In fully filled pressure sewers, CH_4 can be produced and accumulated even beyond saturation concentrations in the transported sewage and then released to the atmosphere at ventilated locations such as pumping stations, manholes or influent headworks and aerated tanks of WWTPs. CH_4 produced in gravity sewers is usually released into the gas phase along the sewer pipe, with more intensive emissions at locations with higher sewage turbulence (Liu et al., 2015, 2016).

Currently, insufficient data are available to quantify the emissions from sewer systems. Though, research indicates that significant amounts of CH_4 can be formed in sewers (Guisasola et al., 2008) and that at least a portion of the produced CH_4 enters WWTPs as dissolved CH_4, where it is then emitted during treatment (Foley et al., 2015). To account for this portion, the refinement 2019 of the IPCC Guideline introduces an emission factor for centralized WWTPs based on literature values to comprise emissions from sewers together with CH_4 generated in settling basins and other anaerobic zones in the water line of the WWTP (mainstream), excluding anaerobic digestion. The suggested emission factor amounts to 7.5 g CH_4 (range: 0.7-22.5) per kg COD influent, detracted the COD removed as sludge. Assuming a COD influent of 120 g COD/PE/d and a COD removed as primary and secondary sludge of 65 g COD/PE/d, this corresponds to approx. 150 g CH_4/PE/a (range 15-450 g CH_4/PE/a)).

Much higher direct CH_4 emissions were estimated by Liu et al. (2015). The authors reviewed worldwide research on methane emissions from sewers and indicate that in fully filled pressure sewers the emission account on average 8.6 g CH_4 per m^3 of transported wastewater (range 4.7-15 g CH_4/m^3). Assuming a specific wastewater production of 180 L/PE/d the emission factor would be 560 g CH_4/PE/a). It can be expected, that in gravity sewers the emissions would be lower.

Summarizing, there is evidence that sewers can contribute significantly to CH_4 emissions from the wastewater sector, nevertheless the application of emission factors from literature to predict emissions from Austrian sewers would need to be critically evaluated, especially due to the relative low average sewage temperature and the abundance of gravity sewers in Austria.

8.6.3 Calculation of CH_4-emissions from UWWTPs and sewer systems in AT

The last chapters showed that the AT database on methane emissions from UWWTPs and sewer systems could be improved. However, in order to calculate methane emissions despite different uncertainties, a value of 300 g CH_4/PE/a can be suggested for sewers in Austria as a rough estimate.

a) Methane emissions from sewers (E_{sewer})

$E_{sewer} = EF_{sewer} * PE_{sewer} / 1000$ [kg CH_4/a]

EF_{sewer} = 300 g CH_4/PE/a

PE_{sewer} = Population equivalents connected to the sewer system [PE]

Approx. 14.8 mio PE municipal wastewater are treated in Austria based on BOD_{60} (ÖWAV, 2019).

$E_{sewer} = EF_{sewer} * PE$

E_{sewer} = 300 g CH_4/PE/a *14,800,000 PE = =4,440,000 kg CH_4/a = 4,440 t CH_4/a

General overview:

According to the treatment process applied and methane emission factor, three groups of WWTPs in Austria can be distinguished:

b) WWTPs with aerobic sludge stabilization:

$EF_{aerobic}$ = 200 g CH_4/PE/a Approx. 11 mio PE capacity in Austria

c) WWTPs with anaerobic digestion, existing systems (5-40 years in operation), requiring optimization (e.g. uncovered thickeners, low efficient CHP with high methane slip):

$EF_{anaerobic\_old}$ = 280 g CH_4/PE/a Approx. 6.5 mio PE capacity in Austria

d) WWTPs with anaerobic digestion, newly built (< 5 years in operation)
State of the art (e.g. covered thickener, highly efficient CHP with low methane slip)
$EF_{anaerobic\_new}$ = 65 g CH_4/PE/a Approx. 4 mio PE capacity in Austria

The total methane emissions for WWTPs can be calculated as:

$$E_{WWTPs} = E_{aerobic} + E_{anaerobic\_old} + E_{anaerobic\_new}$$

$$E_{WWTPs} = 11{,}000{,}000 \text{ PE} * 200 \text{ g } CH_4/\text{PE/a} + 6{,}500{,}000 \text{ PE} * 280 \text{ g } CH_4/\text{PE/a} + 4{,}000{,}000 \text{ PE} * 65 \text{ g } CH_4/\text{PE/a} = 4{,}280{,}000 \text{ kg } CH_4/\text{a} = \underline{4{,}280 \text{ t } CH_4/\text{a}}$$

For Austria the total methane emissions (E) from sewers and municipal wastewater treatment can be estimated:

$$E = E_{sewer} + E_{WWTPs} = 4{,}440 + 4{,}280 = \underline{8{,}720 \text{ t } CH_4/\text{a}}$$

Considering, that the global warming potential of 1 kg CH_4 is equal to 25 kg CO_2 for a timeframe of 100 years (IPCC, 2007), the methane emissions can be the estimated as CO_2 equivalent as follows.

$$8{,}720 \text{ t } CH_4/\text{a} * 25\text{kg } CO_2\text{-eq/kg } CH_4 = \underline{218{,}000 \text{ t } CO_2\text{-eq/a}}$$

Roughly estimated, Austria’s sewer systems and municipal wastewater treatment plants emit 8,720 t CH_4/a, which is equivalent to 218,000 t CO_2-eq/a. This is in the same order of magnitude as the CO_2-eq emissions currently estimated for nitrous oxide (166,232 t CO_2-eq/a). It should be noted, that this emitted load is estimated without considering methane emissions from aerobic and anaerobic industrial wastewater treatment and anaerobic sludge digestion.

9 Factsheet – Circular economy – sludge reuse

Authors:

Matthias Zessner[1]
Florian Kretschmer[2]

[1]Institut für Wassergüte und Ressourcenmanagement (IWR), Technische Universität Wien, Karlsplatz 12/226, 1040 Wien, Mail: sekretariat@iwag.tuwien.ac.at

[2]Institut für Siedlungswasserbau, Industriewasserwirtschaft und Gewässerschutz (SIG), Universität für Bodenkultur Wien (BOKU), Muthgasse 18, 1190 Wien, Mail: sig-office@boku.ac.at

9.1 Background

In addition to effluent sewage, sludge is the second product of wastewater treatment. Successful wastewater treatment is strongly related to successful sludge disposal. Historically, there are two basic routes for sewage sludge after leaving the UWWTP: open area related reuse or further treatment for concentrating pollutants within residues (e.g. by thermal treatment) and disposal of residues (ashes) in landfills as final sink. Both options are implemented in Austria with strong regional differences, as soil protection and sewage sludge management is the competence of the provinces. In respect of valuable substances the focus is on phosphorus in the sewage sludge. For this nutrient the relevance of sewage sludge as secondary resource and the potential to substitute primary resources is by far the highest (ÖWAV, 2014). Up to 50 % of the current application of mineral fertilizers produced from phosphate rocks could be substituted by P recovered from sewage sludges in Austria (Zoboli et al., 2016). Currently, the technological potential and financial and environmental costs of P recovery from sewage sludge are evaluated as a basis for an efficient strategy for the improvement of P recovery from sewage sludge (ÖWAV, 2018; Egle et al., 2016a; Amann et al., 2018; Wagner et al., 2020; Amann et al., 2021). Other potentially valuable substances in wastewater are for instance the nutrients nitrogen, potassium, sulfur, calcium, magnesium (of which nitrogen and potassium are hardly retained in sewage sludge) or organic matter including its energy content (ÖVAW, 2014).

