Criteria for selection of WWTPs for further upgrade with advanced treatment

Report of D.T2.6.1

2023

Nature Needs No Pill

Project LLI-527

"Pharmaceuticals in wastewaters – levels, impacts and reduction" MEDWwater

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- Kurzeme Planning Region, ***www.kurzemesregions.lv***
- Latvian Environment, Geology and Meteorology Centre, ***www.videscentrs.lvgmc.lv***
- University of Klaipeda, ***www.ku.lt***
- State Agency of Medicines of Latvia, ***www.zva.gov.lv***
- State Medicines Control Agency under the Ministry of Health of Republic of Lithuania, ***www.vvkt.lt***

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LATVIJAS HIDROEKOLOĢIJAS INSTITŪTS
KURZEMES PLĀNOŠANAS REĢIONS
LATVIJAS VIDES, ĢEOLOĢIJAS UN METEOROLOĢIJAS CENTRS
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Introduction

This report is prepared in the frame of Latvia – Lithuania Interreg project "Pharmaceuticals in wastewaters – levels, impacts and reduction" (LLI-527) (*MEDWwater*).

Current document summarizes the results of close collaboration between MEDWwater project consortium and external experts from European countries (involved in D.T.2.6.2, D.T3.2.1 and D.T3.2.2) having needed expertise in applying the advanced technologies for pharmaceutical removal. One of the project aims was to investigate which wastewater treatment plants have the greatest need to introduce advanced treatment of pharmaceuticals residuals. The experience collected within MEDWwater initiative enabled to establish criteria for the identification of wastewater treatment plants in both countries, which can be regarded as priority objects for the implementation of advanced treatment technologies in the nearest future. The criteria for the selection of WWTPs covers several aspects, which are briefly described in the textual part of the report as well as flow chart.

1. WWTPs investigated within the project

Within the MEDWwater project, 16 WWTPs (8 from Lithuania and 8 from Latvia) were selected for further detailed investigations. Selection criteria as well as main characteristics of studied WWTPs in Lithuania and Latvia described in a more detailed way in MEDWwater D.T.2.5.2 report "Report summarizing the information on consumption patterns, real loads and environmental impacts". Summary of main characteristics presented in the below tables.

The selected WWTPs cover a wide spread of sizes (2,600 PE – 323,000 PE) and flows (500 m^3/d – 41,000 m^3/d). Selected model-WWTPs in Lithuania vary according to the designed capacity from 17,097 PE (population equivalent) in small city of Radviliškis up to 493,333 PE in Klaipėda. Number of inhabitants connected in 2020 is highest for Klaipėda WWTP (148,396 inh.), while the lowest amount is typical for Joniškis settlement, with 9079 of residents connected to Joniškis WWTP (Table 1).

Table 1. Main characteristics of the studied WWTPs in Lithuania.

WWTP	Total design capacity, PE	Connected number of residents in 2020	Connected number of industries in 2020	Average WW volume (m3/day) in 2020	BOD7 load to WWTP by (kg/day) in 2020	N-tot Out mg/L in 2020	P-tot Out mg/L in 2020	Recipient
Klaipėda	493333	148396	4337	40320	20809	8.3	0.46	Klaipėda Strait
Kretinga	32000	16445	233	4012	2154	5	0.55	Tenžė River
Telšiai	93400	No data	3	9198	3366	4.3	0.76	Channel (Svaigė River)
Mažeikiai	60000	32179	558	7350	142	2.9	1.78	Venta River
Šiauliai	182000	99127	1644	19039	6400	8.7	0.19	Kulpė River
Joniškis	22750	9079	162	664	2207	5.2	1.53	Sidabra River
Radviliškis	17097	12748	No data	2291	713	8.2	1.86	Obelė River
Rokiškis	47000	11569	225	3213	1309	7.4	0.69	Laukupė River

Selected model-WWTPs in Latvia vary according to the designed capacity from 7,500 PE in Kuldīga up to 100,000 PE in Daugavpils. Number of inhabitants connected in 2020 is highest for

Daugavpils WWTP (80,000 inh.), while the lowest number of inhabitants connected to the WWTP is in Aizpute (Table 2).

