Beyond Utility Reach?

How to Close the Rural Access Gap t/o Wastewater Treatment and Sanitation Services

Rural Wastewater Treatment Workshop

January 19-20, 2021

Background document

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Executive Summary

Rural wastewater management is a challenge in all countries of the Danube region. The UN Sustainable Development Goal 6 (SDG 6) on "*Clean Water and Sanitation*" specifically addresses the topic of wastewater management by Target 6.2. (achieve access to safely managed sanitation systems for all) and Target 6.3. (improve water quality by reducing pollution).

Most countries in the Danube basin are either EU Member States, Candidate Countries or Potential Candidates, thus the EU legislation forms the basis. For Moldova and Ukraine, the EU legislation also is a benchmark, as water quality goals should be achieved for the whole basin.

The Urban Wastewater Treatment Directive (UWWTD) regulates the treatment of wastewater from agglomerations larger than 2'000 population. For agglomerations smaller than 2'000 PE, the UWWTD does not give general criteria, just that an "appropriate treatment" shall be foreseen so that after discharge receiving waters can meet the relevant quality objectives. For small WWTPs, most counties only apply discharge limits organic matter (BOD_5 and/or COD) as well as TSS which are in general less stringent than the limits of the UWWTD for WWTPs > 2'000 PE.

According to the UWWTD, WWTPs below 2'000 PE or IAS (individual or other appropriate systems) in the EU legislation should be seen as an exception and connection to centralised systems is favoured. However, there is a very large number of agglomerations smaller than 2'000 PE in the Danube region and a large number of small WWTPs already exist.

Technologies that are simple and robust and that have low operation and maintenance requirements and costs are most suitable for rural areas. A number of studies show that natural treatment technologies such as treatment wetlands are a good option especially for rural areas. Treatment wetland achieve same if not better treatment performance when compared to technical solutions.

Design standards for small WWTPs that allow reaching country specific discharge limits might facilitate the implementation. Training of owners/operator of small WWTPs is key as authorities will not be able to monitor the performance of all small WWTPs just by the high number of these systems. Trained persons take better care of their WWTP, i.e. they take better care of the required operation, monitoring and maintenance work. This results overall in better working WWTPs allowing achieving improve water quality of small receiving waters in rural areas.

1. Introduction to sanitation and wastewater treatment

The UN Sustainable Development Goal 6 (SDG 6) on "*Clean Water and Sanitation*" aims to ensure availability and sustainable management of water and sanitation for all (https://sdgs.un.org/goals/goal6). Access to water and sanitation are recognized by the United Nations as human rights, reflecting the fundamental nature of these basics in every person's life (https://www.unwater.org/water-facts/human-rights/).

Within SDG 6, sanitation and wastewater treatment are specifically covered in Targets 6.2. and 6.3.:

- Target 6.2.: By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.
- Target 6.3.: By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.

Target 6.2. asks for safely managed sanitation systems, i.e. a private improved facility where faecal wastes are safely disposed on site or transported and treated off-site and additionally, have a handwashing facility with soap and water (UN Water, 2018). Lack of access to safe, sufficient and affordable water, sanitation and hygiene facilities has a devastating effect on the health, dignity and prosperity of billions of people. The achievement of Target 6.2. is measured by indicator 6.2.1 by the proportion of population using safely managed sanitation services, including a hand-washing facility with soap and water. In the region, about 22 million people remain without access to flush toilets (World Bank Group, 2018).

Collected but untreated or poorly treated faecal sludge and wastewaters can discharge organic substances, nutrients and hazardous substances (e.g. pathogens, micropollutants with acute or chronic toxicity, persistent substances, carcinogenic, mutagenic or teratogen chemicals, endocrine disrupt substances) in considerable amount into surface and subsurface water bodies. Urban and rural developments, connected to the sewer systems and to wastewater treatment plants with inappropriate treatment technology, are the most important contributors of surface water contamination via point sources. The achievement of Target 6.3. is measured by two indicators:

- Indicator 6.3.1: Proportion of wastewater safely treated
- Indicator 6.3.2: Proportion of bodies of water with good ambient water quality

The SDG 6 Synthesis Report on Water and Sanitation (UN-Water, 2018) clearly demonstrates that achieving Targets 6.2. and 6.3. lacks behind achieving Targets 6.1. (achieve universal and equitable access to safe and affordable drinking water for all).

2. EU legislation and practice relevant for rural wastewater management

2.1. Relevance of the EU regulation for the Danube region

Water management across the EU must respond to a number of legislative acts which lead to concrete actions and investments in the Member States. All these actions and investments are aimed at improving the quality of the waters.

The Danube River basin (DRB) comprises EU Member States (Figure), Candidate Countries (Albania, Montenegro, North Macedonia, Serbia), Potential Candidates (Bosnia and Herzegovina, Kosovo) as well as other countries (Moldova, Ukraine) (https://europa.eu/european-union/about-eu/countries_en). Within a river basin, it is important to encourage all countries – including Non-EU Member States to ensure appropriate level of treatment of wastewater to achieve the water quality goals of the basin. Thus, the EU regulation regarding wastewater treatment is the benchmark also for the Non-EU Member States in the Danube region.

Figure A: EU Member States in the Danube region (https://europa.eu/european-union/about-eu/countries_en).

2.2. EU legislation on urban wastewater treatment

The EU Urban Wastewater Treatment Directive (UWWTD, 1991) regulates the treatment of wastewater from agglomerations larger than 2'000 population. According to Article 2(4), 'agglomeration' means "*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*".

Fulfilment of the UWWTD requires that member states ensure that urban wastewater

- is collected in all agglomerations larger than 2'000 PE (UWWTD Article 3)
- is treated according to the requirements given in the UWWTD (UWWTD Article 4), and
- is more stringently treated in sensitive areas (UWWTD Article 5).

