Small-scale wastewater treatment systems in Austria –Situation, trends and developments

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Abstract
About 95 % of Austria's population (8.6 million) are connected to about 1'000 public wastewater treatment systems>500 P.E. The wastewater of the remaining 5 % is subject to decentralized treatment but the exact number of small WWTPs already implemented was unknown so far. Hence, the aim of this work was to provide a nationaloverview of small WWTPs (design size < 500 P.E.) including information on the type of technologies applied, the size distribution and age.The federal water information systems were used as database. The investigation revealed that currently about 30'000 small treatment systems are in place. The analyses showed that conventional activated sludge systems, SBRs and treatment wetlands have been the most popular treatment technologies during the last decades. In order to reach full coverage of biological wastewater treatment, approximately further30'000 to 40'000plants are needed in future.

Keywords
Wastewater treatment; small scale; treatment technologies; system distribution

INTRODUCTION

The population in Austria is about 8.6 million, the area about 84'000 km². About 1/3 of the population live in cities, 1/3 in villages and 1/3 in rural, mountainous areas, respectively. Hence, the population density is highly variable from 600 to 25'000 persons (P.)/km^2. Almost 25% of the municipalities have no closed settlement structure - a hint for the importance of decentralized infrastructure systems on small scale (Mollay and Neugebauer, 2011).

About 1'800 wastewater treatment plants with a capacity larger than 50 population equivalent (P.E.) serve about 95 % of the population (Table 1).The remaining 5 % of the population live in single houses and small settlements that require on-site wastewater treatment. At the time being, this share of the population uses storage and transport (cesspits) or small wastewater treatment systems (mechanical and biological). Whereas the number of decentralized plants>50 P.E. is known to be about 900 (OEWAV, 2015), there is no comprehensive data onsmaller plants.

OEWAV (2015) reports 13'836 existing WWTPs with a capacity of less than 50 P.E. However, this number includes only those small WWTPs that received subsidies from the national government for construction. Thelack of information is due to the responsibility of the nine federal states to implement the national water act (WRG, 1959), the high number of plants and a missing consolidation of data on national level. Further, district authorities grant permits for the systems, which leads to regional differences in terms of technology application.

Table 1: Existing wastewater treatment plants with capacity > 50 PE in Austria (BMLFUW, 2014).

Design size (PE_{60})	# WWTPs	% WWTPs	PE connected	PE connected
51 - 1.999	1'204	65.4	462'087	2.1
2.000 - 10.000	373	20.2	1'762'099	8.2
10.001 - 15.000	45	2.4	572'675	2.6
15.001 - 150.000	202	11.0	8'887'740	41.1
> 150.000	18	1.0	9'929'267	45.9
Sum	**1'842**	**100**	**21'613'868**	**100**

Since achievingfull coverage of the population with state-of-the-art biological wastewater treatment remains a challenge, more information on the status of Austria’s decentralized wastewater management is needed. The aim of this work was to gather information from all nine federal states on the current situationincluding information on the type of technologies applied, the size distribution of the plants, and age of the plants. Based on consolidated data, trends and regional differences in decentralized wastewater management should be identified.

MATERIALS AND METHODS

The data acquisition was based on the analyses of GIS based water information systems that have been implemented on federal state level over the last decade. The query of data comprised all permitted wastewater treatment plants <500 P.E. (mechanical and biological) available. The data gathered was then analysed for plant design size (grouped for plants <51 P.E. and 51-500 P.E), treatment technology and the date of operation permission. A preliminary report was compiled and harmonized with the responsible federal authorities to avoid miss interpretation and to incorporate additional information where available.