Table 2. Summary information on selected model-WWTPs in Latvia.

WWTP	Total design capacity, PE	Connected number of residents in 2020	Connected number of industries in 2020	Average WW volume (m3/day) in 2020	BOD5 load to WWTP by (kg/day) in 2020	N-tot Out mg/L in 2020	P-tot Out mg/L in 2020	Recipient
Liepāja	57000	74389	18	14742	3340	11.6	0.31	Baltic Sea
Aizpute	7980	3537	3	466	125	35.8	4.79	Tebra River
Kuldīga	7500	11819	n/a	1887	439	18.2	0.83	Ditch (Venta River)
Talsi	47500	8052	n/a	1555	1372	9.8	1.00	Dzelzupe River
Saldus	13263	10154	0.5	1648	338	10.2	0.50	Dīcmaņi Stream (Ciecere River)
Dobele	20414	10121	6	1092	742	9.4	0.12	Bērze River
Bauska	10000	8384		1324	283	7.5	0.90	Lielupe River
Daugavpils	100000	80000	37	10889	4007	6.0	0.70	Šuņupe Stream (Daugava River)

2. Current status of WWTPs

In order to evaluate the readiness of Lithuanian and Latvian WWTPs to introduce advanced treatment there is a need to have a clear picture about current status of the WWTP and to identify potential barriers for certain technologies as well as to find data gaps which would require to analyse missing water quality parameters. A first evaluation of the 16 selected WWTPs from Lithuania and Latvia was done in frame of MEDWwater within technical report (T.3.2.1 Consultation for selected wastewater treatment plants with suggestions for better treatment of pharmaceuticals), prepared by Dipl.-Ing. Michael Stapf from Germany.

The evaluation was done based on data provided by the MEDWwater project (feedback of questionnaires, annual statistical survey).

2.1 Legal obligations for API removal

Monitoring of pharmaceuticals in the environment is very limited in both countries – Latvia and Lithuania. Most data on environmental levels are collected in different projects. As there are no legal obligations, the implementation of a targeted API elimination can currently only be done on a voluntary basis and WWTP operators must have an own motivation to do so.

There will be changes made to the *Urban Waste Water Treatment Directive* in line with the European Commission's water-related proposals for a zero-emission package in the future. Whilst removing some of the substances at the WWTP would be uneconomical, it is nevertheless proposed to start with post-treatment to reduce the environmental burden from micropollutants. At first, the focus will be on ***WWTPs of > 100,000 PE (population equivalent)***, which should start with the removal of micropollutants. The proposed requirement is an 80% removal for 6 substances on the list. Later, the same requirement will be applied to ***WWTPs of > 10,000 PE*** or in areas identified as sensitive to pollution with micropollutants, unless Member States demonstrate the absence of risks to the environment or to public health based on a risk assessment. In this sense total design capacity of WWTP is a first important criteria for selection of priority objects in both countries, which should consider upgrade possibility as a first priority. Among 16 WWTPs investigated within MEDWwater only three (Klaipėda WWTP, Šiauliai WWTP and Daugavpils WWTP) comply with WWTPs of > 100,000 PE criteria.

2.2 API loads

Even though API concentrations vary between the different WWTPs, the overall pattern is similar. The API loads are closely linked to size of the WWTPs and are dominated by a few APIs (Paracetamol, Ibuprofen, Diclofenac, and Oseltamavir). The largest share of all the analyzed APIs entering and leaving 8 WWTPs in Lithuania applies to the **Klaipėda WWTP**, which contributes 1702 kg (58.4 %) and 642 kg (57.9 %) of the total amount respectively. The share of APIs entering and leaving other WWTPs are distributed as follows: Šiauliai WWTP – about 20 %, Telšiai WWTP – around 10 %, Mažeikiai WWTP ~ 4 %, Kretinga, Rokiškis WWTPs ~ 3 %, in the remaining Radviliškis and Joniškis – about 1 %.