General required treatment levels for WWTPs larger than 2'000 PE as well as more stringent treatment levels for sensitive areas are defined in the annex of the UWWTD.

Figure 1 shows the share of population connected to sewage collection systems of varying treatment levels in 12 countries in the Danube region. At basin scale, more than 60% of the organic emissions into surface water via urban wastewater stem from agglomerations with existing sewer systems but without treatment. For nutrients, these figures are 30% (nitrogen) and 40% (phosphorus). Considering that these agglomerations represent only 10% of the total PE of the basin, implementation of measures for a relatively small proportion of the agglomerations can result in substantial progress. The pollutant discharges of the new EU MS and the non-EU MS are substantially influenced by untreated wastewater releases (Danube Region Strategy, 2016).

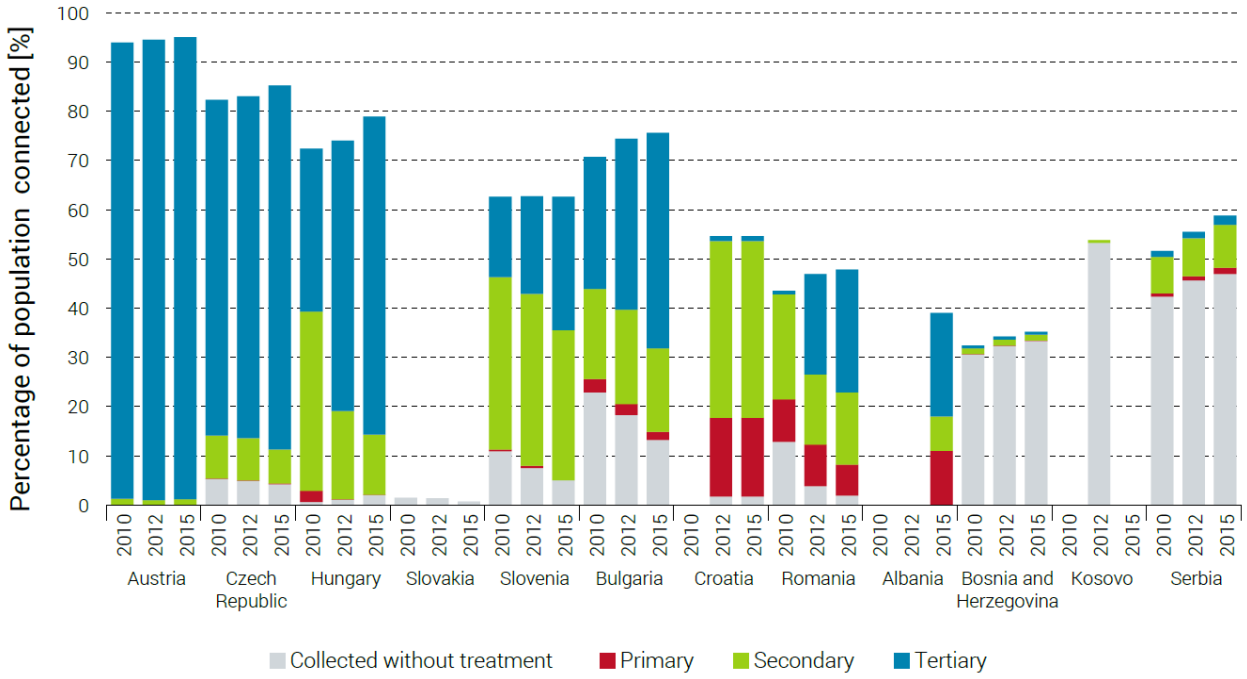

Figure 1: Share of population connected to sewage collection systems of varying treatment levels in the Danube region in 2010, 2012 and 2015 (World Bank Group, 2019).

Figure 2 the share compliance with UWWTD Articles 3, 4 and 5, respectively, in Danube EU member states. Figure 3 shows the compliance with Article 4 (treatment) of the UWWTD in Danube EU member states at regional level. The level of connection and treatment compliance varies significantly in the Danube River Basin (DRB) whereby upstream states generally show higher rates compared to downstream states. Data on Non-EU Member States are not reported in the EU reports.

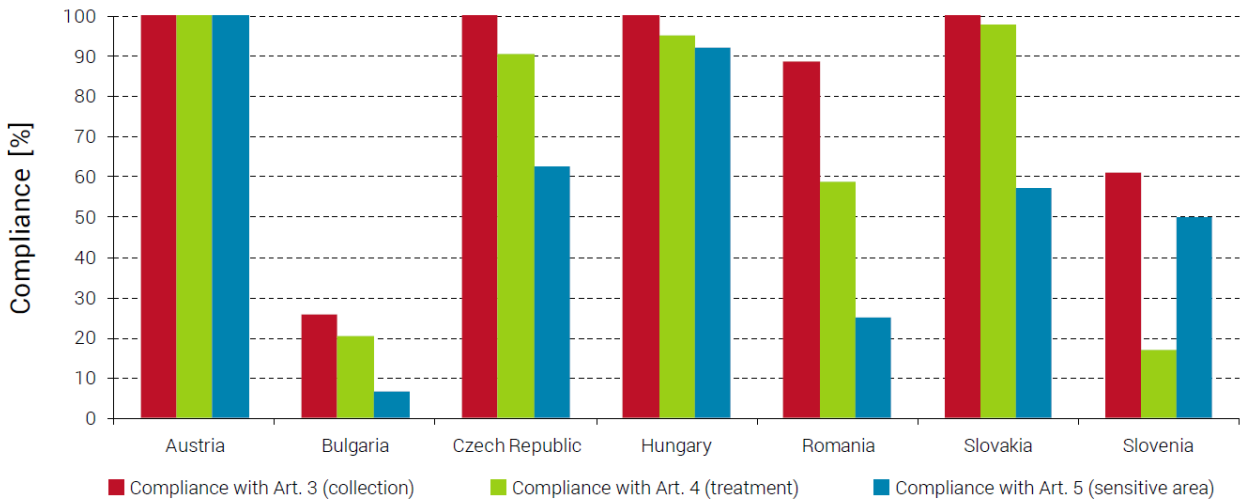

Figure 2: Share of compliance with UWWTD Articles 3, 4 and 5 in Danube EU member states (World Bank Group, 2019).