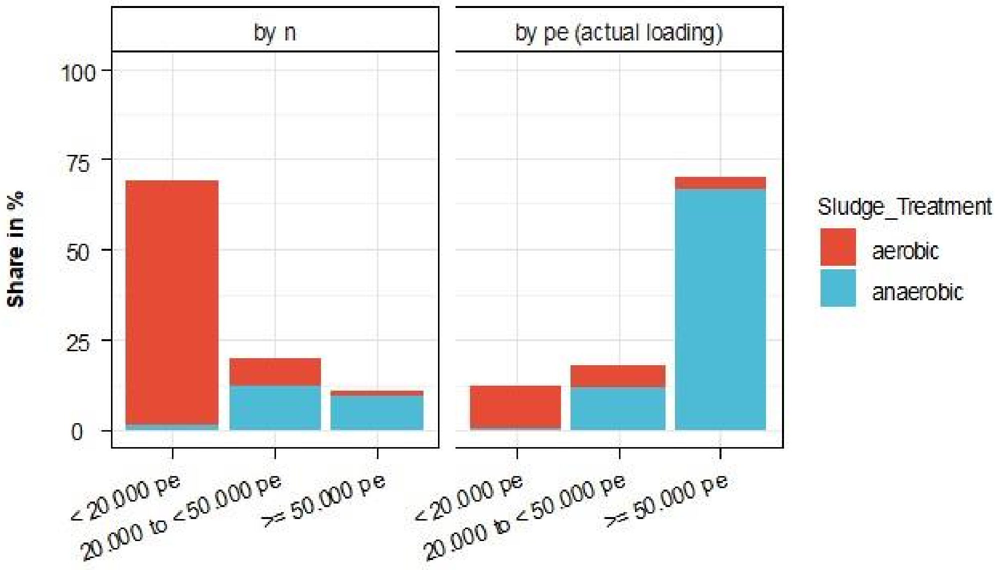
The policy options proposed by the EC are the following:

a) Minimum phosphorus recovery and other valuable material. (all or only large facilities)
b) Impose anaerobic digestion (see also Factsheet "Energy consumption and renewable energy production")
c) Review sludge reuse in agriculture thresholds (for now set in the Sewage Sludge Directive)
d) Impose prevention at source strategies that would ensure that the sludge is not polluted for all agglomerations or only large ones or only those using sludge in agriculture

9.2 Current situation in Austria

Legal basis	• Austrian Water Act (BGBl. Nr. 215/1959) • Indirect Discharger Regulation (BGBl. II Nr. 222/1998) • Waste Management Act (BGBl. I Nr. 102/2002) • Compost Regulation BGBl. II Nr. 292/2001 • Federal Waste Management Plan https://www.bmk.gv.at/themen/klima_umwelt/abfall/aws/bundes_awp.html • Soil protection legislation of the provinces (Bgld: LGBl. Nr. 87/1990, Kt: LGBl Nr 54/1997, Nö: LGBl. 6160-0, Oö: LGBl.Nr. 63/1997, Sbg: LGBl Nr: 80/2001, Stmk: LGBl. Nr. 66/1987, T: LGBl. Nr. 56/2002, Vrbg: LGBl.Nr. Nr. 26/2018, W: LGBl. Nr. 08/2000). Details see Annex Table 50.
Current situation	• Sludge stabilization Typical municipal sludge treatment schemes in AT for smaller plants contain simultaneous aerobic stabilization – thickening – dewatering and sometimes pre-thickening – separate aerobic stabilization – post-thickening – dewatering and for larger plants pre-thickening – separate anaerobic stabilization – post-thickening – dewatering. Almost 80 % of AT UWWTPs > 2,000 PE perform aerobic stabilization and the remaining 20 % anaerobic stabilization (Figure 17). In respect of treated PE about 80 % of the treated PE receive anaerobic digestion, indicating that about 80 % of Austria's municipal sewage sludges currently receive this type of stabilization including methane recovery for energy use.

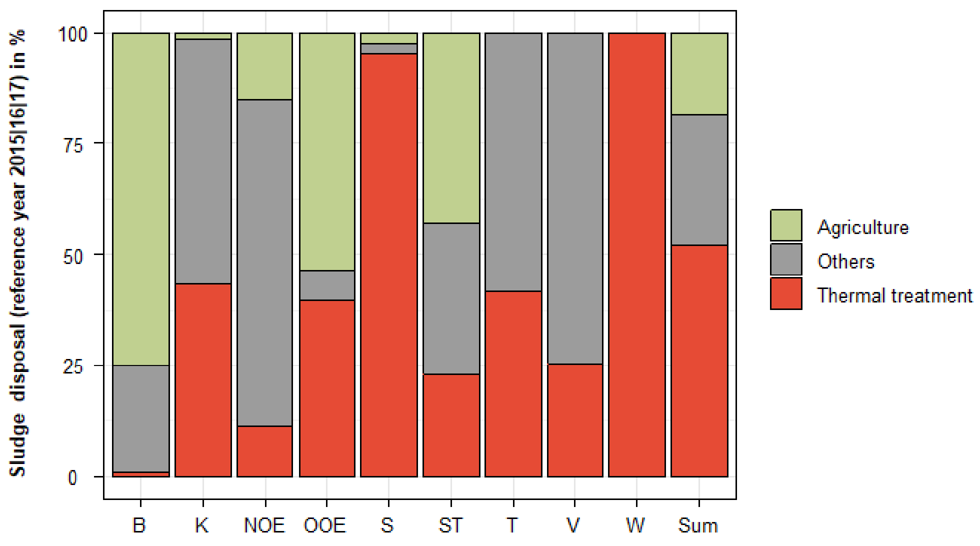
Figure 17: Share of AT UWWTPs (left) and share of PE treated in AT UWWTPs (right) with aerobic or anaerobic sludge stabilization for different size categories of treatment plants in the years 2015-2017 (The Vienna main UWWTP has been equipped with anaerobic digestion in 2020, which is also considered in this graph) (Amann, 2021)



Most of the UWWTPs with aerobic stabilization have a design capacity of < 30,000 PE. In AT only in rare cases there is additional sludge treatment directly at the UWWTP further than dewatering like composting or drying. Typically, dewatered sludge is transported to either direct reuse in agriculture or to further treatment (composting or incineration) and subsequent reuse in agriculture or landscaping or disposal in landfills.

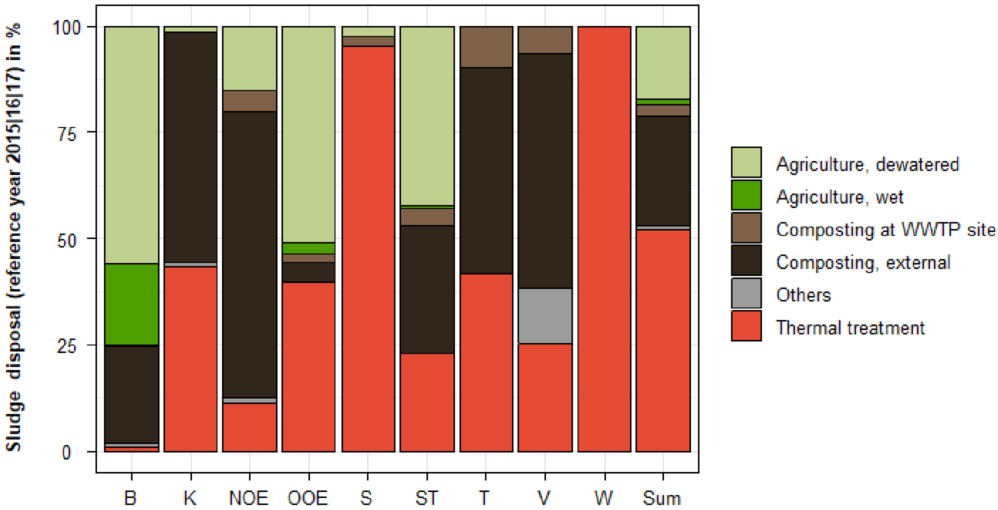
- Sludge reuse and disposal
  Figure 18 shows the share of different sludge management options according to federal statistics for the year 2016 (BMNT, 2019). More recent investigations with additional data collected in the frame of the StraPhos-project (Amann et al., 2021) succeeded to subdivide the category “others” in more detail (Figure 19). The only way that phosphorus is currently reused, is agricultural application. While this is realized via dewatered or wet application, the fate of sludges that are composted cannot fully be clarified by available data. Nevertheless, data indicate that - depending on the province - these composts are used in landscaping (no special P-requirements) to an extent of 50 to 100%. This form of use can therefore not be considered a reuse of P.

Figure 18: Sludge reuse and disposal in the AT provinces according to official statistics (BMNT, 2019)



In Austria on average about 24% of the total P potential contained in sewage sludge is applied on agricultural land. For the different provinces this varies between about 85 % in Burgenland and 0 % in Vienna or the Tyrol as in these provinces agricultural reuse of sludges and sludge composts is forbidden.

