HELCOM Stakeholder Conference 2020

Constructed wetlands - a potential win, win, win solution

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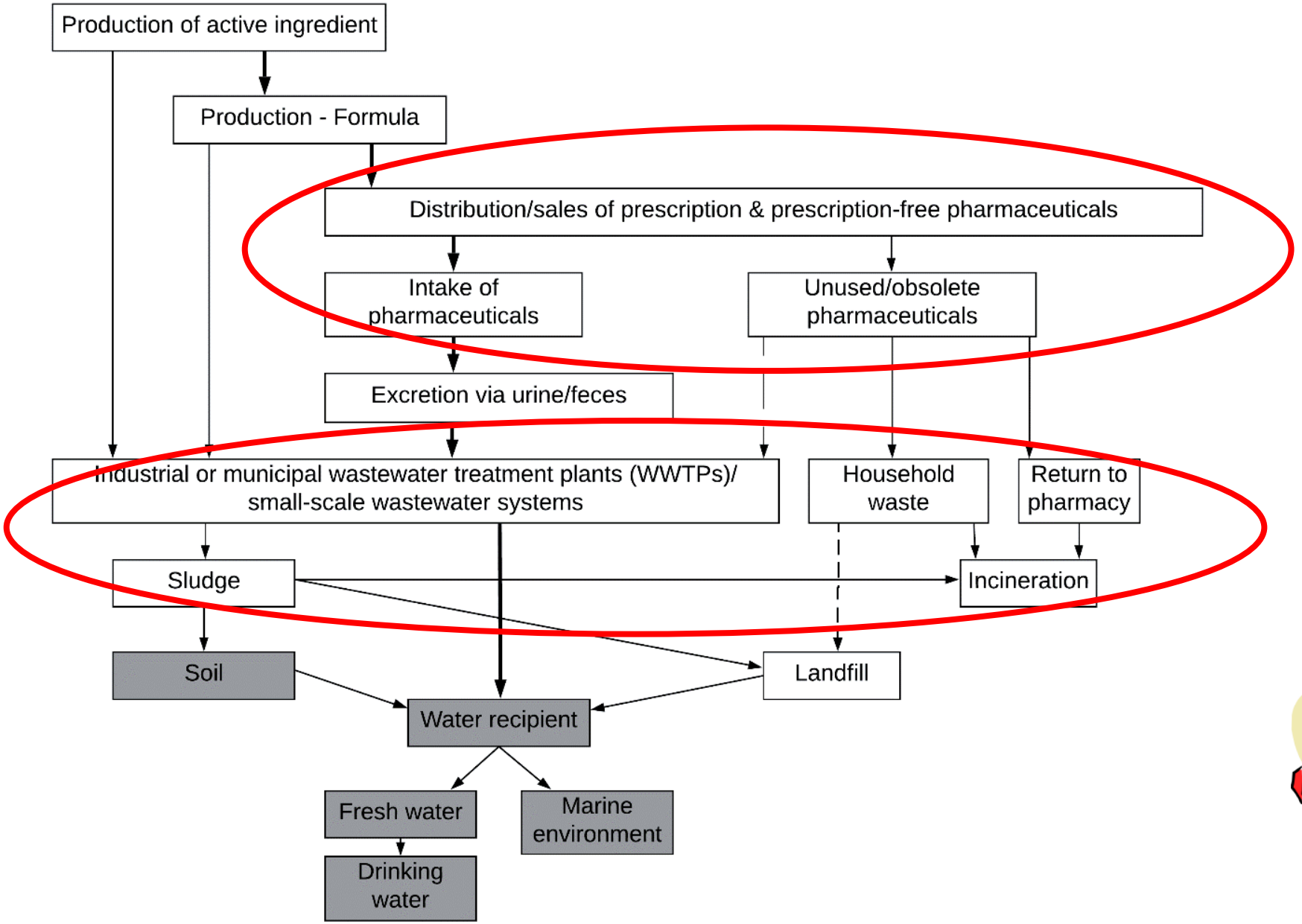
Production of active ingredient
Production - Formula
Distribution/sales of prescription & prescription-free pharmaceuticals
Intake of pharmaceuticals
Unused/obsolete pharmaceuticals
Excretion via urine/feces
Industrial or municipal wastewater treatment plants (WWTPs)/ small-scale wastewater systems
Household waste
Return to pharmacy
Sludge
Incineration
Soil
Landfill
Water recipient
Fresh water
Marine environment
Drinking water