RESULTS AND DISCUSSION

Regional distribution of WWTPs

The estimated total number of small WWTPs in Austria is about 29'350 (Table 2), whereby about 930 WWTPs have size of 51-500 P.E. 25'270 WWTPs have been identified with design size less than 50 P.E. and for more than 3'000 WWTPs the design size is unknown. As data for WWTPs larger than 50 P.E. are reported in compliance to the Urban Wastewater Treatment Directive (91/271/EC), it can be assumed that the 3'000 WWTPs with unknown design size are below 50 P.E. Thus, the total number of WWTPs with design size less than 50 P.E. is estimated to be about 28'400. The regional distribution of the small systems is dependent on the settlement structures. The overview on Austria’s settlement distribution (Figure 1) shows the differences between the western federal states (Vorarlberg, Tyrol and Salzburg) and the eastern federal states with the clear influence of the Alps from the west of Vienna over the centre of the country to the Swiss border in the west.

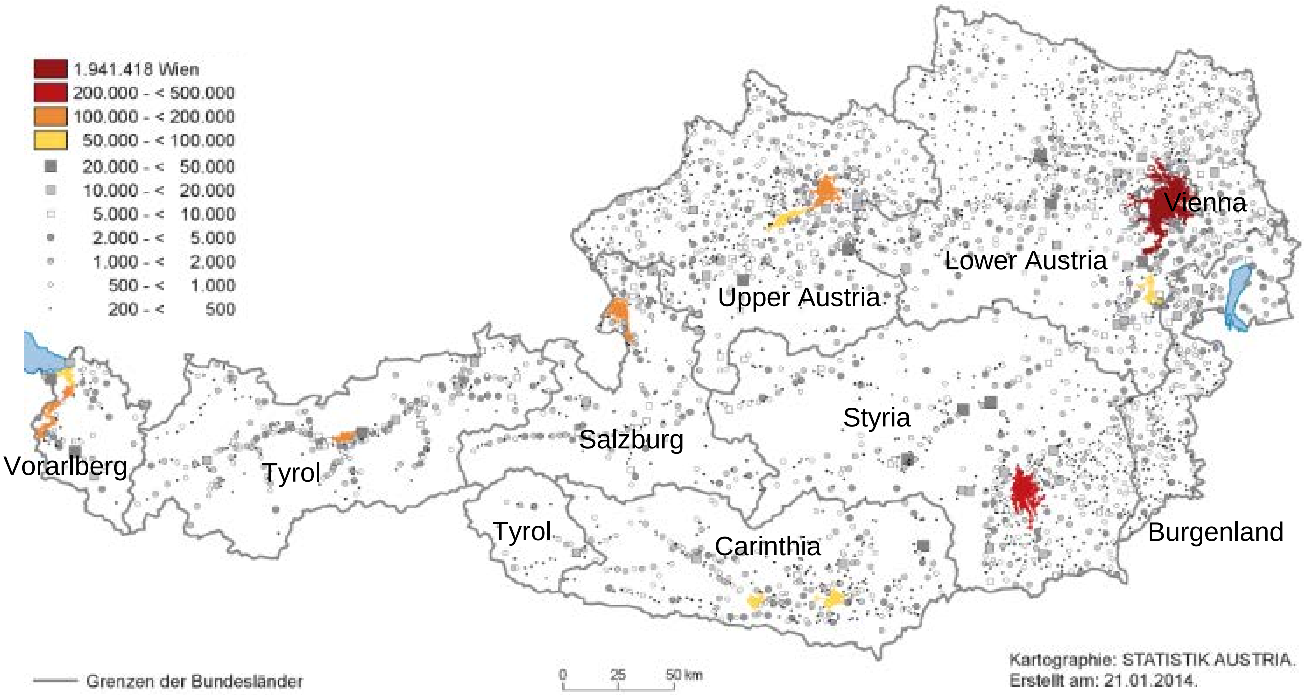

Figure 1. Distribution of settlement units in Austria [P., Source: Statistik Austria, 2016; adapted].

Throughout the Alpine regions, the settlements concentrate in the valleys with relatively low numbers of decentralized wastewater treatment systems in comparison to the low lands of the eastern regions with dispersive settlements and a high ratio of single housings outside of settlements. Compared to an average of 3.4 wastewater treatment plants per 1’000 persons for the whole country, Carinthia (south centre) and Styria (southeast) show with more than the double value the regional importance of decentralized wastewater management (Table 2).