Figure 19: Sludge reuse and disposal in the AT provinces according to investigations in the frame of the StraPhos-Project (Amann, 2021)

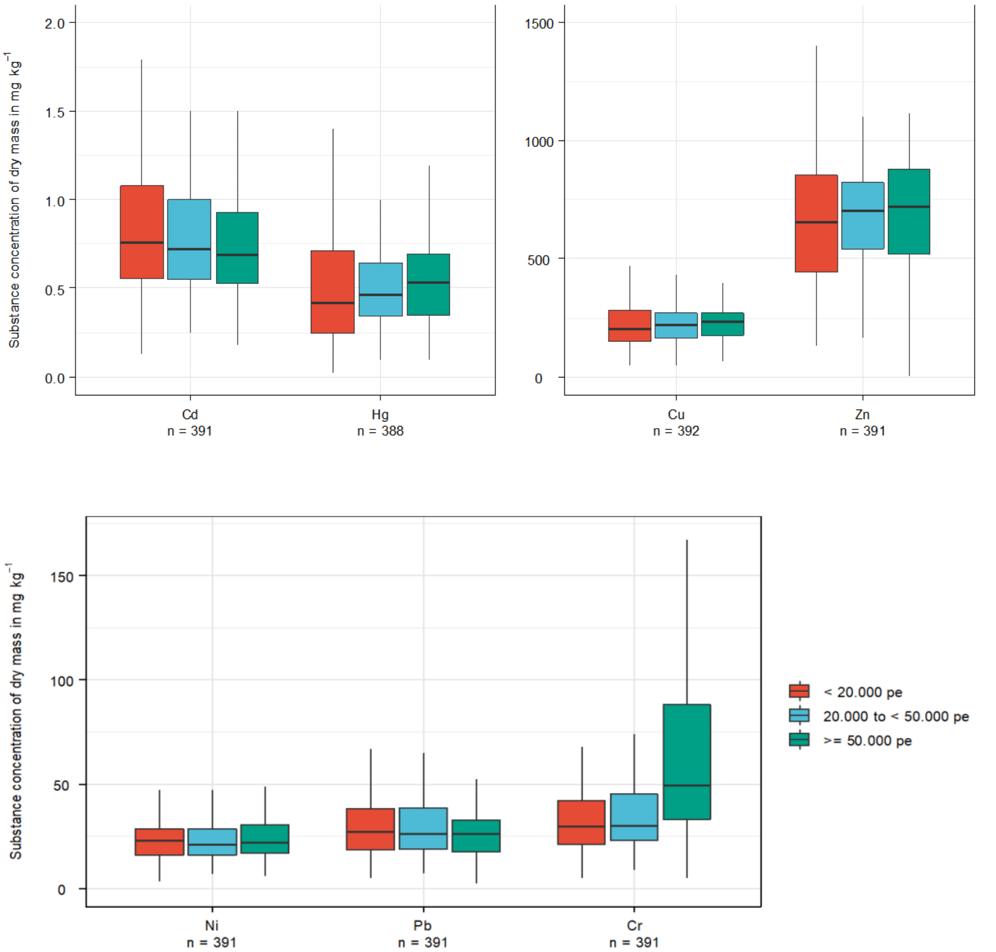


- Sludge quality
  Compared to limit values for heavy metal concentrations in sewage sludge for use in agriculture from the Sewage Sludge Directive (86/278/EEC) (Table 48) typical concentrations in municipal sewage sludge in AT (Figure 20) are much lower. For zinc concentrations are lower by a factor of about 4, for Copper by a factor of about 5. For the other metals with limit values (Cadmium, Nickel, Lead and Mercury) the factor by which concentrations in municipal sewage sludges in AT are lower as the limit values of the Sewage Sludge Directive is > 10.

Table 48: Limit values for heavy metal concentrations in mg/kg of dry matter in sludge for use in agriculture from the Sewage Sludge Directive (86/278/EEC)

Parameters	Limit values
Cadmium	20 to 10
Copper	1,000 to 1,750
Nickel	300 to 400
Lead	750 to 1,200
Zinc	2,500 to 4,000
Mercury	16 to 25
Chromium	-

Figure 20: Heavy metal concentrations in municipal sewage sludges from UWWTPs of different size categories in Austria, 2006 – 2020. Data from 130 UWWTPs < 20,000 PE, 72 UWWTPs 20,000 PE -50,000 PE and 43 UWWTPs > 50,000 PE (Amann, 2021 based on sludge certificates)



Limit values for application are determined at province level. All limit values are much lower than the limit values at EU-level (cf. Annex Table 49). In addition to heavy metals some organic substances such as AOX, PAH, PCB are regulated in some of the provinces. Even limit values for microplastics are laid down in the most recent edict on soil quality criteria of Vorarlberg (LGBl.Nr. 77/2018). In AT sewage sludge in most cases meets the limit values of the regulations in the provinces (compare Figure 20 to Annex Table 49). Currently, the main concerns with regard to agricultural sewage sludge application are no more about heavy metals but organic contaminants, microplastics, nanoparticles and other contaminants of emerging concern (ÖWAV, 2014).

- Source control
  In AT the main instrument for imposing contaminant prevention at source is directly in the competence of the water management authorities in form of the Indirect Discharger Regulation (BGBl. II Nr. 222/1998). It defines, when permits of industry and trade discharging to municipal sewer systems are required, the

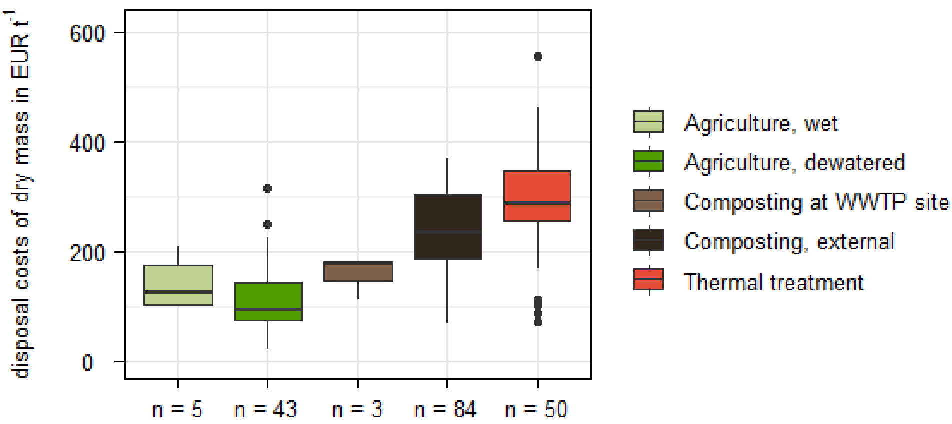
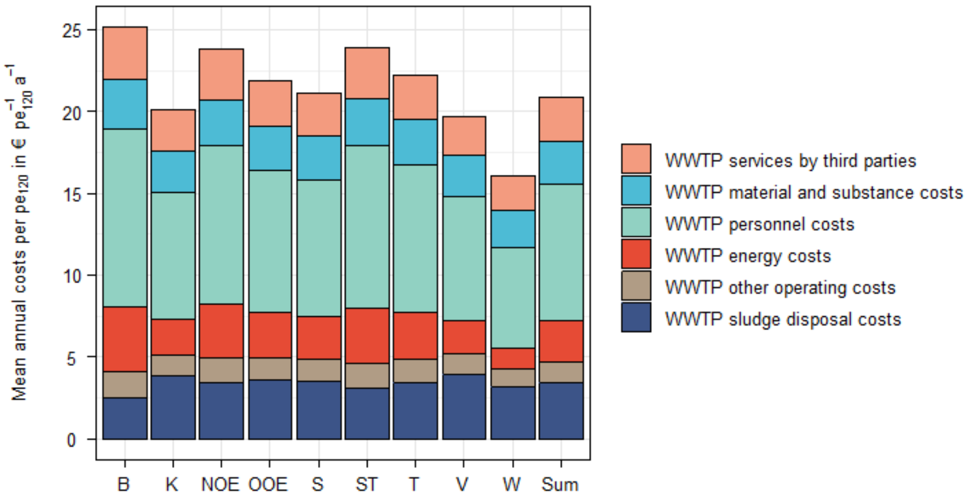
	required monitoring of these indirect dischargers and the responsibilities of the indirect dischargers as well as of the operators of the sewer system. The latter must operate an inventory of all indirect dischargers. Nowadays, most of the contaminants of emerging concern stem from widespread usages in households (e.g. pharmaceuticals, personal care products), applications on urban surfaces (e.g. pesticides) or street runoff (e.g. PAH) and industrial discharge is not their major source of input into the sewer system and sewage sludge. As a consequence, source control becomes an overall challenge for society for the protection of the environment and of the water resources (ÖWAV, 2019).
Costs (estimates)	• Costs of sludge disposal in Austria Figure 21 shows an overview of disposal costs for different reuse and disposal options obtained from a survey at AT UWWTPs from 2018 (Damm et al., 2020). Expressed as €/PE/a or €/inh./a costs are approximately 2 €/PE/a or 3.1 €/inh./a for agricultural application of dewatered sludge and 6 €/PE/a or 9.4 €/inh./a for thermal treatment. Costs for composting of sewage sludge at external companies are in the same order of magnitude as those for thermal treatment. The results of this survey are well in line with costs derived by the Austrian benchmarking initiative (ÖWAV, 2017) Figure 21: Costs of different sludge reuse and disposal routes (2015-2018, adopted from Damm et al. 2020)  Costs for sludge reuse and disposal are only one aspect in the overall costs associated with wastewater disposal (wastewater collection, wastewater treatment and sludge reuse or disposal). Overall costs for wastewater disposal in AT are on average about 95 €/PE/a and 150 €/inh./a.