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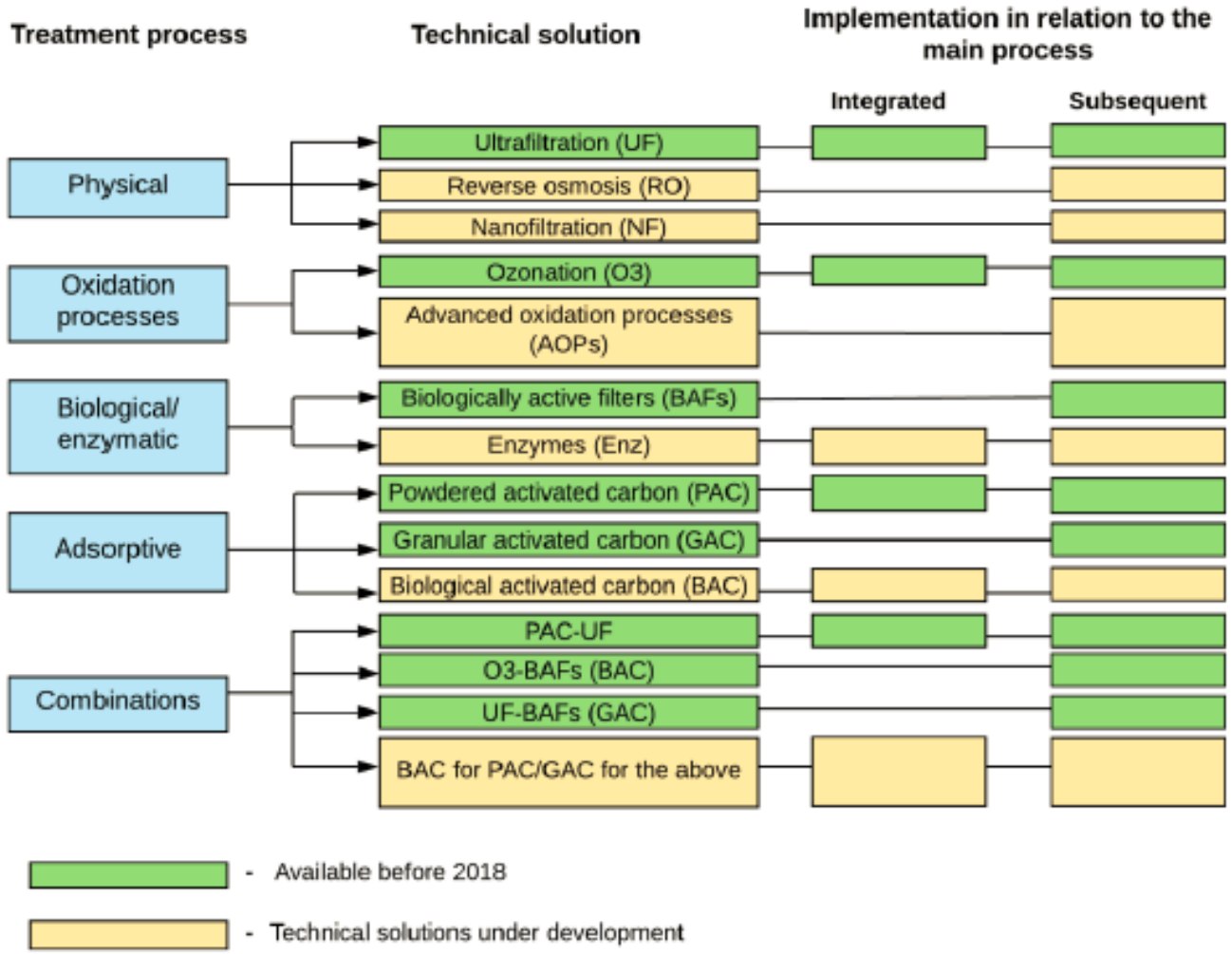
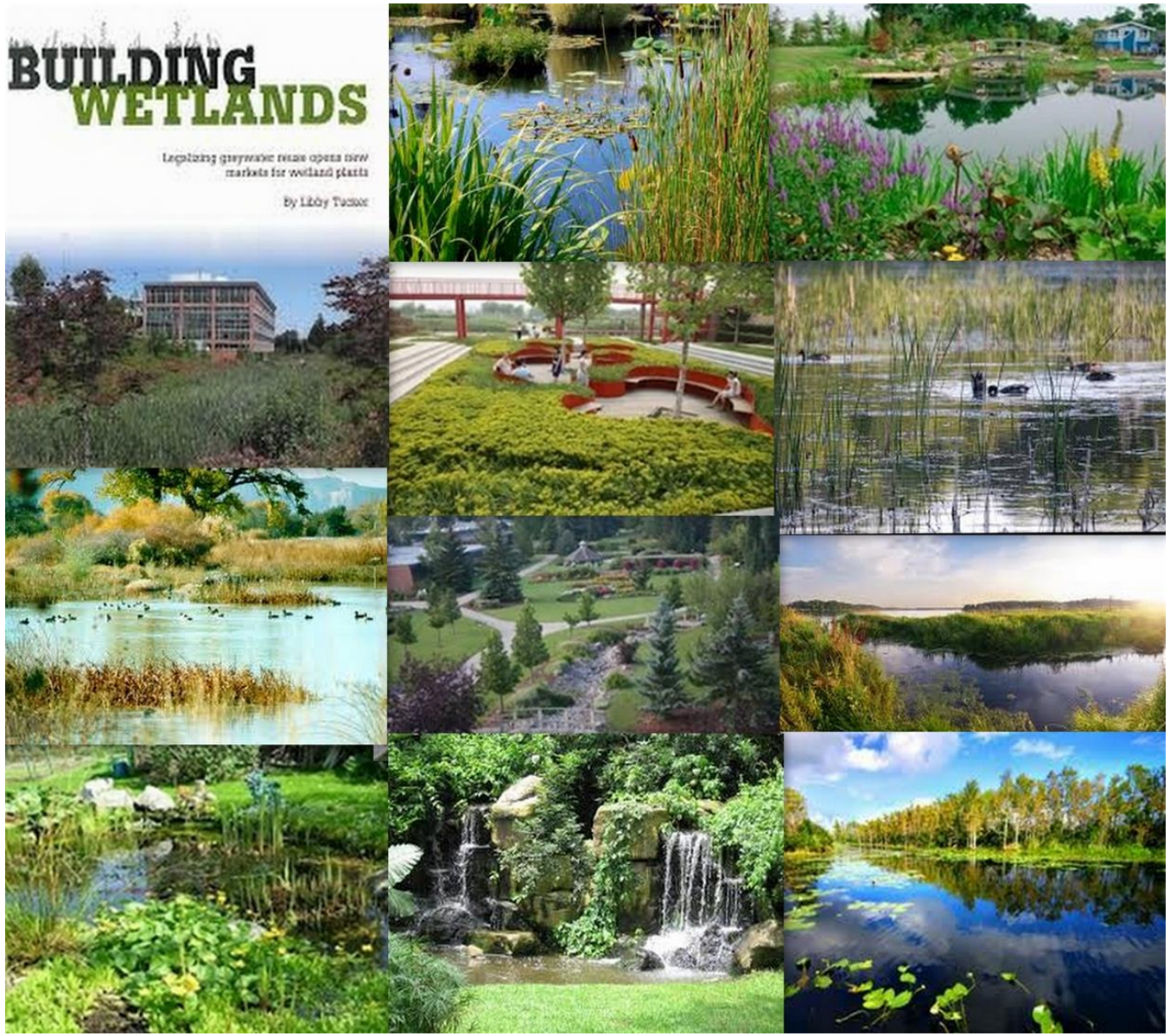