Table 2. Total number and size distribution of wastewater treatment plants with design size < 500 P.E. in Austria.

Federal state	Population***	#WWTP/ 1’000 P.	# WWTPs, design size			
			< 500 P.E.	< 50 P.E.	51 – 500 P.E.	Unknown
Burgenland *	290’000	0.34	100	100	0	0
Carinthia	560’000	13.00	7'279	6'343	318	618
Lower Austria **	1‘640‘000	3.36	5'504	4'803	133	568
Salzburg	540‘000	3.21	1'732	1'612	75	45
Styria	1‘220‘000	8.80	10'731	9'178	53	1'500
Tyrol	730‘000	1.77	1'294	673	197	424
Upper Austria	1‘440‘000	1.75	2'524	2'398	126	0
Vienna *	1‘800‘000	0.02	32	32	0	0
Vorarlberg	380‘000	0.41	156	129	27	0
Total	**8‘600‘000**		**29'352**	**25'268**	**929**	**3'155**
Average		3.41				
Percentage			100%	86.1%	3.2%	10.7%

* Total number derived from older estimates.

** Total number estimated from 2'752 small WWTPs that were implemented with subsidies (KPC, 2016) and a ratio of 50 % between number of small WWTPs with subsidies and total number of small WWTPs; Size distribution estimated using average from Carinthia, Styria and Upper Austria.

***Source: Statistik Austria, 2015; rounded.

Distribution of treatment technologies

Table 3 shows the treatment technologies applied for wastewater treatment plants with design size < 500 P.E. Still more than 26% are classified as mechanical treatment, which are mainly old septic tanks from which pre-treated wastewater is discharged. This technology is no longer state-of-the-art and most of these WWTPs were implemented prior to 1991 and still have a valid operation permit. Since 1991, nitrification is required for all WWTPs. For plants with design size < 500 P.E. the maximum effluent concentrations are 25 mg BOD_5/L; 90 mg COD/L and 10 mg NH_4-N/L, respectively (1. AEVkA, 1996).

The main types on technologies used are activated sludge (27%), wetland systems (19%) and SBRs (12%). The number of wetland systems is thus estimated to be amount 5'700 and therefore much higher than former estimates that assumed "*more than 3'000*" wetland systems in Austria (Langergraber and Haberl, 2012).

Table 3. Treatment technologies applied for wastewater treatment plants with design size < 500 PE in Austria.

Federal state	Mechanical	Biological						Unknown **
		Activated Sludge	SBR	Trickling Filter	Fixed bed	Soil Filter	VF Wetland	
Burgenland *	26	27	12	2	2	6	19	6
Carinthia	1'911	3'137	573	8	55	306	563	726
Lower Austria *	1'452	1'475	645	134	98	307	1'069	324
Salzburg	313	255	285	84	55	373	290	77
Styria	2'928	2'123	996	323	297	463	3'182	419
Tyrol	709	132	128	53	9	87	75	101
Upper Austria	383	686	764	104	0	27	490	70
Vienna	2	21	1	3	1	0	3	1
Vorarlberg	19	10	36	3	4	68	10	6
Total	**7'743**	**7'866**	**3'440**	**714**	**520**	**1'636**	**5'702**	**1'730**
	26.4%	26.8%	11.7%	2.4%	1.8%	5.6%	19.4%	5.9%

* Technology distribution estimated using average from other 7 federal states.
** including 57 MBR plants and 119 RBC plants.

Distribution of design size and periods of implementation

In the following, the distribution of design size and implementation periods are described for the three most frequently applied biological treatment systems. Concerning the mechanical treatment systems,which represent about 25% of all systems, the technical design (e.g. septic tank) was not analysed in detail. The majority of these systems was implemented before 1991 as stated above. This fact and the following increase of the implementation of biological systems is due to the amendment of the water act in 1990 (Chovanec and Vogel, 1994), where the ‘state-of-the-art’ was defined as criterion for technology selection. Following this – with a compliance period of 15 years for systems < 2’000 P.E. – biological treatment applied for all system sizes.