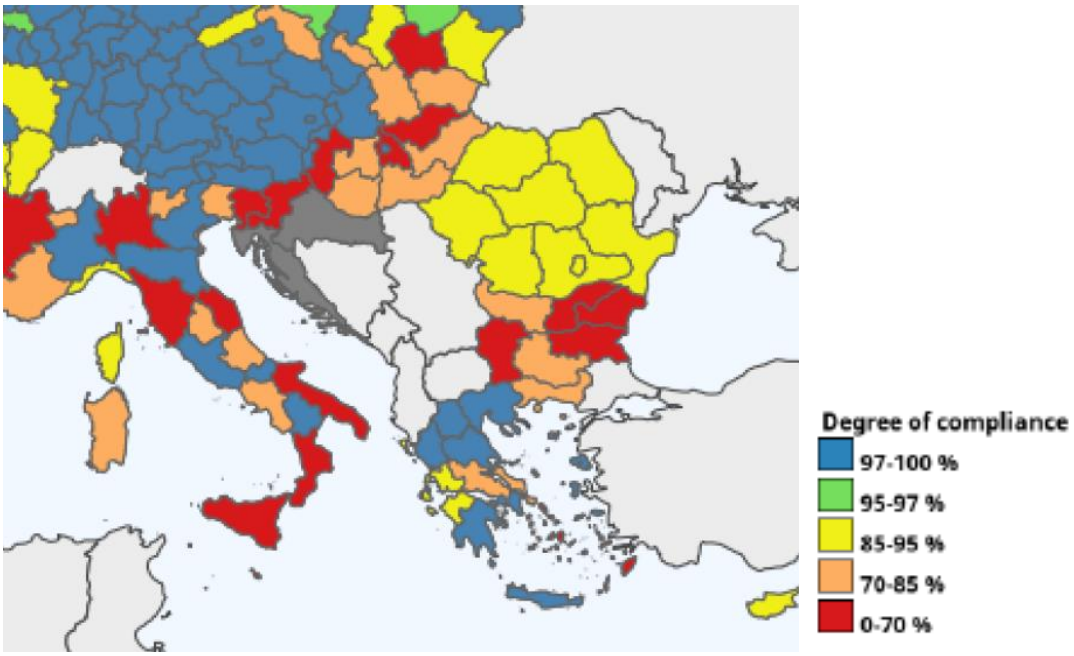

Figure 3: Map of compliance with Article 4 (treatment) of the UWWTD at regional level in 2016; Croatia not subject to compliance due to ongoing transition period until 2023 (adapted from EC, 2020a).

2.3. Relevance of the UWWTD for rural wastewater management

The UWWTD does not give general criteria 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 "*means treatment of urban waste water by any process and/or disposal system which after discharge allows the receiving waters to meet the relevant quality objective*".

Thus, appropriate treatment for agglomerations of less than 2'000 PE discharging to fresh-water and estuaries should have been achieved by 31 December 2005 for old EU Member States and according to the date of joining the EU later for new EU Member States.

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

According to the "*Guidance on the correct interpretation of UWWTD*" (EC, 2007), IAS are considered a compliant approach under the following conditions:

- Requirements for design, construction and maintenance of IAS to ensure 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.

Currently, the revision of the UWWTD is discussed, whereby 20 points have been listed as potential revisions raised for discussion (EC, 2020b). Currently a survey under EU Member States regarding these potential revisions is carried out. The following two revision points have strong relevance for rural areas:

- Smaller agglomerations:
  - decrease threshold of agglomeration from 2000 to 1000, 500 or 200 PE
  - EU fixed approach to define agglomerations of PE per ha
- Individual or other Appropriate Systems (IAS)
  - 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
  - Control of design and functioning: EU standards for IAS design (linked to Construction Products Regulation) combined with maintenance instructions.

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

2.4. Importance of rural wastewater treatment

Figure 4 shows the wastewater load connected to IAS per EU Member State in 2016. The highest load of EU Member States in the DRB comes from Hungary with more than 1.4 million PE, followed by Slovakia with about 600'000 PE and Bulgaria and Czech Republic with more than 500'000 PE

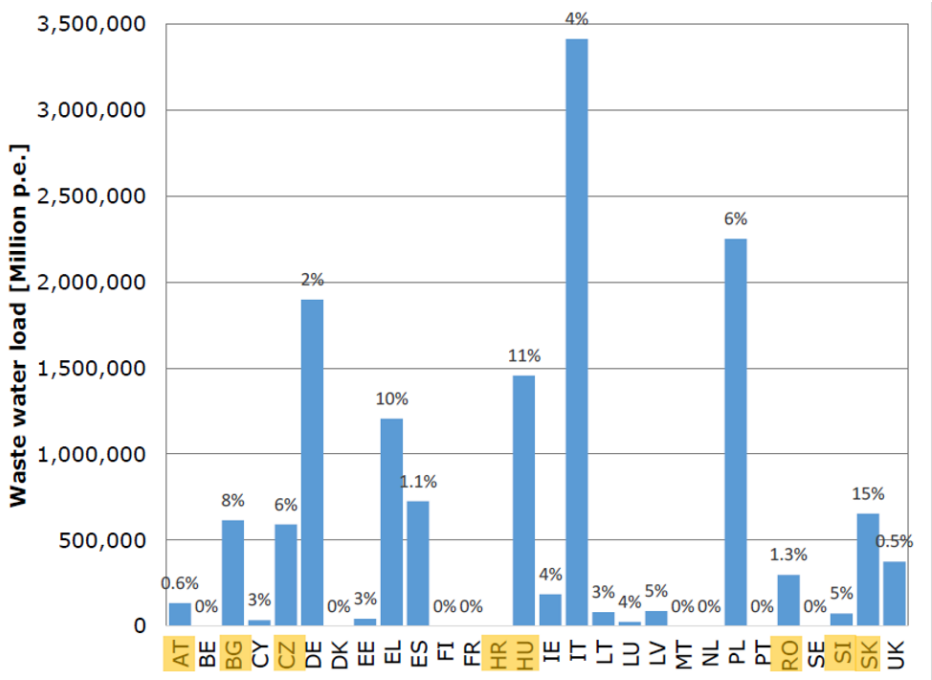

Figure 4: Wastewater load in PE connected to IAS per EU Member State in 2016, EU Member States in the DRB are marked in orange (adapted from EC, 2020a).