Figure 22: Operating costs for wastewater treatment in Austria and in different provinces (Amann et al., 2021 based on Assmann et al., 2020 and Lindtner, 2018)



The mean operating costs for wastewater treatment alone are about 21 €/PE/a, which is about 33 €/inh./a (Figure 22). Out of this about 17 % (3.5 €/PE/a or 5.5 €/inh./a) are costs for sludge disposal. The lowest sludge disposal costs are found in Burgenland (B) (2.5 €/PE/a or 3.7 €/inh./a), the highest in Vorarlberg (V) (4.0 €/PE/a or 9.4 €/inh./a). This is in line with the prevailing route of reuse or disposal, if 2 €/PE/a are considered as costs for direct agricultural reuse and 5 €/PE/a for external composting, which are the prevailing disposal routes in these two provinces.

9.3 Policy options – future possibilities for implementation in Austria

9.3.1 Minimum phosphorus recovery and other valuable material. (all or only large facilities)

Possible implementation in AT	• Currently about 7,600 t/a phosphorus are discharged via raw wastewater into UWWTPs in AT. Of these about 90 % (6,800 t/a) are retained in sewage sludges of which about 24 % of P (1,700 t/a P) reach agricultural areas via application of wet, dewatered or composted sewage sludge (Amann et al., 2021). According to Kratz et al. (2019) plant availability of P in sewage sludge amounts to 50 % in sludges from UWWTPs with chemical P precipitation and 80 % in UWWTPs with biological P removal. Consequently, about 13 % (900 t/a P) of P in sewage sludge is finally applied to agricultural soils in plant-available form. This leaves a lot of room for improvement. Currently, increasing the application of wet, dewatered or composted sewage sludge to agricultural areas is unrealistic as there is no political and societal acceptance because of potential risks from contaminants (ÖWAV, 2014). • With a theoretical recovery rate of 90 % of P in sewage sludges, which is a recovery potential of about 6120 t/a P, almost 50 % of AT mineral fertilizer application (which currently is about 13,000 t/a) could be substituted by recovered P from sewage sludge (Zoboli et al., 2016). Other materials in sludge are considered to be of much lower relevance (e.g. N, orgC, S, Ca,…) (ÖWAV, 2014). The AT Federal Waste Management Plan (BAWP) defines the goal of more efficient use of P in sewage sludge by increasing the recovery rate of P from sludge to 65 % - 85 % while at the same time destroying or removing pollutants contained in sludges (BMNT, 2017). Currently potential scenarios are being evaluated with respect to costs, environmental impacts and technical feasibility. On this basis regulations to achieve this goal shall be developed. (Centralised) sludge incineration with subsequent P recovery is seen as the most promising solution (BMNT, 2017 and ÖWAV, 2018). It has not been decided, yet, whether only large facilities or also smaller ones should be included in an overall P recovery strategy in AT.
Advantages	• Reduction of P losses to landfills and saving of primary resources of P • Improved flexibility of P uses from sewage sludge as secondary resource • Recovery of energy from sludge incineration and potentially other valuable materials from sewage sludge ashes • Destruction of a high number of organic hazardous substances contained in sludge and potentially removal of heavy metals
Disadvantages	• Losses of nitrogen and organic matter from sludge in case of incineration • Potentially increasing traffic for transport of dewatered or dried sludges • Potentially increasing costs of sludge disposal especially in regions where currently agricultural sludge reuse is practiced

	• Technical, logistical and organizational challenges of decentralized sludge production and centralized treatment and recovery • Technical, logistical and organizational efforts for incineration, ash storage and later P recovery
Costs	• 1 -5 €/inh./a on average according to Egle et al. (2016b). More detailed investigations are currently performed

9.3.2 Impose anaerobic digestion

Possible implementation in AT	• In the AT context an installation of anaerobic digestion is considered to be feasible from environmental (increasing CH_4 and N_2O emissions) and economic point of view for UWWTPs > 30,000 PE. In AT most of UWWTPs > 30,000 PE are already equipped with anaerobic digestion and energy recovery from produced methane. Currently about 7 % of the total wastewater in AT is treated in UWWTPs > 30,000 PE where sludge is stabilized aerobically (Amann, 2021). That means that for this wastewater load a change from aerobic stabilization to anaerobic digestion could be considered. Expressed in absolute values altogether almost 1 mio PE are treated at 27 different UWWTPs (Amann, 2021). The potential gain of CH_4 in case of a change to anaerobic digestion in these cases can be estimated to be 10-15 L CH_4/PE/d or 3.7-5.5 mio m^3/a in total.
Advantages	• Increase of recovery of energy from wastewater • Reduced volume of aeration tank • Slightly reduced operational costs
Disadvantages	• Reduced N-removal and increased N_2O emissions • Higher CH_4 losses per PE from digestor with decreasing size of UWWTP • Additional costs for digestors • Sludge stabilization (C removal) also has to be seen in the context of a possible later sludge incineration (which requires C)
Costs	• Increase of about 30-50% of capital costs for wastewater treatment, potentially reduction of operating costs. For details see Factsheet “Energy consumption and renewable energy production”

9.3.3 Review sludge reuse in agriculture thresholds (for now set in the Sewage Sludge Directive)

Possible implementation in AT	• From the AT perspective the Sewage Sludge Directive is completely outdated. Limit values of heavy metals are 4 to 10 times higher than typical concentrations in AT sewage sludges. The provinces in AT either completely prohibit agricultural use of sludge (by law) or require much higher standards of soil protection as laid down in the directive at EU-level. Many of the

	directives on province level include standards for organic micropollutants in addition to heavy metals.
Advantages	• Regain of relevance of this directive • Strengthen soil protection in the EU • Avoid application of highly contaminated sludges in the EU
Disadvantages	• -
Costs	• Cannot be estimated, currently no additional costs are expected

9.3.4 Impose prevention at source strategies that would ensure that the sludge is not polluted for all agglomerations or only large ones or only those using sludge in agriculture

Possible implementation in AT	• Prevention at source no longer is a subject that is mainly related to discharges from industry and trade into municipal sewer systems and therefore goes far beyond the competence of water authorities. Nowadays many substances of concern stem from day-to-day use of consumables of the population and from multiple diffuse sources.
Advantages	• A prevention strategy that includes all types of settlements and does not only ensure that sludge used in agriculture is not polluted would be an overall benefit for environmental protection, as many chemicals are not retained in the sludge or removed at UWWTPs and enter the environment via combined sewer overflows, rain water sewers or UWWTP effluents.
Disadvantages	• Even the best prevention strategy cannot completely prevent sludge from being polluted as some chemicals (e.g. pharmaceuticals) are of such essential societal relevance that society will not completely relinquish their use.
Costs	• This question goes far beyond this context and needs to be handled by an overall prevention strategy of releases of persistent chemicals into the environment.

9.4 Further data collection/ data evaluation

- The results of the StraPhos-project (Amann et al., 2021) will provide additional results in respect to costs and environmental impacts of different strategies of P recovery from sewage sludge.
- The topic of prevention at source strategies is much too complex to be handled comprehensively in this context.