Activated sludge systems. As Table 3 shows, conventional activated sludge systems account for about 27 % of all plants <500 P.E. The majority of plants have a design size between 5 P.E. and 10 P.E. (Figure 1). After the implementation of more than 3’000 plants in the late nineties, the number of new implementation is decreasing (Figure 2).

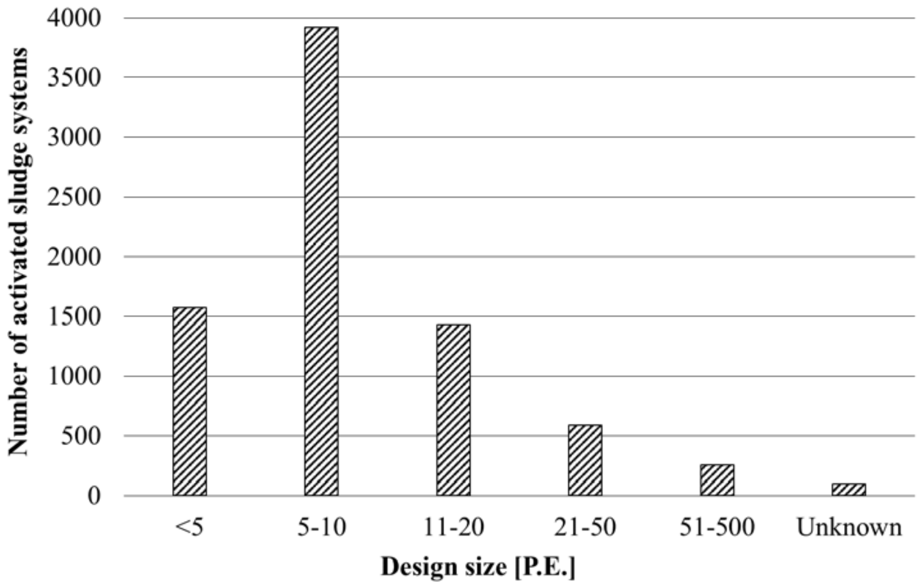

Figure 2. Design size distribution of activated sludge systems < 500 P.E. in Austria.

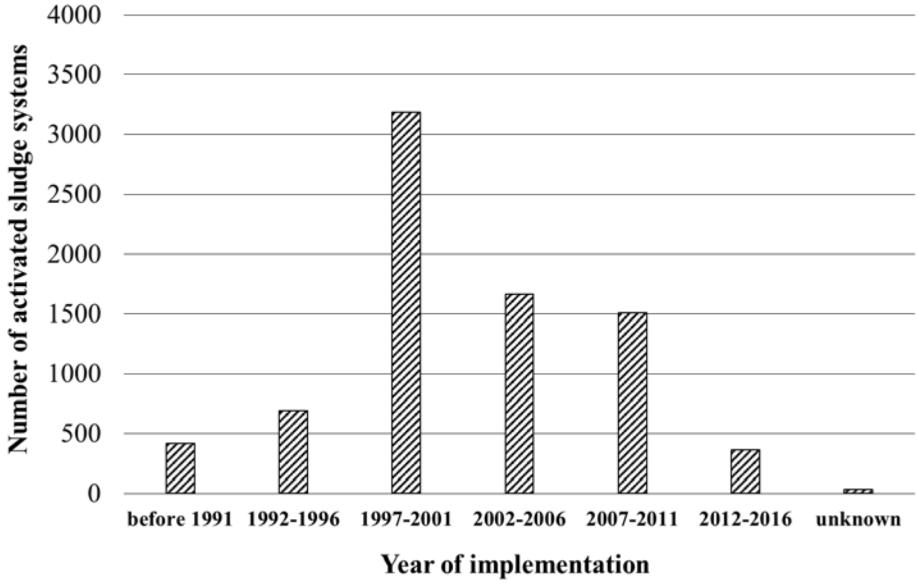

Figure 3. Periods of implementation of activated sludge systems < 500 P.E. in Austria.