Pistocchi et al. (2019) investigated the influence of the IAS to the receiving water quality. Figure 5 shows the increase of BOD_5, N and P in streams assuming that all agglomerations would be at full compliance and all IAS correspond to only primary treatment instead of full compliance. The highest impact from IAS on receiving water quality in the DRB countries was found for Hungary, Croatian and Slovakia. As receiving waters of IAS in rural areas are often small IAS represent a potentially significant residual share of the pollutant load discharged to the receiving water bodies.

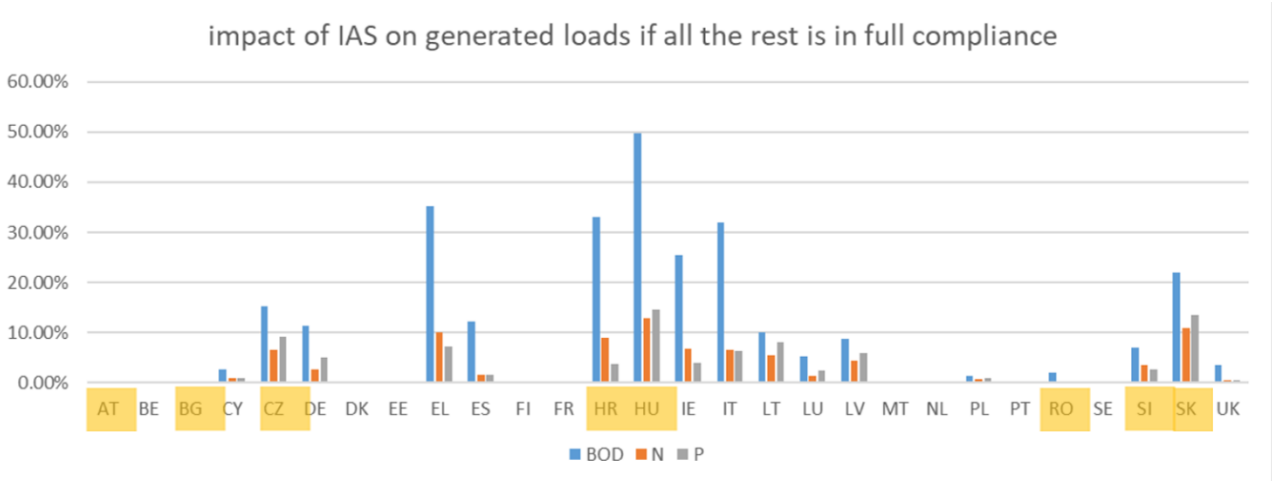

Figure 5: Potential load assuming IAS correspond to a primary treatment, as a percentage of the total load under full compliance, for BOD_5, N and P from wastewater, EU Member States in the DRB are marked in orange (adapted from Pistocchi et al., 2019).

Figure 6 shows the spatial distribution of emissions (in PE) from IAS and improvement of river water quality in terms of BOD_5 if all IAS treat the wastewater according to the UWWTD requirements. According to Pistocchi et al. (2019), the impact of IAS in terms of BOD_5 is potentially significant, but lower than for coliforms, with certain regions increasing the length of the stream network below good status thresholds by up to more than 20% (Figure 6, right).

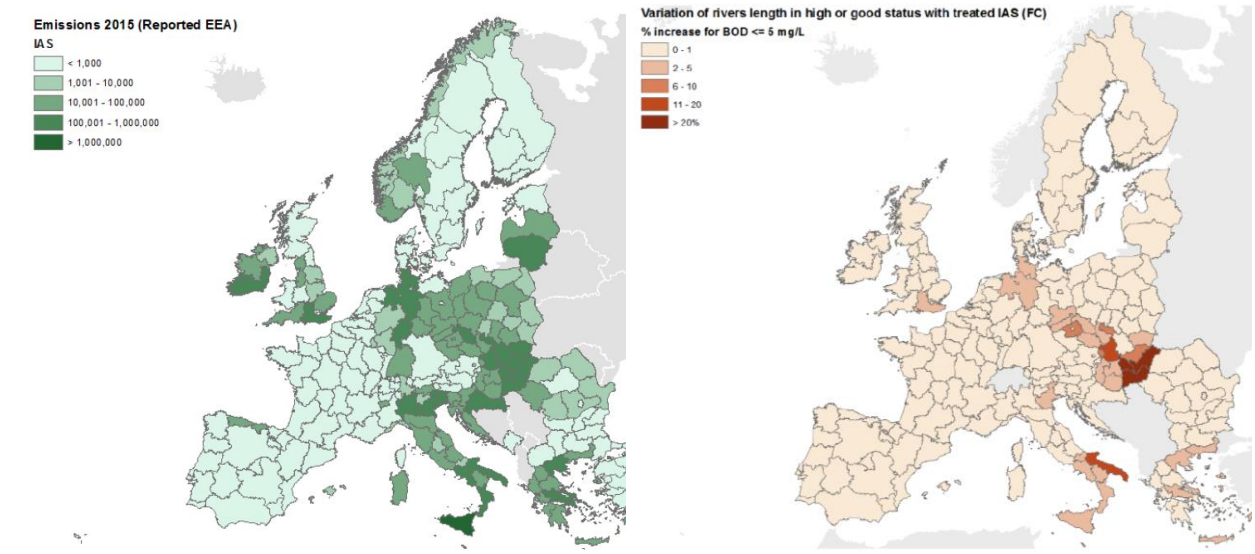

Figure 6: Spatial distribution of emissions (in PE) from IAS (left) and improvement of river water quality in terms of BOD_5 if all IAS treat the wastewater according to the UWWTD requirements (right: %-age of increase of river length with good water quality) (Pistocchi et al., 2019).