Figure 2: Schematic overview of various treatment technologies and their implementation in wastewater treatment plants. (Based on Baresel et al., 2017)

- **Tech availability?**
- **Small-scale?**
- **Cost?**
- **Efficiency?**



[“Constructed Wetlands Save Frogs, Birds Threatened With Extinction”, Science News Jan. 21, 2014]

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<u>Trosa wetland:</u>
5,200 p.e.
Area 6 ha
Retention 8 days

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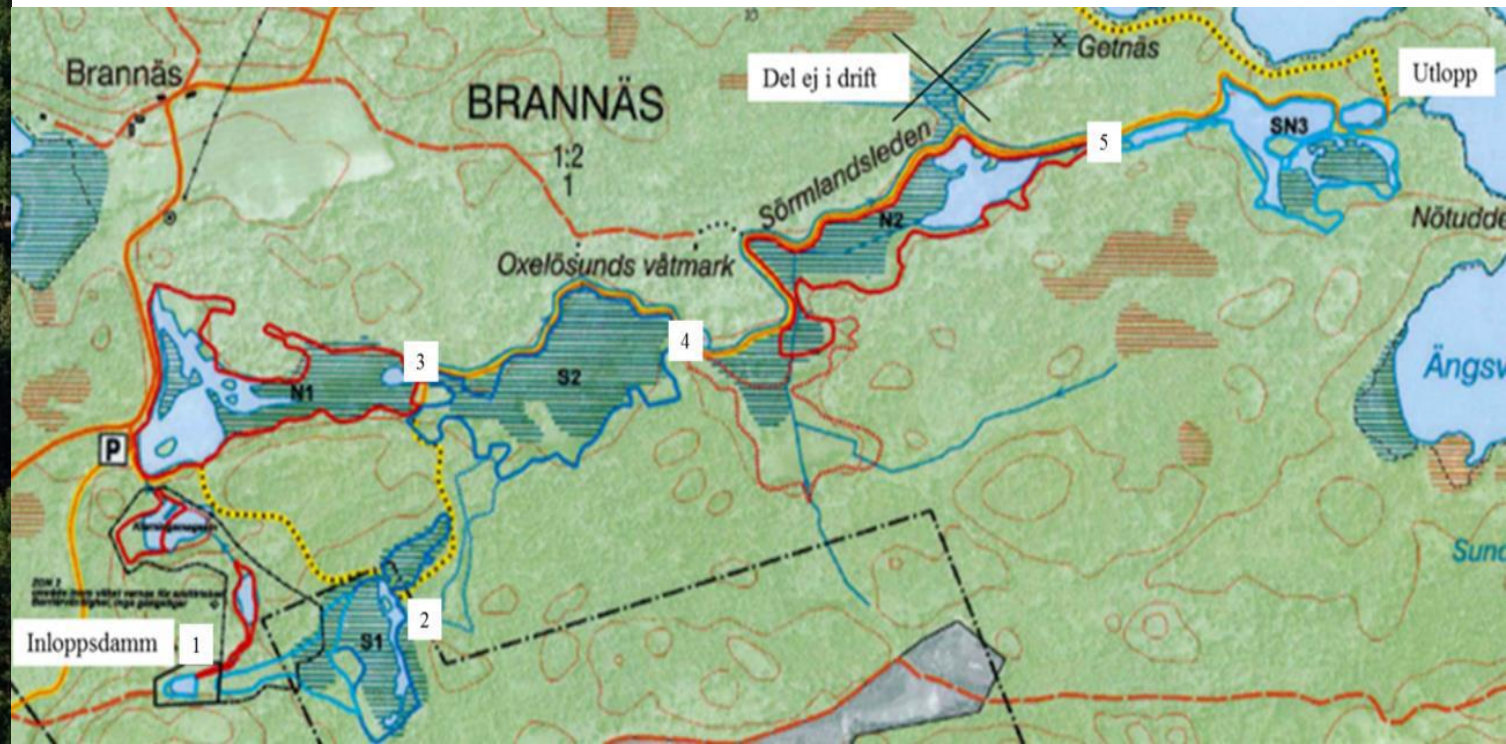
Brannäs wetland, Oxelösund:

Capacity 11,500 p.e.