Vertical Flow Treatment Wetlands. After conventional activated sludge systems, treatment wetlands are with about 5'700 plants the second most frequently applied treatment technology for decentralized wastewater treatment systems in Austria. The size distribution is also comparable to the AS systems (Figure 3), but the implementation periods showed that this technology gained more attention during the last fifteen years. In contrast to technical systems, they can be operated even without any electrical equipment (at sufficient terrain gradient) withlimited operation and maintenance requirements. These advantages led to broad application. Concerning the design size there are restrictions in some federal states (e.g. Lower Austria, < 70 P.E.) which limit the application.

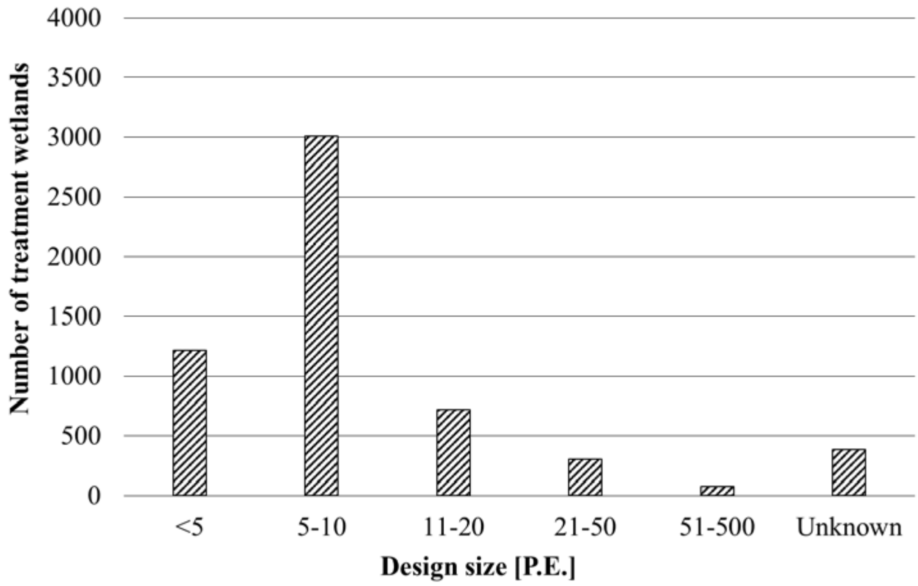

Figure 4. Design size distribution of VF treatment wetlands < 500 P.E. in Austria.

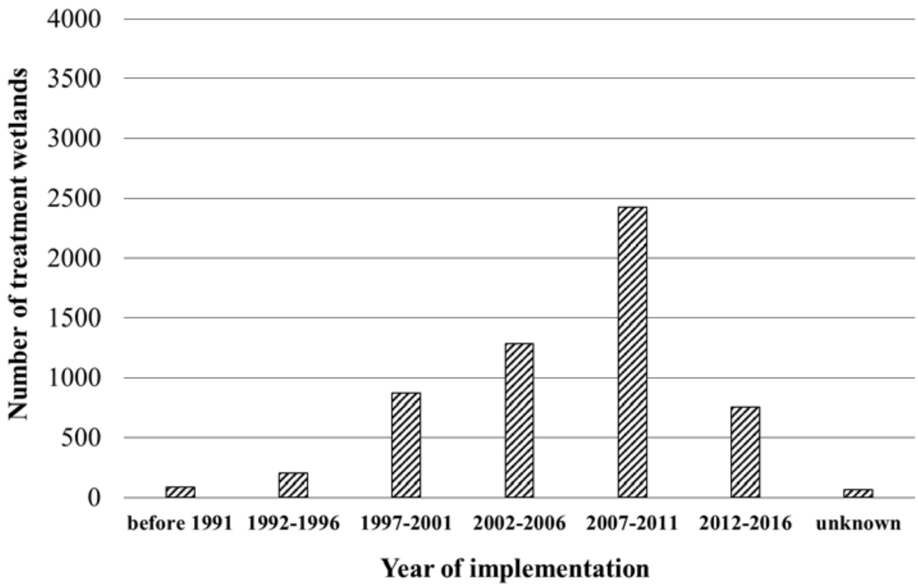

Figure 5. Age distribution of VF treatment wetlands < 500 P.E. in Austria.