WWTPs of Latvian cities of **Daugavpils** and **Liepāja** process significantly larger amounts of pharmaceuticals than WWTPs of remaining towns, what is natural taking into account these are among largest WWTPs in Latvia. WWTPs of Daugavpils and Liepāja together processed more than 90 % of the total API load involved in MEDWwater research for both influent and effluent.

APIs in the WWTP effluent that have the highest potential to pose a risk to the aquatic environment, are Diclofenac, Ibuprofen, Azithromycin, and Amoxicillin. However, more sampling campaigns are required to improve the current data basis (two sampling campaigns).

2.3 WWTP treatment processes

Primary treatment

Except for the WWTP Joniškis (Lithuania), all WWTPs use screening during the first treatment stage. All Lithuanian WWTPs use a sand/grid removal, whereas in only half of the investigated WWTPs in Latvia use it. A primary clarifier is only used by the two WWTPs (Klaipėda and Šiauliai) that treat more than 20,000 m^3/d. A special case is WWTP Telšiai, because it uses also rotary drums as primary treatment (Stapf, 2022).

Secondary treatment

All WWTPs use standard biological treatment approaches (nitrification and denitrification processes), with sludge ages that are usually between 20 and 32 days. An exception is WWTP Radviliškis for which a comparable low sludge age was reported (11 days). Dried excess sludge of the investigated WWTPs primarily ends up in agriculture (in 9 WWTPs out of 16). WWTP Liepaja is the only WWTP that reported that some of its sludge is used for landscaping purposes. Sludge is only (partially) incinerated by four Lithuanian WWTPs, whereas none of the Latvian WWTPs dispose of their sludge this way. This can be attributed to the fact that there is no sludge incineration facility in Latvia. **Thus, at most of the WWTPs, PAC cannot be used**. Share of industrial wastewater (IWW) varies strongly, but is low or very low for the majority of the 16 WWTPs. Only for the three WWTPs: Rokiškis (20 - 25 %) and Klaipėda (24 %) in Lithuania as well as Daugavpils in Latvia (37 %), industrial wastewater exceeds a share of 20%. Depending on the share and type of IWW it cannot be ruled out that the efficiency of the API elimination technologies will be different to WWTPs that treat mainly municipal wastewater. Therefore, it is recommended to carry out lab-tests with the local water matrix to rule out unexpected behavior.

Tertiary treatment

Only two Lithuanian WWTPs use a tertiary treatment: WWTP Kretinga already use a granulated activated carbon (GAC) filter for a partial stream (15%) along with a microfilter, whereas WWTP Rokiškis is using disk filters. Except for using potential available unused infrastructure (e.g. basins), there is not much potential to combine available treatment stages with API elimination technologies (e.g. as post-treatment).

2.4 API treatment efficiency

The median removal rates for all API (25) studied within MEDWwater ranged from 40% to 60% and the average removal is nearly 50%. As part of this project, also the API concentrations in waste activated sludge were estimated and the results suggest that significant API loads actually end up in the sewage sludge. If the sludge is used, for example, in agriculture or as a gardening soil, the API loads can end up in the environment again. It is therefore necessary to consider its whole potential circle when analysing the API routes and selecting treatment technologies.

2.5 Water quality parameters

Dissolved organic carbon (DOC) as well as bromide is not measured by any of the WWTP (or simply was not reported). Other parameters such as total COD, TSS, nitrite, water temperature, and pH were almost always reported for the Lithuanian WWTPs. Except for elevated nitrite concentrations at WWTP Rokiškis (C = 1.3 mg-N/L) and elevated water temperature at WWTP Mažeikiai (T > 30°C), parameters vary in typical ranges. However, it has to be noted that for almost all Latvian WWTPs no data was provided even though it is expected that at least some of the parameters (nitrite, pH and temperature) are measured by the WWTPs.

Thus, **for all WWTPs that intent to implement an API elimination technology, it is recommended to start a measuring DOC and bromide on a regular basis** (also nitrite in case it is not already measured). Based on these measurements, a solid basis for later feasibility studies or decisions on further actions (e.g. source investigation at high bromide levels) is given.