9.5 References

9.5.1 Legislation Austria

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Soil protection legislation of the nine AT provinces → see Annex

9.5.2 Legislation EU

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9.6 Annex

Table 49: Geltende Grenzwerte für anorganische und organische Schadstoffe in Düngemitteln (DMVO, 2004) und für die landwirtschaftliche Verwertung von Klärschlamm(-kompost) (ÖVAW, 2018

		DMVO (2004)	Klärschlammverordnungen der Länder											Kompostverordnung (2001)				
		Mineral. DM mit mehr als 5% P2O5	Bgld[1]		K[2]				Vbg[3]	NÖ[4]	OÖ[5]	Stmk[6]	Grenzwerte für KS als Ausgangs-material		Grenzwerte für (Klärschlamm)-Kompost		
			GK I	GK II	B	AB	B	I		I**/II			Komp.	QKK	B	A	A+
As	mg/ kg TS	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cd		75 mg/kg P_2O_5	2	10	2,5	2	1	0,7	3	2	5	2	3	2	3	1	0,7
Co		-	-	-	-	-	-	-	-	-	-	-	300	70	250	70	70
Cr		-	100	500	100	70	70	70	200	70	400	70	-	-	-	-	-
Cr(VI)		2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cu		-	300	500	300	300	150	70	500	300	400	300	500	300	500 (400*)	150	70
Hg		1	2	10	2,5	2	0,7	0,4	2	2	7	2	5	2	3	0,7	0,4
Ni		100	60	100	80	60	60	25	60	60	80	60	100	60	100	60	25
Pb		100	100	500	150	150	150	45	100	100	400	100	200	100	200	120	45
V		1 500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zn		-	1 000	2 000	1 800	1 200	500	200	1 800	1 500	1 600	1 200	2 000	1 200	1.800 (1.200*)	500	200
U		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AOX	[mg/ kg TS]	500	-		500***				500	500	500	500	500		-		
PAK		6[PAK6]	-		6***				-	-	-	6	-		-		
PCB7		0,2[PCB6]	-		1***				1	-	-	-	-		-		
PFT		0,1	-		-				-	-	-	-	-		-		
OCP		0,5	-		-				-	-	-	-	-		-		
Dioxin		-	-		50***				-	-	-	-	-		-		
PCDD/F	[ng/ kg TS]	20	-		-				50	-	-	-	-		-		
Aktivität	[Bq/g]	0,5	-		-				-	-	-	-	-		-		

DM: Düngemittel, KS: Klärschlamm, QKK: Qualitätsklärschlammkompost, OCP: Organochlorpestizide
*Kennzeichnungspflicht;
** Qualitätsklasse I darf die durchschnittlichen regionalen Oberbodengehalte nicht übersteigen; ***Im Verdachtsfall zu prüfen
****jeweils für Polychlorierte Biphenyle (PCB) der Komponenten Nr. 28, 52, 101, 138, 153 und 180
[1]Bgld. Klärschlamm- und Müllkompostverordnung (1991);
[2]Kärntner Klärschlamm- und Kompostverordnung (2000);
[3]Vbg. Bodenqualitätsverordnung 2018: Werte gelten für Klärschlämme als Ausgangsmaterialien für die Herstellung von Klärschlammkomposten; für Materialen für eine Aufbringung gelten weiter Begrenzungen z.B. für den Gehalte an Kunststoffen und anderen Materialine > 2mm;
[4]NÖ Klärschlammverordnung (2015);
[5]OÖ. Klärschlammverordnung (2006);
[6]Steiermärkische Klärschlammverordnung (2007)

Table 50: Rechtsvorschriften betreffend Klärschlammanwendung zu Düngezwecken

	Rechtsvorschriften
Bundesweit	Bundeskompostverordnung BGBl. Nr 325/1990 i. d. F. BGBl. II Nr. 292/2001
Burgenland	Burgenländisches Bodenschutzgesetz LGBl. Nr. 87/1990 i.d.F LGBl. Nr. 32/2001 Burgenländische Klärschlamm- und Müllkompostverordnung LGBl. Nr. 82/1991 i.d.F. LGBl Nr. 4/2001
Kärnten	Kärntner Abfallwirtschaftsordnung 2004 (LGBl. Nr.17/2004 i.d.F LGBl Nr. 85/2013) Kärntner Klärschlamm- und Kompostverordnung (LGBl. Nr. 74/2000 i.d.F LGBl Nr. 74/2000)
Niederösterreich	NÖ Bodenschutzgesetz NÖ BSG LGBl. Nr. 6160-0 i.d.F LGBl. Nr. 6160-5 NÖ Klärschlammverordnung LGBl. Nr. 6160/2 i.d.F LGBl. 6160/2-5
Oberösterreich	OÖ Bodenschutzgesetz LBGl. Nr. 63/1997 i.d.F LGBl. Nr. 3/2014 Oberösterreichische Bodengrenzwerteverordnung LBGl. Nr. 50/2006 OÖ Klärschlammverordnung LBGl. Nr. 62/2006
Steiermark	Steiermärkisches landwirtschaftliches Bodenschutzgesetz LGBl. 66/1987 i.d.F LGBl. Nr. 8/2004 Steiermärkische Klärschlammverordnung 2007 LGBl. Nr. 89/2007 i.d.F LGBl. Nr. 94/2007 Bodenschutzprogrammverordnung LGBl. Nr. 87/1987 i.d.F. LGBl. Nr. 11/1988
Vorarlberg	Gesetz zum Schutz der Bodenqualität LGBl. Nr. 26/2018 Bodenqualitätsverordnung LGBl. Nr. 77/2018
Salzburg	Bodenschutzgesetz Salzburg LGBl Nr. 80/2001 i.d.F LGBl. Nr. 31/2009 Klärschlamm-Bodenschutzverordnung Salzburg LGBl Nr. 85/2002 i.d.F LGBl. Nr. 74/2016
Tirol	Tiroler Feldschutzgesetz 2000 LGBl.Nr. 58/2000 i.d.F. LGBl. Nr. 26/2017
Wien	Wiener Klärschlammgesetz LGBl. Nr. 08/2000

10 Factsheet – Monitoring

Authors:

Clemens Steidl[1]
Katharina Lenz[1]
Stefan Lindtner[2]

[1]Umweltbundesamt, Spittelauer Lände 5, 1090 Wien, Mail: office@umweltbundesamt.at

[2]Ingenieurbüro kaltesklareswasser, Obere Augartenstraße 18/8/20, 1020 Wien, Mail: office@k2w.at

10.1 Background

Section D of Annex I of the UWWTD describes the reference methods for monitoring and evaluation of results. The reference methods regulate the numbers of samples per year as well as the maximum number of samples which are allowed to fail the requirements. In addition, the sampling strategy foresees flow-proportional or time-based 24-hour sample.

Reference methods of measurements are defined for BOD_5, COD and total suspended solids, with potassium dichromate mediated oxidation being the reference method for COD measurement. Under the Commission Regulation (EU) no 348/2013 of 17 April 2013 (REACH) potassium dichromate production is to cease by 16 September 2017, unless authorized for particular uses. Therefore, in recent years the idea to replace COD monitoring by means of measurements of Total Organic Carbon (TOC) was discussed among UWWTD-experts. For N_{tot} and P_{tot} the molecular absorption spectrophotometry is determined as reference method of measurement.

The policy options proposed by the EC are the following:

a) Reinforce the sampling frequencies and conditions, especially as regards what 'normal operating conditions' mean to ensure comparability of the monitoring data
b) Replacement of COD with TOC
c) Align parameters with WFD/ EQSD parameters

10.2 Current situation in Austria

Legal basis	• The first wastewater emission ordinance for UWWTPs > 50 PE (**1st AEVkA)** describes the requirements for the removal of carbon and nutrients, the number of samples to be taken in one reference year, and the maximum number of samples which are allowed to fail the requirements. • The national ordinance on an emission register for point sources (**EmRegV-OW** 2017) defines that specific priority substances have to be measured in the effluents of UWWTPs > 10,000 PE once every six years (number of wastewater samples to be taken depending on the max. daily volume of wastewater according to the wastewater permit: ≤ 100 m^3/d: 3 samples/a, > 100 m^3/d - ≤ 1,000 m^3/d: 6 samples/a, > 1,000 m^3/d: 12 samples/a). Substances of concern were selected on the basis of a literature review and a study (Umweltbundesamt, 2009) and revised on the basis of two further studies (BMLFUW, 2017a and BMLFUW, 2017b) taking into account the occurrence of substances in the effluents of UWWTPs and the feasibility (achievable quantification limits) and costs of routine analysis of these substances. Until 2022 these substances are cadmium, diuron and nonylphenols (BGBl. II Nr. 29/2009), while from 2023 onwards the substances will be nickel, nonylphenols and mercury (BGBl. II Nr. 207/2017). According to the draft of the 3rd WFD River Basin Management Plan, PFOS will soon be included (BMLRT, 2021). • The **Ordinance on water test methods** (BGBl. II Nr. 129/2019; MVW) lays down methods for sampling, sample treatment, wastewater flow measurement, analysis of wastewater parameters and standards for quality assurance. It further specifies the type of sampling and sample pretreatment for each wastewater parameter. Annex A of the ordinance also sets the minimum limit of quantification for each parameter. The scope of this ordinance covers monitoring according to 1st AEVkA and EmRegV-OW 2017. • According to the **European PRTR Regulation (166/2006)** and the accompanying regulations **BGBl. II Nr. 380/2007** UWWTPs > 100,000 PE have to report emissions of certain substances in case a defined quantity threshold is exceeded
Current situation	• The UWWTD and the 1st AEVkA show some differences and some consistencies (see **Table 52** and **Table 53** in the Annex). These are in brief: Differences: – Mandatory minimum number of samples to be taken within a reference year (1st AEVkA requires more samples) – Requirements for external monitoring only in 1st AEVka – 1st AEVkA (§5): Sampling must be carried out at regular time intervals over the entire year of investigation and must also cover periods of high influent load. – 1st AEVkA doesn not distinguish OTNOCs (other than normal operating conditions) from NOCs (normal operating conditions). The UWWTD foresees in Annex 1.D.3 that "*The minimum annual number of samples*

shall be […] collected at regular intervals during the year." Annex 1.D.4.b specifies for parameters with a permitted number of failing samples that *"…failing samples taken under normal operating conditions must not deviate from the parametric values by more than 100 %"*. Finally, Annex 1.D.5 clarifies that "*Extreme values for the water quality in question shall not be taken into consideration when they are the result of unusual situations such as those due to heavy rain.*"

Consistencies:

- The maximum permitted number of samples, which fail to conform, depending on the numbers to be taken per year
- UWWTD: flow-proportional or time-based 24-hour samples. Ordinance on water test methods: quantity-proportional not settled homogenized 24-hour sample
- In AT the analysis of TOC is allowed as an alternative to BOD_5 or COD in the monitoring of municipal wastewater emissions (§4 of the 1st AEVkA). The ratio of 3 between TOC and COD might be useful for an approximation in the calculation of loads, for monitoring reasons it is not accurate enough.