Sequencing Batch Reactors. With almost 3’500 implemented systems (Table 3), SBRs are the third most frequently applied treatment technology in Austria. Again, the majority of plants has a design size between 5 P.E. and 10 P.E. Similar to the treatment wetlands, implementation numbers increased within the last decade (Figure 6). In comparison to the treatment wetlands, the SBR systems allow an easy implementation of phosphorus removal (with chemical dosing). This aspect is relevant in areas with sensitive receiving water bodies (QZV Chemie OG, 2006).

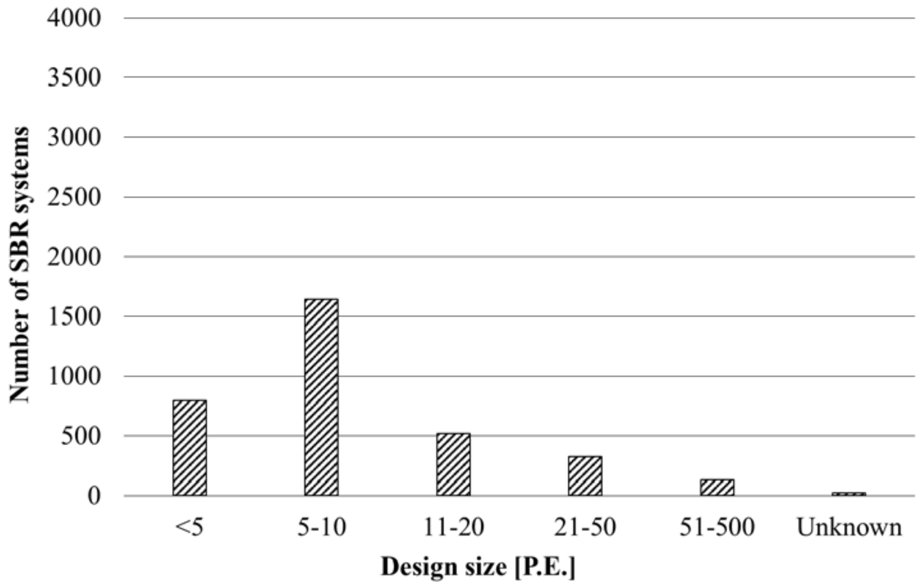

Figure 6. Design size distribution of SBR systems < 500 P.E. in Austria.

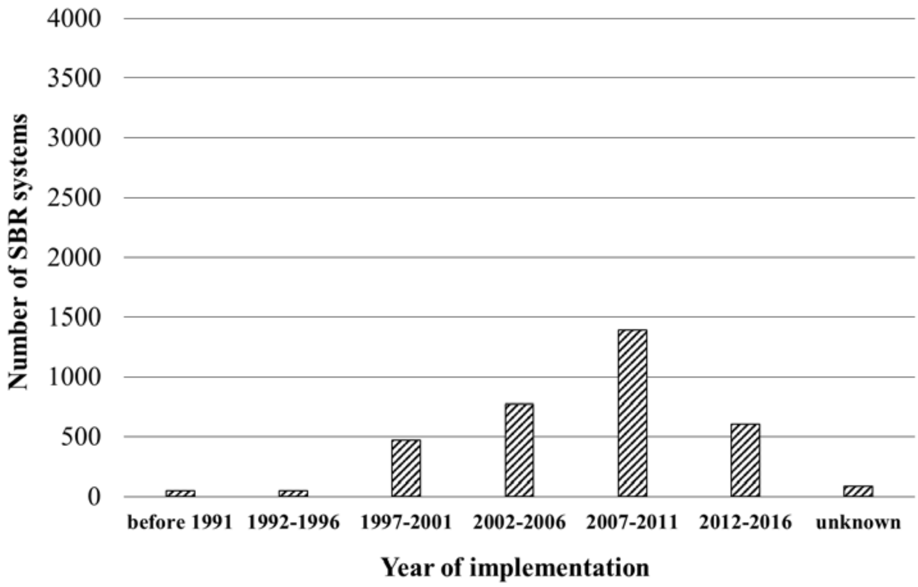

Figure 7. Design size distribution of SBR systems < 500 P.E. in Austria.