3. National legislation in and practice of rural wastewater management in the Danube River Basin

3.1. Legal requirements for small WWTPs

In general, most EU Member states in the DRB apply for WWTPs < 2'000 PE only discharge limits for organic matter in terms of BOD_5 and/or COD as well as for TSS discharge limits (Table 1). Usually the discharge limits for small WWTPs less than 2'000 PE are higher than the UWWTD requirements for larger 2'000 PE (i.e. 15 mg BOD_5/l, 125 mg COD, and 35 mg TSS/l). In the Czech Republic, for WWTPs between 500-2'000 PE also a limit for ammonium nitrogen (NH_4-N) applies. In Austria, Hungary and Romania NH_4-N discharge limit applies for all small WWTPs; for Hungary also TP discharge limits for all small plants, in Austria TP discharge limits apply for plants larger 1'000 PE.

Table 1: Comparison of main discharge limits for WWTPs < 2'000 PE in selected DRB countries.

Country	**Design size** (PE)	Parameter				
		BOD_5 (mg/l)	**COD** (mg/l)	**TSS** (mg/l)	**NH_4-N** (mg/l)	**TP** (mg/l)
Austria	≤ 50	25	90	-	10 [1]	-
	51-500	25	75	-	5 [1]	-
	501-5'000	20	75	-	5 [1]	1 [2]
Czech Republic	< 500	40	150	50	-	-
	500-2'000	30	125	40	20	-
Hungary [4]	< 500	80	300	80	4	4
	500-2'000	50	200	75	4	4
Romania [4]	≤ 2'000	20	125	60	15	2
Serbia	≤ 600	80	-	100	-	-
	601-2'000	50	-	75	-	-
Slovakia	≤ 50	40	-	-	-	-
	51-2'000	30	135	30	-	-
Slovenia	< 50	-	200	-	-	-
	50-2'000	30	150	-	-	-
Ukraine [4]	≤ 2'000	15	80	15	0.39	-
UWWTD	> 2'000	25	125	35	-	- [3]

[1] NH_4-N discharge limits are linked to wastewater effluent temperature, i.e. 12°C for WWTPs < 5'000 PE; [2] for WWTPs > 1'000 PE; [3] for WWTPs > 10'000 PE; [4] according Bodík et al. (2012).

Candidate Countries and Potential Candidates usually have adjusted already their legislation towards the UWDDT and already similar requirements as EU Member States (see e.g. Serbia in Table 1). Albania is currently on the way to adopt their wastewater regulation to be in line with the EU regulation.

However, in Bosnia and Herzegovina no specific regulation has been determined for agglomerations smaller than 2000 PE and relatively significant percentage of the population rely on self-provision of water and sanitation services. Most small communities (< 2'000

people) do not have WWPTs or no specific investments have been implemented for small settlements (Danube Region Strategy, 2016).

Legal requirements for Ukraine (Table 1) are the most stringent for small plants, they are even stricter than for large plants in the EU. Discharge limits of < 0.4 mg NH_4-N/l are almost impossible to fulfil for smaller WWTPs of any technology.

3.2. Design guides or norms for small WWTPs

In most countries, no specific design guides or norms exist or have to be applied. The requirements are defined through effluent quality that needs to be consistently achieved. Usually a permit has to be given to each WWTP, whereby authorities can decide on more stringent discharge requirements for sensitive receiving water bodies.

In several countries, the European standard EN 12556 for compact technical WWTPs less than 50 PE is used. The certification procedure requires testing for organic matter removal and thus cannot be applied in countries where NH_4-N discharge limits are existing.

Austria has specific design guidelines for small WWTPs ≤ 50 PE, i.e. Ö-NORM B 2502-1 (2012) for technical plants and Ö-NORM B 2505 (2009) for treatment wetlands. If small WWTPs are designed according to these design standards, the process for getting the permission for operating the WWTP is simplified (Langergraber et al., 2018).

3.3. Management and monitoring of small WWTPs

In general, monitoring intervals and parameters to be monitored are given in the permits of the individual WWTP. Monitoring of small WWTPs is poorer compared to larger WWPTs in all countries.

In Austria, self-monitoring below 50 PE usually includes weekly routine checks if the WWTP is working properly and monthly sampling and analysis of the following parameters: temperature and pH of effluent, effluent concentration of ammonia nitrogen and settleable solids, and (if applicable) the sludge volume. All results gained from self-monitoring as well as operational and maintenance work have to be documented in an operations diary. Besides self-monitoring, external monitoring is requested. External monitoring has to be carried out in specified intervals (e.g. once per year or every two year). In some federal states, the period of the external monitoring will be extended, e.g. from two to three years, if owners of WWTPs successfully complete the training course for operators. During external monitoring, effluent samples are analysed and the operations diary including the data gained from self-monitoring is checked and evaluated. Reports from external monitoring are sent to the local authorities for evaluation. To get the permission several local authorities request that owners have a contract for operation and maintenance with a company and/or that owners of WWTPs take part in the training course for operators. Once the 1.5 days training course is passed successful, the authorities may increase the interval for the external monitoring (Langergraber et al., 2018).

One main objective of the trainings for operators of small WWTPs is that the likelihood that these plants are also operated well increases if owners/operators are trained. This is required because these small WWTPs are less often monitored and evaluated.