- So far, in Austria the use of COD in the wastewater treatment sector has been determined by governmental regulations as well as by standards and technical rules. In 2016 a study on the replacement of COD by TOC was conducted for AT and revealed that a replacement is not easily feasible (see section **10.3.2**).
- As for the alignment of parameters with WFD/ EQSD parameters this has already been done in AT in the context of implementing the WFD and the EQSD. As the analysis of priority substances is costly, it was foreseen that priority substances which are relevant for wastewater discharge are measured once every six years and that annual loads in the non-measurement years are estimated on the basis of effluent concentrations and annual wastewater loads. Substances determined for regular monitoring were selected carefully (see section 'Legal basis').

Current situation on TOC/COD ratio:

- In the Framework Service Contract ENV.D2/FRA/2012/0013 "Support to the implementation of the UWWTD: COD substitution scoping study" of 2016 parallel measurements of COD and TOC in the influent and effluent of UWWTPs were evaluated.
  An explicit correlation between COD and TOC could neither be identified on the level of single wastewater treatment plants nor on the level of aggregates of wastewater treatment plants. Only for UWWTPs with wastewater from selected industries the correlation between both parameters seemed to be good in several cases.

Dataset 1: UWWTPs from each size category (< 2,000 PE to > 150,000 PE) except 10,000 - 15,000 PE (influent and effluent)

Figure 23: Correlation COD/TOC in UWWTP

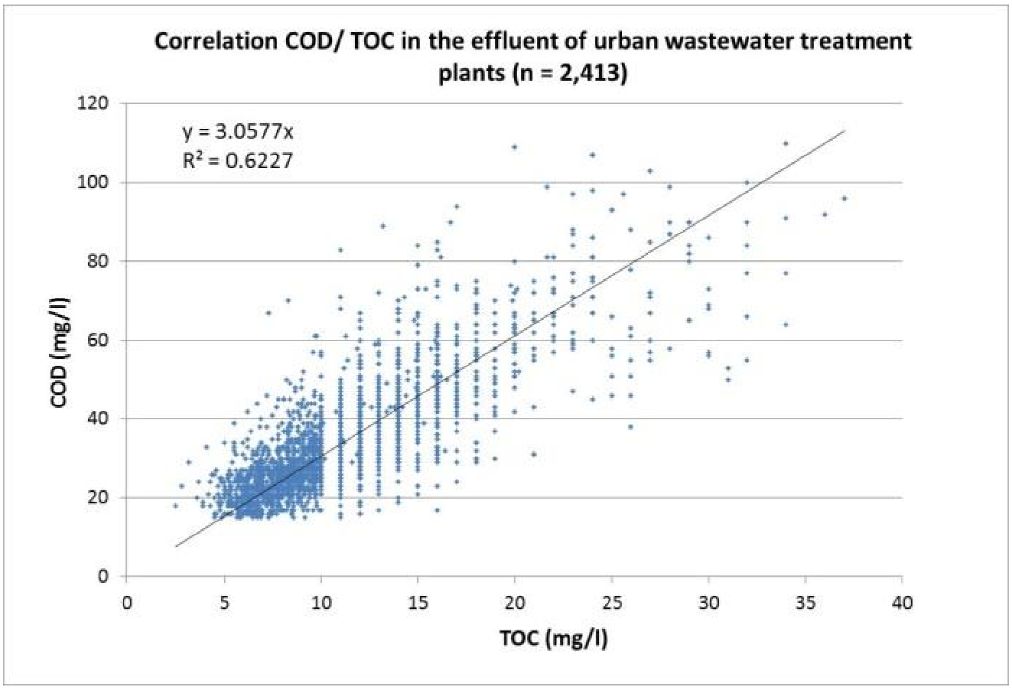


Figure 24: Ratio COD/TOC in UWWTP

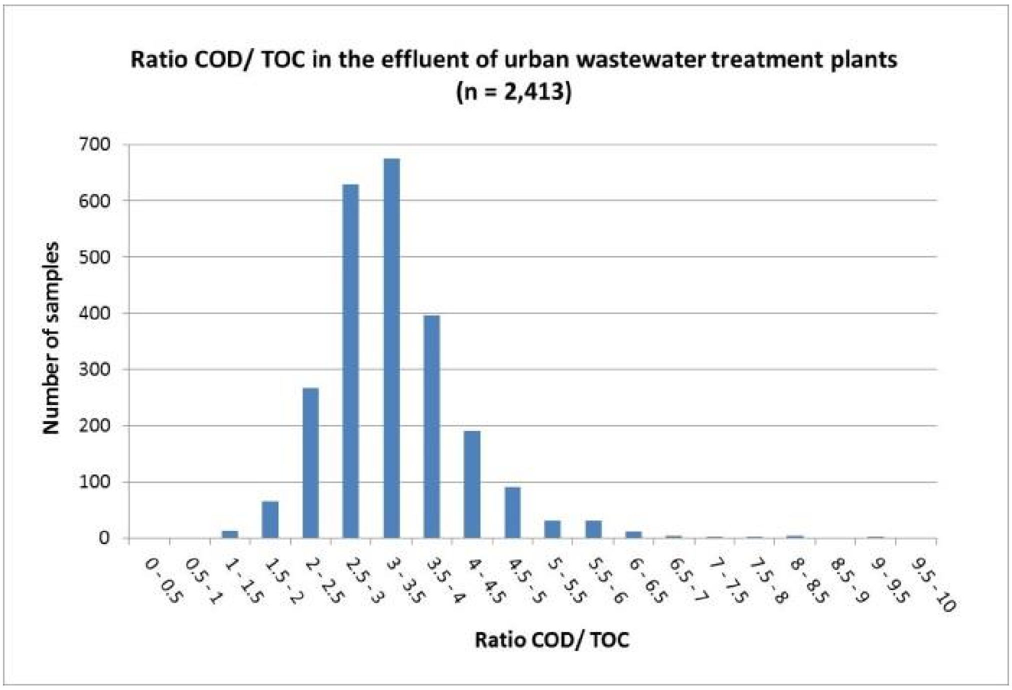
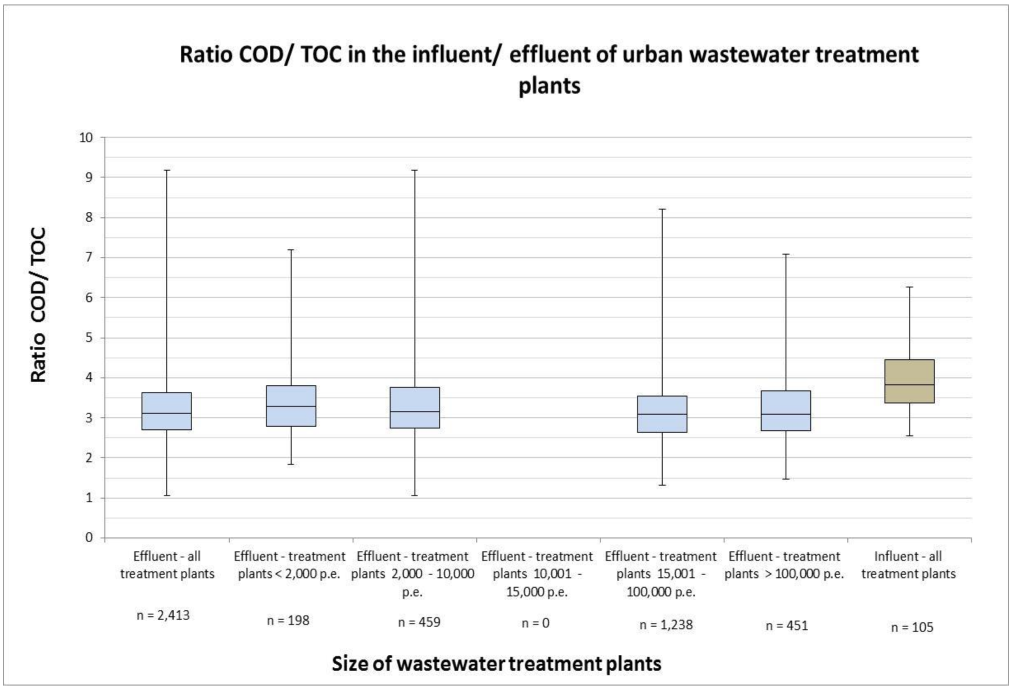
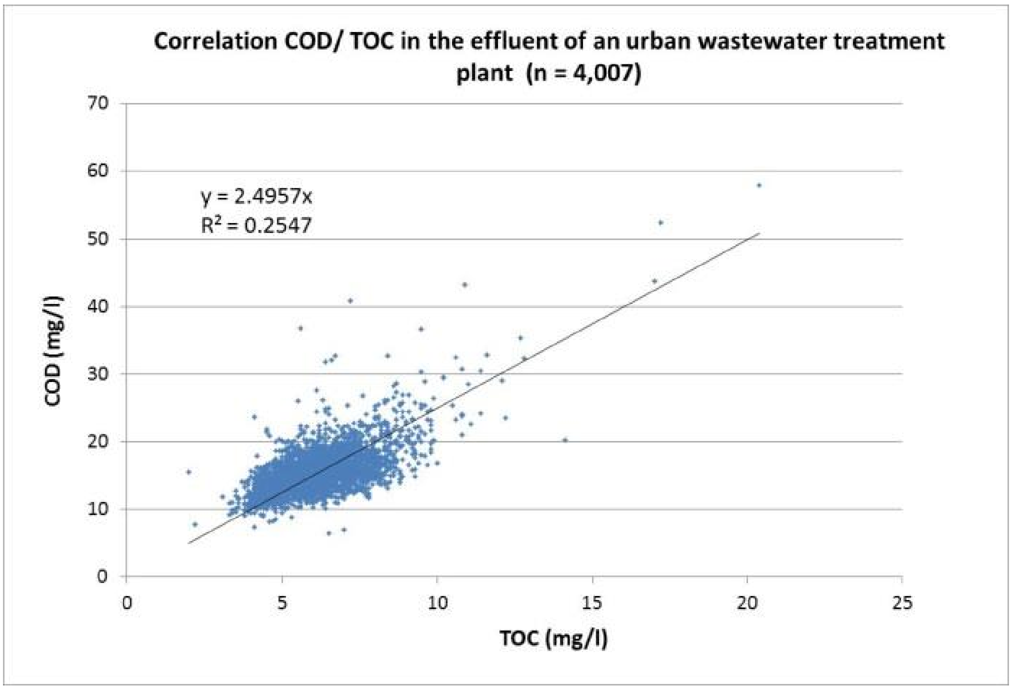