Area 23 ha

Flow 3,700 m3/day

Retention 7 days



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Removal rate
P: 91 %
N: 78 %

Alhagen wetland, Nynäshamn:
Capacity 17,000 p.e.
Area is 28 ha
Flow 4,000 m3/day
Retention 11-14 days

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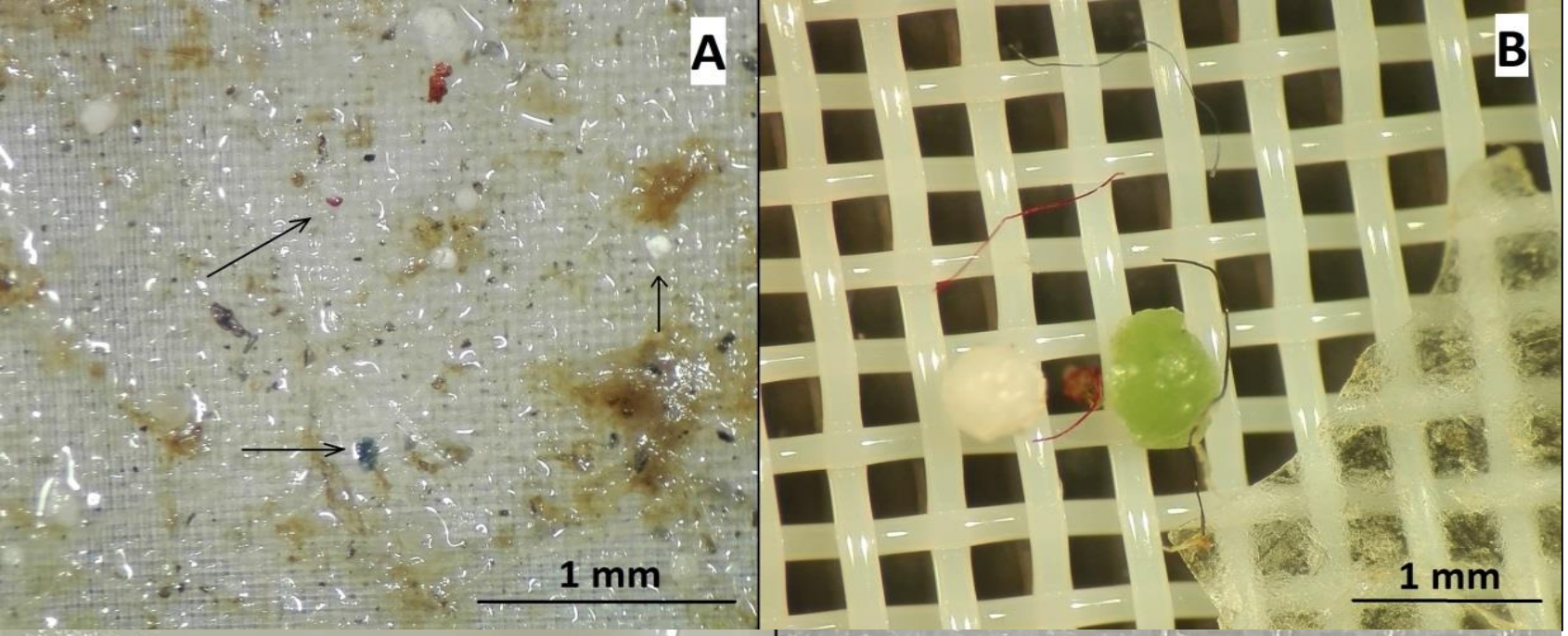
Ekeby wetland, Eskilstuna:

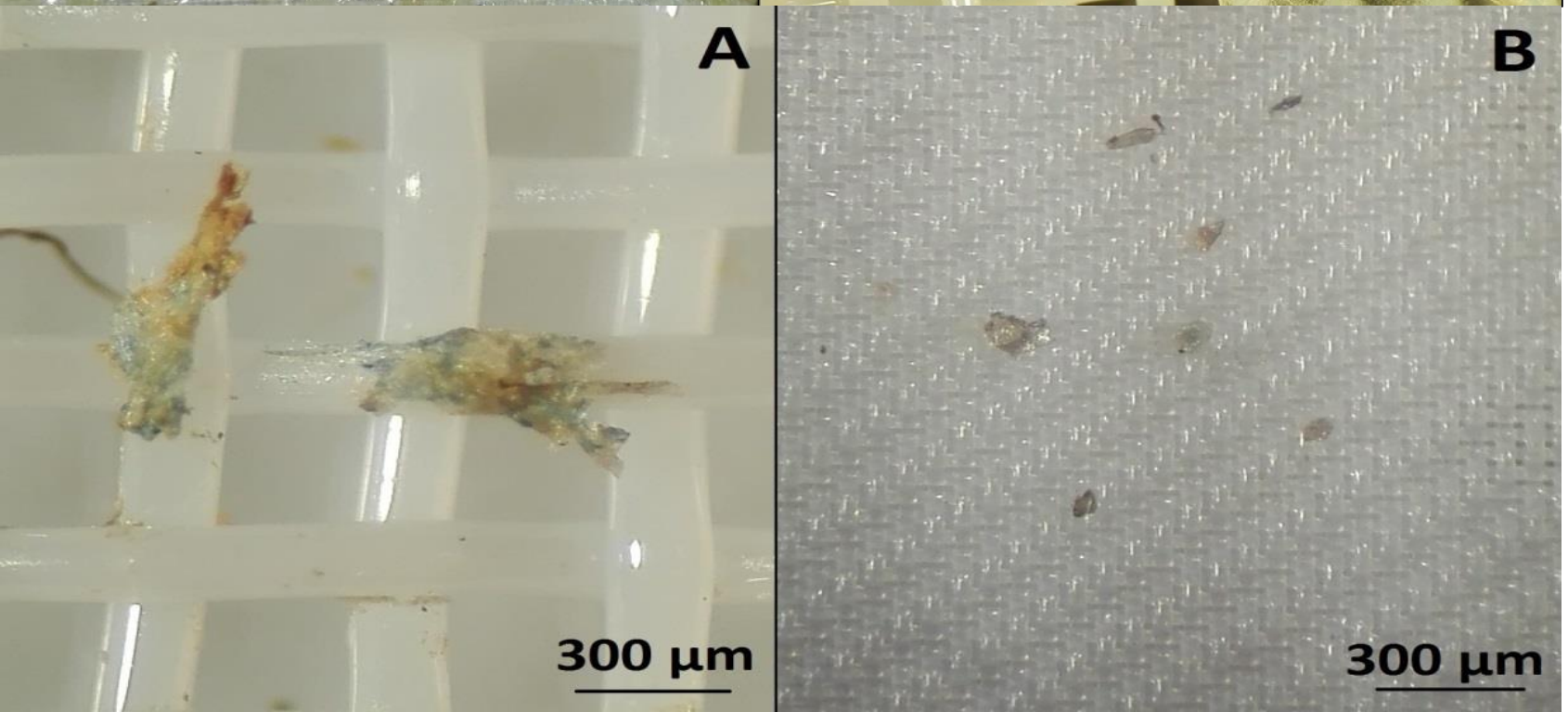
Capacity 90,000 p.e.

Area 28 ha

Flow 43,200 m3/day.