3. Potential barriers for advanced treatment

Possibilities to implement API treatment technologies on-site may be limited due to lack of available space in the area of existing WWTPs, missing of financial support and legal obligations as well as no willingness to do it by WWTP operators.

Within MEDWwater vast majority of the investigated WWTPs indicated no interest to measure API on a regular basis (except Klaipėda WWTP and Kretinga WWTP in Lithuania). A potential explanation for this feedback could be that the WWTP operator expect to face many barriers by the implementation of API elimination technologies: About 80% of the WWTPs indicated a missing financial support as well as that they have to cope with other water quality parameters (e.g. C/N/P) first. About 75% of the WWTPs mentioned a missing legal obligation for API reduction. A lack of knowledge with the required technologies was marked by about 63% of the WWTPs.

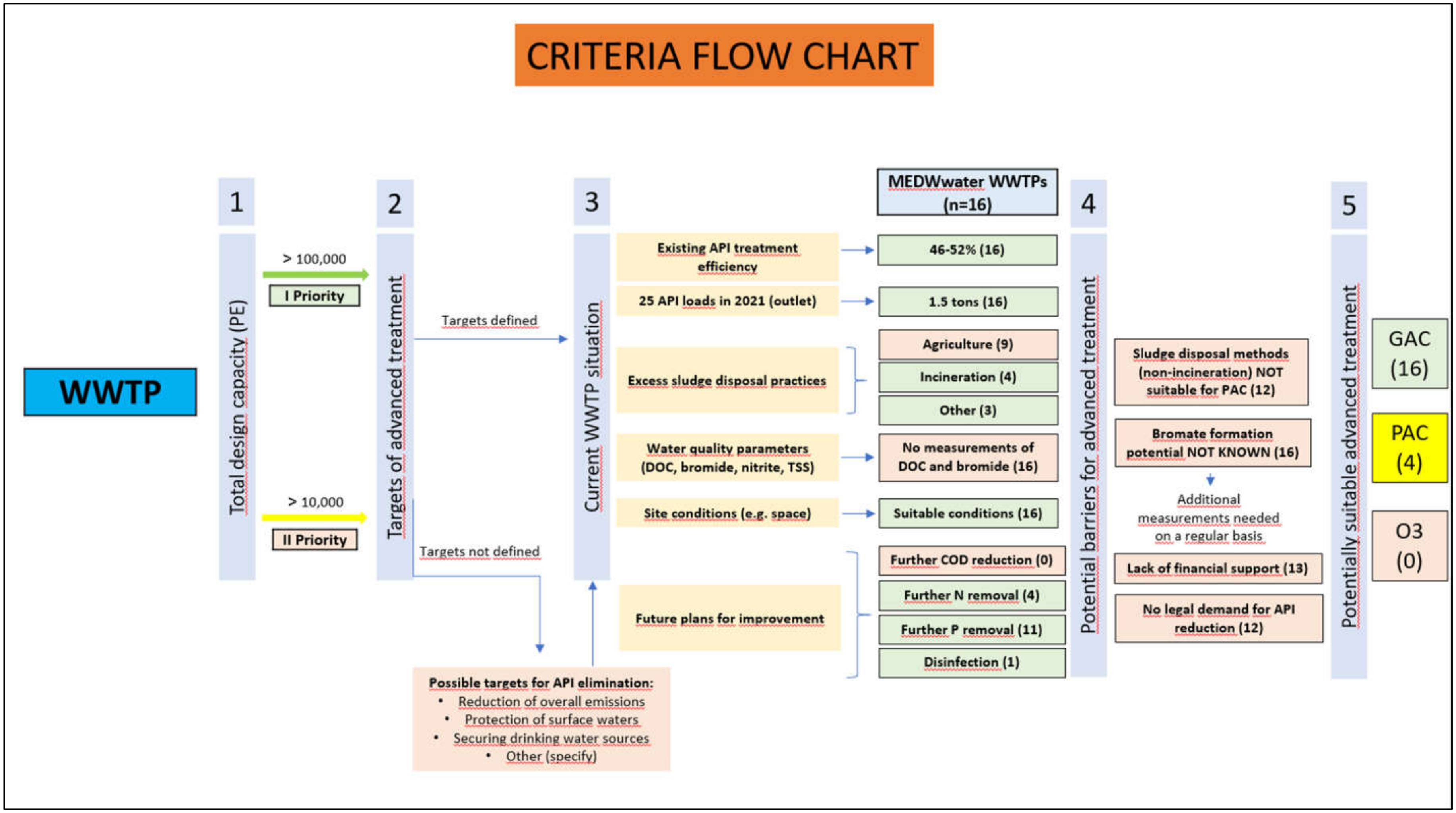
4. Priority WWTPs for future upgrading

Based on the available data for the 16 selected WWTPs, following conclusions can be drawn:

- API concentrations vary between the different WWTPs, however the overall pattern is similar. The API loads are closely linked to size of the WWTPs with highest values applicable to **Klaipėda WWTP** in Lithuania, **Daugavpils WWTP** and **Liepaja WWTP** in Latvia.
- DOC as the most important design parameter is not measured at any of the investigated WWTPs. Due to lack of information on bromide and nitrite concentrations, it is currently not possible to assess the suitability of an ozonation. In this sense ozonation as possible advanced treatment technology currently cannot be considered for further implementation at any of WWTPs.
- Most of the investigated WWTPs are not suitable for a PAC treatment, because of their current way of excess sludge disposal (exception goes for **Klaipėda WWTP**, **Mažeikiai WWTP**, **Radviliškis WWTP**, **Šiauliai WWTP**).