Figure 25: Ratio COD/TOC in UWWTP per size category (the box shows the median value and the 25 & 75% quartiles)



Dataset 3: UWWTPs with a size of ≥ 100,000 PE (influent and effluent)

Figure 26: Correlation COD/TOC in UWWTP ≥ 100 000 PE



Additional information on potassium dichromate (expert judgment from 2016):

Based on the reference year 2012, the following figures were estimated by expert judgment (DI Alfred Rauchbüchl, BMLRT)

- Required amount for potassium dichromate and mercury per cuvette test for self-monitoring is based on ÖNORM ISO15705 and on ÖNORM M 6265 for external monitoring (MVW)

Table 51: Estimation of the amount of potassium dichromate and mercury used in wastewater monitoring

	Number UWWTP	Samples per UWWTP and year	Samples per year	$K_2Cr_2O_7$ per sample [g]	$K_2Cr_2O_7$ per year [g]	Hg per sample [g]	Hg per year [g]
Self-monitoring	1,838	730	1,341,740	0.0147	19,724	0.0541	72,588
External monitoring	1,838	70	128,660	0.0588	7,565	0.2704	34,789
Total					**27,289**		**107,377**

After the analysis in a cuvette test, Chrome is available mainly as Chrome (III), which is much more stable and less dangerous than Chrome (VI). Furthermore, the cuvettes need to be recycled by vendors in their own recycling systems. The environmental pollution as well as the exposure of the UWWTP staff is minimized.

Costs (estimates)

- Current laboratory costs (costs for analysis of BOD_5, COD, NH_4-N, Nt_{ot} and and P_{tot} -self-monitoring) (expert judgement S. Lindtner)

UWWTPs		**laboratory costs* [€/ PE/ a]**	**material costs**[€/ PE/ a]**	**design capacity [PE]**
All (n = 112)	25% Perc.	1.5	0.3	10,000
	Median	2.2	0.5	25,000
	75% Perc.	3.9	0.8	45,388
> 100,000 PE (n = 19)	25% Perc.	0.6	0.2	127,500
	Median	0.7	0.3	167,000
	75% Perc.	1.2	0.4	280,000

> 50,000 PE (n = 26)	25% Perc.	0.7	0.2	100,425
	Median	1.1	0.4	135,250
	75% Perc.	1.5	0.5	251,250
> 5,000 - 50,000 PE (n = 74)	25% Perc.	1.8	0.4	11,000
	Median	2.5	0.6	22,000
	75% Perc.	4	0.9	31,750
≤ 5,000 PE (n = 12)	25% Perc.	3.1	0.7	2,338
	Median	4.2	0.9	2,550
	75% Perc.	6.3	1.3	4,000

*laboratory costs (including material and staff labour)
**material costs (materials used in laboratory, infrastructure, administration)

- In the context of the revision of EmRegV-OW, the costs for measurements of priority substances were evaluated (costs based on the assumption of ten samples): Costs for cadmium, diuron, nonylphenols: around 420 €/sample; Costs for nickel, nonylphenols and mercury: around 370 €/sample.

10.3 Policy options – future possibilities for implementation in Austria

10.3.1 Reinforce the sampling frequencies and conditions, especially as regards what 'normal operating conditions' mean to ensure comparability of the monitoring data

Possible implementation in AT	• The AT legislation does not foresee exemptions from the consideration of samples to be taken into account for monitoring of the treatment plant (as the UWWTD does). In addition, the AT legislation foresees more samples to be taken per reference year (see Annex). • It is therefore not assumed that this policy option will have negative implications for AT
Advantages	• Improve comparability of monitoring results among different MS
Disadvantages	• In the past there were considerations from the EC to request detailed monitoring results per UWWTP on a regular basis (e.g. biennially under Art. 15) → disproportional reporting burden for MS
Costs	• Costs of reinforcement could not be evaluated

10.3.2 Replacement of COD with TOC

Possible implementation in AT	• From the results of the "COD substitution scoping study" from 2016 in Chapter 2 it can be concluded that TOC does not qualify as determinant replacement for COD. • For only monitoring reasons by the authority (no information about compliance and process-control of the UWWTP) TOC can be used as an indicator, the parameter is already included in the national EMREG-OW dataset.
Advantages	• Avoidance of purchasing potassium dichromate in line with REACH-Commission Regulation (EU) no 348/2013 of 17 April 2013
Disadvantages	• TOC-measurement gives an indication of the organic load of wastewater discharges, but does not provide information about the O2-demand of pollutants, which impacts the receiving aquatic environment. Consequently, this O2-demand would have to be calculated/ estimated taking into account safety and more generous dimensioning of wastewater treatment plants (e.g. aeration, tank volumes,…) and therefore increasing costs. • At the UWWTPs COD measurement is used for compliance and process-control purposes. Mass flow and balance models are elaborated on the basis of COD (and not the TOC). The use of cuvette tests is simple and well

	approved and delivers reliable results. In addition, the recycling system of cuvette tests is well established.
Costs	• The costs were estimated based on price lists from one provider of cuvette-tests for COD and TOC, which supplies many UWWTPs in AT. Without taking into account the costs for additional laboratory equipment for TOC-analysis (e.g. shaker) and training of laboratory technicians, the costs for cuvette-tests would increase by 50% (expert judgement).