The Austrian Wastewater and Waste Association ÖWAV is responsible for the training of operators of wastewater treatment plants. In most Danube region waterworks and wastewater associations offer trainings among their services (World Bank Group, 2019) and thus these associations should also be including trainings for operators of small WWTPs in their portfolio. A short summary on the situation in relation to policy-making and sector

institutions, service provisions and service coverage is given for Serbia, Bosnia and Herzegovina, Montenegro, Moldova and Ukraine in Table 2.

Table 2: Summary on policy-making and sector institutions, service provisions and service coverage for wastewater in Serbia, Bosnia and Herzegovina, Montenegro, Moldova and Ukraine (adapted from Danube Region Strategy, 2016).

	Policy-making and sector institutions	**Service provisions**	**Service coverage**
RS	Five main ministries constitute the national institutional framework of the water sector, with no clear line ministry and often overlapping mandates.	Local governments are responsible for water and wastewater service provision through 152 public utility companies. In rural areas, inhabitants rely on self-provision.	Only 11% of the population is connected to wastewater treatment. Effluents are treated mostly below UWWTD standards, resulting in significant environmental and public health hazards. Most small communities (<2,000 people) do not have public wastewater collection and treatment plants.
BIH	The sector is controlled and regulated at different administrative levels. Despite the existence of two clear line ministries, some overlaps can be noted.	Local governments are responsible for water and sanitation services and provide them through 142 public utility companies. 42% of the population relies on self-provision.	Only 3% of the population is connected to wastewater treatment plants.
ME	The sector is controlled and regulated at the national level by several ministries, with one clear line ministry. Local water and wastewater service providers are regulated and controlled by five national institutions.	Municipalities provide water and wastewater services to their population. Local governments are responsible for water and wastewater services and provide them through 22 public utility companies.24% of the population rely on self-provision	Only 18% of all wastewater produced is effectively treated, mostly below the Urban Waste Water Treatment Directive standards, resulting in significant environmental and public health hazards. However, the situation in urban and rural areas is markedly disparate.
MD	Several ministries and agencies regulate the water sector.	Municipal utilities are in charge of water provision. Currently, throughout the country, 52 municipally owned operators provide water and sanitation services to 43% of the population mainly located in urban areas. The rest of the population (57%) relies on self-provision	However, there are significant coverage differences between urban and rural areas. In urban areas, 50% of the population is connected to a public collective sanitation system, with rates ranging from 30% to over 90%. In fact, the rate of connection in big municipalities Chisinau and Balti, (both out of the Danube River basin) is more than 90%. According to various estimates, from 1% to 5 % of rural population is connected to the wastewater collection system, and practically, no rural wastewater is treated. Eleven percent of inhabitants in rural villages use unimproved sanitation solutions, causing major risks of health hazards and environmental pollution.
UA	The sector is controlled at the national level by several institutions. Several ministries and agencies control the water sector at the national level, with no clear line ministry and mandate overlaps. There is a lack of rational and optimal distribution of responsibilities among the administrative authority levels	Local self-governments are the owners of water and wastewater infrastructure. 35% of the population relies on self -provision.	Only 37% of the population, most of which live in urban areas, is connected to a wastewater treatment. Only over a third of the wastewater collected is effectively treated, resulting in a large volume of untreated wastewater being directly discharged into the environment, causing pollution and health hazards

4. Studies on rural wastewater management in the DRB

4.1. General European studies including issues of rural wastewater management

The evaluation study of the UWWTD (EC, 2019) made some general comments/suggestions regarding the relevance of rural wastewater management:

1. Small agglomerations and non-connected dwellings can be a factor in not reaching good status under the WFD. The impact of small agglomerations and non-connected dwellings and their discharges depends on local conditions such as the discharge point and the type and size of the receiving water body. It is expected that in many small agglomerations substantial use of IAS is made.
2. The UWWTD is not clear on how costs and benefits need to be assessed in order to ascertain whether IAS could be used, what 'sufficiently concentrated' means in the context of agglomerations or how Member States need to monitor the effectiveness of IAS use.
3. At technical level, the ISO EN 12566 standard prescribes rules for IAS used for up to 50 inhabitants. Not all technologies described in this standard treat the wastewater to the same level. Few Member States adopted stricter standards for IAS to address their concerns about having a negative environmental impact on small receiving waters in rural areas.

Wood et al. (2019) conclude that

- increased pressures on wastewater infrastructure may result from migration away from rural areas has led to the reduction in the size of agglomerations and the reduction in the wastewater generated and this in turn can lead to over-dimensioned plants, and
- rural areas are relying on small scale water sanitation systems which often provide lower levels of service. These systems are often operated by untrained or undertrained individuals who lack specialised knowledge and have limited awareness on the requirements of water and sanitation services. Due to the sheer number of such systems, their location (on private properties or in remote areas) it is often challenging for the competent authorities to access and inspect these.

4.2. Studies specifically on rural wastewater management in the DRB

Several studies have been carried out specifically for the Danube Region. The main recommendations from these studies related to rural wastewater management are:

1. ***Study on the experience of implementation of the UWWTD in EU Member Countries*** (Umweltbundesamt and IOW, 2017)

   Rural areas have been not the focus of this study, however, some recommendations regarding smaller settlements and IAS have been provided, i.e. that the UWWTD should

   "provide more flexibility on the choice of technology especially in rural areas and small towns:

   - *In rural areas or small settlements, just above 2'000 PE, some flexibility should be given to local utilities to adopt measures such as green infrastructure or nature-based solutions that could be well adapted to their issues, less costly, sufficient to achieve WFD objectives, and financially sustainable. The concept*

and definition of "individual and other appropriate systems" could be revisited and considered as an alternative sanitation solution.