- There are no obvious barriers for implementation of a GAC filtration. At the moment, most of the investigated WWTPs do not have an existing tertiary treatment stage that can be used in combination with API elimination technologies (e.g. ozonation post-treatment). **Kretinga WWTP** is special in that way that is already has a GAC-filter that works well in combination with the existing drum filters (reduction of suspended solids, less frequent backflushing of GAC filter). Compared to other Lithuanian WWTPs the existing GAC-filter effectively increase the overall API reduction from 47% (only biological treatment) to 84% (biological treatment + GAC-filter). Thus, if Kretinga wants to go for a full stream API removal, probably the best option would be to simply build additional GAC filters and to make use of the available drum filters.
- As there are no legal obligations, the implementation of a targeted API elimination can currently only be done on a voluntary basis and WWTP operators must have an own motivation to do so.

Results of detailed WWTPs investigations, communication with WWTP operators and experienced foreign experts as well as existing/planned legislative basis for API removal enabled to develop schematic model flow chart of main criteria, which needs to be considered when analyzing the opportunity to upgrade existing WWTP with advanced treatment technology (Figure 1).


CRITERIA FLOW CHART
WWTP
1
Total design capacity (PE)
> 100,000
I Priority
> 10,000
II Priority
2
Targets of advanced treatment
Targets defined
Targets not defined
Possible targets for API elimination:
• Reduction of overall emissions
• Protection of surface waters
• Securing drinking water sources
• Other (specify)
3
Current WWTP situation
Existing API treatment efficiency
25 API loads in 2021 (outlet)
Excess sludge disposal practices
Water quality parameters (DOC, bromide, nitrite, TSS)
Site conditions (e.g. space)
Future plans for improvement
MEDWwater WWTPs (n=16)
46-52% (16)
1.5 tons (16)
Agriculture (9)
Incineration (4)
Other (3)
No measurements of DOC and bromide (16)
Suitable conditions (16)
Further COD reduction (0)
Further N removal (4)
Further P removal (11)
Disinfection (1)
4
Potential barriers for advanced treatment
Sludge disposal methods (non-incineration) NOT suitable for PAC (12)
Bromate formation potential NOT KNOWN (16)
Additional measurements needed on a regular basis
Lack of financial support (13)
No legal demand for API reduction (12)
5
Potentially suitable advanced treatment
GAC (16)
PAC (4)
O3 (0)