10.3.3 Align parameters with WFD/ EQSD parameters

Possible implementation in AT	• Policy option could be interpreted as a monitoring obligation for priority substances (i.e. substances, which are already regulated in water legislation). A distinction must be made between priority substances relevant for wastewater discharge and substances, whose pathway in the aquatic environment is dominated by diffuse pollution • In AT the occurrence of priority substances and further substances under the EQSD watch list in UWWTPs was investigated in different studies (Umweltbundesamt, 2009, BMLFUW, 2017a, BMNT, 2019) and the substances for regular monitoring in UWWTPs were carefully selected for inclusion into legal requirements (EmRegV-OW 2009 and EmRegV-OW 2017) • Policy option could be seen in context with contaminants of emerging concern and their possible future consideration in the UWWTP (see fact-sheet 6) • General requirements for implementation: – Definition of UWWTP size categories, which have to monitor selected parameters – Definition of monitoring intervals (e.g. in line with WFD) – Definition of standard analytical methods and minimum detection limits
Advantages	• Regular availability of data for a broader range of substances from UWWTP discharges (e.g. to be used for WFD and EQSD) • Better comparability (data under E-PRTR is not always sufficiently comparable, covers only a part of the substances and only from UWWTPs > 100,000 PE and does not have to rely on measurements)
Disadvantages	• Costs for regular monitoring at UWWTPs and reporting under UWWTD
Costs	• Costs for analysis of single parameters from the list of 45 priority substances regulated under the EQSD range from around 50 €/sample (mercury) to 500 €/sample (tributyltin). The analysis of all 45 priority substances would amount to around 5,500 €/ sample (estimation based on costs for ten samples, reference year 2021).

10.4 Further data collection

No need for further data collection

10.5 References

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10.6 Annex

Table 52: Minimum number of samples to be taken in one reference year for carbon parameters

<table>
<tr><th colspan="4">1st AEVka</th><th colspan="2">UWWTD</th></tr>
<tr><th>Size class [PE]</th><th>BOD$_5$</th><th>COD</th><th>TOC</th><th>Size class [PE]</th><th>BOD$_5$ and COD</th></tr>
<tr><td>1,001 - 5,000</td><td>12</td><td>26</td><td>-</td><td>2,000 - 9,999</td><td>12 (first year), 4 (subsequent years)</td></tr>
<tr><td>5,001 - 50,000</td><td>52</td><td>104</td><td>26</td><td>10,000 - 49,999</td><td>12</td></tr>
<tr><td>> 50,000</td><td>104</td><td>260</td><td>52</td><td>≥ 50,000</td><td>24</td></tr>
<tr><th colspan="4">Compliance assessment as regards</th><th colspan="2"></th></tr>
<tr><td>% reduction</td><td colspan="3">Arithmetic mean of all % reductions measured within a reference year > minimum % reduction</td><td rowspan="2">% reduction and ELV</td><td rowspan="2">Maximum number of samples which are allowed to fail the requirements, expressed in concentrations (ELV) and/or % reduction.
For ELV the failing samples taken under normal operating conditions must not deviate from the parametric values by more than 100 %.</td></tr>
<tr><td>ELV</td><td colspan="3">Maximum number of samples which are allowed to fail the requirements and no measured value in a reference year must exceed the ELV by more than 100 %</td></tr>
</table>

ELV: Emission limit value: maximum concentration in the effluent

Table 53: Minimum number of samples to be taken in one reference year for nutrient parameters

1st AEVka				UWWTD	
Size class [PE]	**NH4-N**	**N_{tot}**	**P_{tot}**	**Size class [PE]**	**N_{tot} and P_{tot}**
1,001 - 5,000	104	-	52	2,000 - 9,999	12 (first year), 4 (subsequent years in case of no exceedance)
5,001 - 50,000	156	26	104	10,000 - 49,999	12
> 50,000	365	52	260	≥ 50,000	24
Compliance assessment as regards					
% reduction	-	Arithmetic mean of all % reductions measured within a year at 12°C wastewater temperature > minimum %-reduction	-	Compliance (% reduction and/or ELV)	Annual mean of the samples for each parameter shall conform to the relevant parametric values. N_{tot}: Alternatively, the daily average must not exceed 20 mg/L N at a water temperature of ≥ 12° C during the operation of the biological reactor of the UWWTP As a substitute for the condition concerning the temperature, it is possible to apply a limited time of operation, which takes into account the regional climatic conditions.
ELV	Maximum number of samples, which are allowed to fail the requirements and no measured value in one year must exceed the ELV by more than 100 %. Applies to samples taken from wastewater at temperatures of 12°C (≤5,000 PE) or 8°C (>5,000 PE)	-	Arithmetic mean of all measured values of a reference year ≤ ELV and no measured value exceeds the ELV by more than 100 %.		

ELV: Emission limit value: maximum concentration in the effluent

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Abbrevations

1st AEVka	First wastewater emission ordinance for UWWTPs > 50 PE (1. Abwasseremissionverordnung für kommunales Abwasser)
3rd AEVka	Third wastewater emission ordinance for urban wastewater (3. Abwasseremissionsverordnung für kommunales Abwasser)
AAEV	General Waste Water Ordinance (Allgemeine Abwasser-emissionsverordnung)
AD	Anaerobic digestion
AOX	Adsorbable organic halides
AT	Austria
BAC	Biologically activated granular activated carbon
BAWP	Austrian Federal Waste Management Plan
BOD_5	Biochemical Oxygen Demand within 5 days
CAPEX	Capital costs
CAS	Conventional activated sludge plant
COD	Chemical Oxygen Demand
CECs	Contaminants of emerging concern
CSO	Combined sewer overflows
DS	Dry substance
E1	Estrone
E2	17β-estradiol
EE2	17α-ethinylestradiol
EBM	Effect-based monitoring
EBT	Effect based trigger value
EC	European Commission
EIA	Environmental Impact Assessment
ELV	Emission limit values
EMREG-OW	Emission register surface water
EmRegV-OW 2017	National ordinance on an emission register for point sources
E-PRTR	European Pollution release and Transfer Register
EQS	Environmental quality standards

EQSD	Environmental Quality Standards Directive (2013/39/EU)
GAC	Granulated active carbon
GHG	Greenhouse gas
CHP	Combined heat power plant
GZÜV	Ordinance on the Monitoring of the Quality of Water Bodies (Gewässerzustandsüberwachungsverordnung)
IAS	Individual and appropriate systems
JRC	Joint Research Center
KAN	Sewer and wastewater treatment plant neighbourhoods (Kanal- und Kläranlagennachbarschaften)
mio	Million
MNQ/ Q_{95}	Mean annual low discharge
MQ	Mean annual discharge
MS	Member State
NAPV	Nitrate Action Program Ordinance (BGBl II No. 385/2017)
ND	Nitrates Directive (91/676/EEC)
NGP	Water Management Plan under the WFD (Nationaler Gewässerbewirtschaftungsplan)
NIR	National Greenhouse Gas Inventories (National Inventory Reports) under the UNFCCC
N_{tot}	Total nitrogen
OPEX	Operational costs
ÖWAV	Austrian Wastewater and Waste Association
PAC	Powder activated carbon
PAH	Polycyclic aromatic hydrocarbons
PBDE	Polybrominated diphenyl ethers
PCB	Polychlorinated biphenyl
PE	Population equivalent. 1 PE = organic biodegradable load having a five-day biochemical oxygen demand (BOD_5) of 60 g of oxygen per day
PFC	Perfluorinated compounds
PFOS	Perfluorooctanesulfonic acid
PNEC	Predicted no effect concentration

P_{tot}	Total phosphorus
QA/QC	Quality assurance/ quality control
QKchron	Chronic quality criteria
QZV Chemie GW	Quality Target Ordinance/Chemical Condition of Groundwater Qualitätszielverordnung Chemie Grundwasser
QZV Chemie OG	Quality Target Ordinance/Chemical Condition of Surface Water Qualitätszielverordnung Chemie Oberflächengewässer
QZV Ökologie OG	Quality Target Ordinance/Ecological Condition of Surface Water Qualitätszielverordnung Ökologie Oberflächengewässer
SBR	Sequence Batch Reactor
SRT	Sludge retention time
TOC	Total Organic Carbon
UNFCCC	United Nations Framework Convention on Climate Change
UWWTD	Urban Waste Water Treatment Directive (91/271/EC)
UWWTP	Urban waste water treatment plant
WFD	Water Framework Directive (2000/60/EC)
WG	Working group
WISA	Water Information System Austria
WRG	Austrian Water Act (Wasserrechtsgesetz)
WWT	Waste water treatment
WWTP	Waste water treatment plant

Federal Ministry of Agriculture, Regions and Tourism
Stubenring 1, 1010 Vienna, Austria
bmlrt.gv.at