- *Wastewater treatment facilities with secondary treatment tend to have significant O&M costs that need to be covered by wastewater system users. In some situations, extensive "nature near" ecological WWTP solutions (such as constructed wetlands or lagoons) may be favoured because they have significantly lower O&M costs and can achieve required level of pollution reduction with smaller per PE costs.*
- *Development of a modular conception of WWTPs may also help in reducing O&M costs, through allowing use of part of the treatment plant depending on received load (e.g., in situations of major load variations, as in seasonal tourist areas)."*

Comment: This statement proposes the use of nature-based wastewater treatment with treatment wetlands for smaller communities. However, from the statement it could be concluded that treatment wetlands treat wastewater less effectively compared to technical solutions (such as activated sludge). This is misleading and a common false understanding, treatment wetlands if properly designed and constructed can achieve the same if not better treatment levels as technical solutions.

2. ***Study on wastewater treatment in the Danube region: opportunities and challenges*** (Pistocchi et al., 2020)

The JRC-study (Pistocchi et al., 2020) comprises two feasibility studies: (1) for small decentralized wastewater treatment solutions in a rural area of Slovenia, and (2) a centralized wastewater treatment solution for two municipalities in Serbia.

For feasibility study 1 (decentralized solutions), Pistocchi et al. (2020) describe the advantages and disadvantages of various technologies for the application in rural areas. The considered technologies included

- Technical solutions:

  Membrane bioreactor (MBR) and Sequencing batch reactor (SBR).
- Treatment wetlands:

  Free Water Surface (FWS) wetlands, Horizontal Flow (HF) wetlands, Vertical Flow (VF) wetlands and Hybrid wetlands.
- Enhanced treatment wetlands:

  Forced-bed aeration (FBA) and French Reed Bed (FRB, or French VF wetland).
- Solutions with reuse and resource-utilisation in mind:

  Algae bioreactors, Evaporative willow systems and reuse of the treated wastewater after HF and VF wetlands.

It has to be noted that not all technologies investigated result in the same treatment level.

Various wastewater treatment solutions for three villages (with population of 220, 300 to 820, respectively) have been designed and evaluated against costs, social acceptability, technical issues and ecosystem services by experts and stakeholders.

The outcomes of the study suggest that there are considerable advantages for the development of decentralized wastewater treatment through nature-based solutions, i.e. treatment wetlands, in rural areas and small agglomerations, throughout the DRB countries. The authors state that treatment wetlands offer significantly higher cost-effectiveness than more "technological" and centralized solutions, particularly because it can significantly reduce the O&M costs compared to technical solutions.

For various treatment wetlands, parametric CAPEX and OPEX curves have been developed. As an example, the curves for FRB and VF wetlands are given in Table 3. With both technologies, comparable treatment levels can be achieved. Pistocchi et al. (2020) state that the OPEX curves include maintenance costs and that the functions are applicable to a wide range of DRB countries.

Table 3: Parametric CAPEX and OPEX curves for French Reed Beds (FRBs) and VF wetlands (Pistocchi et al., 2020)

	Net area	**CAPEX parametric curve**	**OPEX parametric curve**
	m^2/PE	EUR/PE	EUR/PE/y
FRB	2	$CAPEX = 903.79\ PE^{-0.19}$	$OPEX = 99.155\ PE^{-0.375}$
VF wetland	4	$CAPEX = 3746.4\ PE^{-0.391}$	$OPEX = 60.623\ PE^{-0.101}$

Details for feasibility study 1 (decentralized solutions are Slovenia) and the developed cost functions are also available in Masi et al. (2017).

3. ***Status of decentralised wastewater treatment systems and barriers for implementation of nature-based systems in central and eastern Europe*** (Istenič et al., 2016)

The aim of the study was to survey the status of wastewater management in 11 central and eastern European (CEE) countries, with a focus on rural areas and on small treatment wetlands for settlements of below 2,000 people. The results indicate that CEE countries have insufficient sanitation systems with different performance efficiencies. These differences stem from the different historical, political and economic developments as well as legislation in the previous five to six decades. CEE settlements with less than 2,000 inhabitants represent almost 30 % of the overall number of persons living in CEE countries.

Table 4 shows the number of small WWTPs with design capacity between 50 and 2'000 PE. The about 4'400 WWTPs of this size treat the wastewater of about 2 Mio people (about 1.7 Mio in the Danube countries investigated). However, the vast majority of the plants have only primary treatment (i.e. septic tanks). The lowest percentage of septic tanks are reported for Czech Republic and Slovakia with 65%. The technology applied second most is activated sludge systems whereas natural systems such as treatment wetlands are applied seldom (Bodík et al., 2012).

The results of the study have revealed that there is a high level of knowledge regarding implementation and performance of treatment wetlands at the expert and scientific levels in CEE countries. However, the transfer into practice is insufficient,

and there is low awareness and recognition of treatment wetlands at the institutional and administrative levels.

Table 4: Total number of small WWTPs with connection below 2'000 inhabitants (excluding WWTPs with less than 50 PE); countries in the DRB covered in the study are marked in orange (adapted from Bodík et al., 2012)

Table 12		Population connected to municipal WWTPs	Total number of all WWTPs in country	Average connected inhabitants on WWTP	Total number of small WWTPs with < 2000 inh.	
		%	pcs	10^3inh/wwwt	pcs	%
Bulgaria	BUL	47.6	89	39.4	57	64.0
Czech Rep.	CZE	78.8	2188	3.8	1550	70.8
Estonia	EST	88.0	863	1.3	826	95.7
Hungary	HUN	72.5	660	11	270	40.9
Latvia	LAT	56.0	1100	1.1	1020	92.7
Lithuania	LTU	71.0				
Poland	POL	64.0				
Moldova	MLD	n.a.	n.a.	n.a.	n.a.	n.a.
Romania	ROM	30.7	427	15.4	82	19.2
Slovakia	SVK	58.9	607	5.3	382	62.9
Slovenia	SLO	30.0	269	2.3	190	70.6
Ukraine	UKR	53.0	2100	11.6		
Average/total	**CEE**	**59.1**	**8303**	**10.1**	**4377**	**52.7**