Future trends and developments

With the aim of a full coverage of the Austrian population,a number of 30’000-40’000 small-scale wastewater treatmentplants will be necessary in future. This assumption bases on a remaining part of maximal 3% of the population (250’000 P.), the same design size distribution as the existing systems, the full extension of mechanical systems with biological stages and finally the replacement of cesspit storage by on-site treatment. Certainly, the demographic development and settlement development will also influence the future need for decentralized wastewater management. According to Molley and Neugebauer (2011) further splinter development is the most realistic scenario for the rural areas. This means an ongoing trend towards decentralized systems. However, since wastewater infrastructure is currently publically subsidised, the future availability of public funds will therefore be crucial for system adaptation and implementation. In terms of information management, the currently available GIS platforms with public access are a good basis but the high number of plants and the lack of a common national database remain a challenge.

CONCLUSIONS

The analyses of the permits of all wastewater treatment plants < 500 P.E. showed the statusand an outlook of small-scalewastewater treatment in Austria:

- Conventional activated sludge systems, treatment wetlands and SBRs account for 80% of all biological wastewater treatment systems < 500 P.E. (and for 60% of all systems).
- About 25% of all systems < 500 P.E. are still systems with mechanical treatment stage only.
- Treatment wetlands and SBRs replaced conventional activated sludge systems over the last decade as most frequently applied technologies.
- Settlement structures and regional implementation policies led to differences in number, design size distribution and applied technologies between federal states.
- About 30’000 to 40’000 small wastewater treatment plants will be necessary in future to reach full coverage of the Austrian population with state-of-the-art decentralized wastewater treatment.

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REFERENCES

1.AEVkA (1996): 1. Abwasseremissionsverordnung für kommunales Abwasser (Austrian regulation for emissions from domestic wastewater). BGBl.210/1996, Vienna, Austria [in German].

BMLFUW (2014): EU Richtlinie 91/271/EWG über die Behandlung von kommunalem Abwasser - Österreichischer Bericht 2014 (EU Directive 91/271/EWG on Urban Wastewater Treatment - Austrian Report 2014). Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Vienna, Austria [in German].

Chovanec, A.,Vogel, W. (1994) Rechtliche Grundlagen des Gewässerschutzesin Osterreich. Umweltbundesamt Wien (Austrian EPA), Vienna, Austria [in German]

KPC (2016): Unpublished data.

Langergraber, G., Haberl, R. (2012): Constructed wetland technology in Austria – History, current practices and new developments. Sciences Eaux & Territoires 9 (December 2012), 32-34. http://www.set-revue.fr/recherche-et-ingenierie-au-service-des-acteurs-de-l-assainissement (last access: 26 June 2016).

Mollay,U.,Neugebauer,W. (2011) Auswirkungen der Raumplanung – Szenarien der Siedlungsentwicklung. ExpertInnen Workshop EISERN, 22.09.2011, Österreichisches Institut für Raumplanung. [in German] http://oir.at/files/eletter/e2011_11/EISERN_Siedlungsenwicklung_OIR_20110922.pdf (last access: 4th July 2016).

OEWAV (2015): Branchenbild der österreichischen Abwasserwirtschaft 2016 (Sector report on wastewater management in Austria 2016). Österreichischer Wasser- und Abfallwirtschaftsverband (ÖWAV), Vienna, Austria [in German].

QZV Chemie OG (2006) Qualitätszielverordnung Chemie Oberflächengewässer;BGBl. II Nr. 96/2006. Vienna, Austria [in German].

WRG (1959) Wasserrechtsgesetz (Austrian Water Act), Bundesgesetzblatt No. 215/1959, i.d.g.F. [in German].