4. ***Review of Rural Water and Sanitation Services in Seven Countries of the Danube Region*** (World Bank Group, 2018)

This review focussed mainly on the situation of water supply and sanitation/toilet provision, and less on wastewater management. However, for the seven countries investigated in more detail (i.e. Albania, Bosnia and Herzegovina, Croatia, Kosovo, Moldova, Romania, Ukraine), the following comments/recommendations regarding sanitation and wastewater management on rural areas can be found:

- development of a comprehensive sanitation strategy for the country including
    - decentralized solutions on-site solutions and IAS (reported for Albania, Bosnia and Herzegovina, Croatia, Kosovo, Moldova, Romania, Ukraine),
    - faecal sludge management (reported for Albania, Bosnia and Herzegovina, Croatia, Kosovo, Moldova, Romania, Ukraine),
    - small-town sanitation strategy (reported for Romania, Ukraine).
- Building and/or strengthening the institutional and legal framework and local implementation capacities
    - for rural sanitation along the entire sanitation service chain (reported in general for Albania, Croatia, Kosovo, Moldova, Romania, Ukraine) and

  - specifically for faecal sludge management (reported for Bosnia and Herzegovina, Croatia, Kosovo, Moldova, Romania, Ukraine).
- A sanitation marketing program to support upgrading from pit-latrines (reported for Moldova, Ukraine)

5. Summary

Access to water and sanitation is a human right that is recognized by the United Nations. The UN Sustainable Development Goal 6 (SDG 6) on "*Clean Water and Sanitation*" specifically addresses the topic of wastewater management by Target 6.2. (achieve access to safely managed sanitation systems for all) and Target 6.3. (improve water quality by reducing pollution).

In the Danube region, the EU legislation is the basis as countries in the region are either EU Member States, Candidate Countries or Potential Candidates. As water quality goals should be achieved for the whole basin, also for the other Danube basin countries Moldova and Ukraine the EU legislation is a benchmark.

The Urban Wastewater Treatment Directive (UWWTD) regulates the treatment of wastewater from agglomerations larger than 2'000 population. Candidate Countries and Potential Candidates already have or are on the way to implement the UWWTD in national legislations. In general, the fulfilment of the requirements of the UWWTD (in term of collection and treatment) is less in Candidate Countries and Potential Candidates compared to Member States, however, also in Member States the grade of fulfilment varies a lot.

For agglomerations smaller than 2'000 PE, the UWWTD does not give general criteria, just that an "appropriate treatment" shall be foreseen so that after discharge receiving waters can meet the relevant quality objectives. The term IAS (individual or other appropriate systems) is used to describe this smaller WWTPs in the EU legislation. However, the UWWTD sees the use of IAS as an exception and connection to centralised systems is favoured. IAS should only be implemented, in the case of collection would result in excessive costs and is they can ensure the same level of environmental protection as a collecting system. The UWWTD is not clear on how the costs and benefits need to be assessed.

For small WWTPs < 2'000 PE, most countries in the DRB only apply organic matter (BOD_5 and/or COD) as well as TSS discharge limits which are in general less stringent than the limits of the UWWTD for WWTPs > 2'000 PE. In some countries (e.g. Austria, Czech Republic, Hungary, Romania) also discharge limits for ammonium nitrogen (NH_4-N) are set and discharge limits for small plants can be also more stringent than the UWWTD requirements for larger plants.

The number of small agglomerations is high in all countries of the Danube region. Small agglomerations and non-connected dwellings might be a factor in not reaching good status of receiving waters if collected wastewater is not treated. Treatment of wastewater from small sites is thus a very important environmental issue. Too high discharge limits for small WWTPs might be an environmental problem, as IAS – according to the UWWTD – should result in the same level of environmental protection as a collecting system.

In principle, a large number of technologies are offers and can be applied for small WWTPs. Technologies that are simple, have a robust treatment performance and have low operation and maintenance requirements and costs are more suitable for rural areas. A number of studies show that natural treatment technologies such as treatment wetlands are a good

option especially for rural areas. Treatment wetland already have been applied in most countries of the Danube region in various sizes. If properly designed, constructed and operated, treatment wetlands achieve the same if not better treatment levels when compared to technical solutions.

In most countries, no specific design guides or norms exist or have to be applied. For small technical WWTPs up to 50 PE, several countries apply the European standard (ISO EN 12566) for pre-fabricated systems. Few countries have design guides for small technical plants and treatment wetlands that allow fulfilment of country specific discharge limits. If existing design guides are applied, usually the process of getting the permit for operating the WWTP is simplified and/or quicker.

For a number of countries, for new developments the permit for operating the WWTP is linked to the building permit. Monitoring intervals and parameters to be monitored are given in the permits of the individual WWTP.

Monitoring the performance of small WWTPs by authorities is in general poor for small WWTPs in all countries when compared to larger WWPTs. This is mainly caused by the high number of theses systems as well as the fact that they are often not easily accessible as they are on private properties. Thus, training of owners and operators of small WWTPs would be very important. Experience shows that trained persons more likely take better care of their WWTP, i.e. they take better care of the required operation, monitoring and maintenance work. In most Danube region countries, the local waterworks and wastewater associations could be in charge of such a training program (such as the ÖWAV in Austria).

Acknowledgements

The author acknowledges the colleagues from the DRB countries that provided information on their country, i.e. Jan Vymazal & Tereza Hnatkova (Czech Republic), Darja Istenič, Natasa Atanasova & Tjasa Griessler Bulc (Slovenia), Veronika Gezik (Slovakia), Stjepan Gabric (Croatia), Milica Karanac (Serbia), and Enkelejda Gjinali, Eriona Canga, Aida Bani (Albania)

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