Retention 6–7 days





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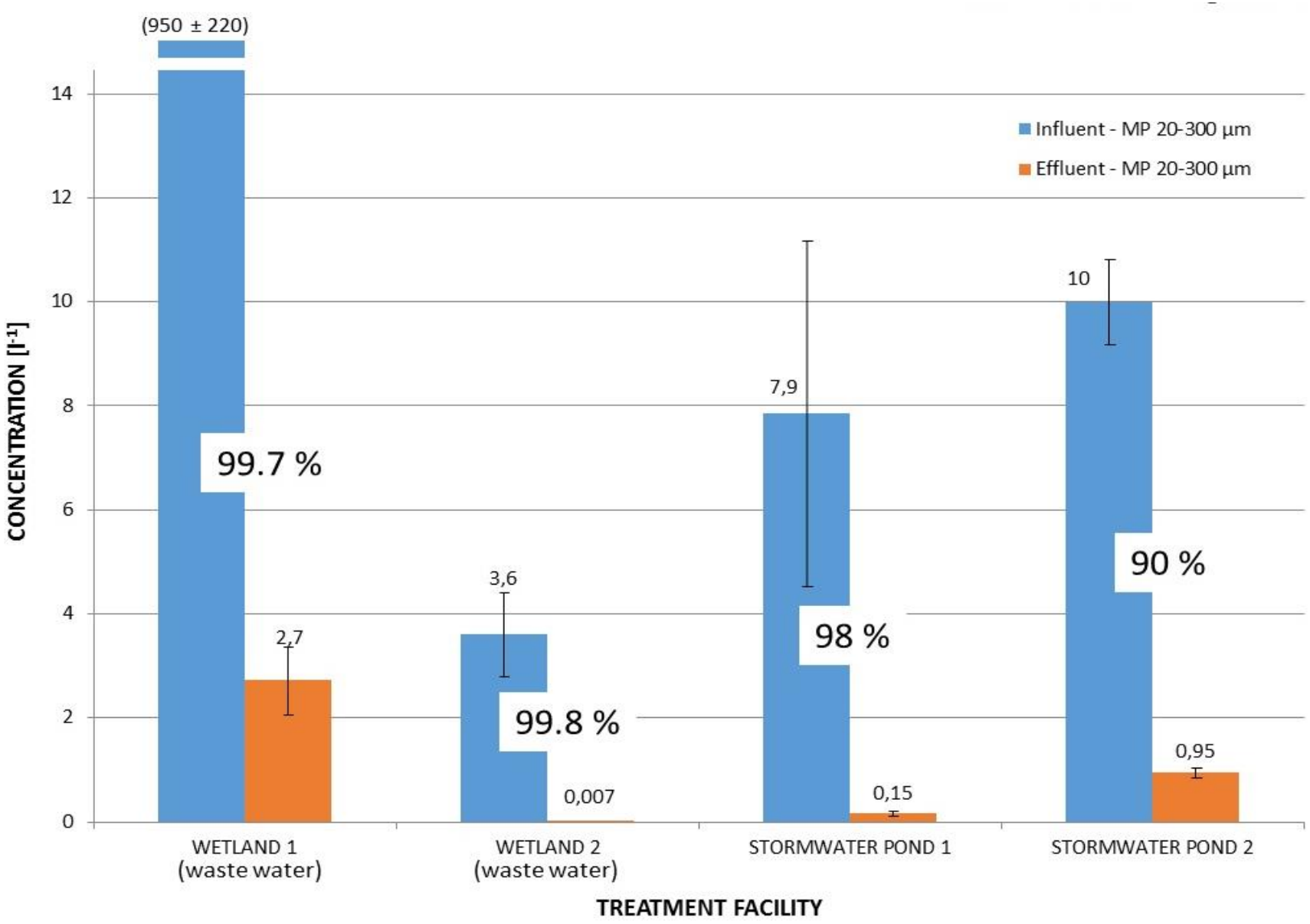
Microplastics particles removal: ~ 99%

[Constructed wetlands a concrete way to remove micro plastics, CCB, 2016]



[Constructed wetlands a concrete way to remove micro plastics, CCB, 2016]

Summary

- **5 wetlands** (CW), all connected to MWWTPs, **5,000-90,000 p.e**.
- **19 of 24** investigated **APIs** were found in CW
- **Highest** concentrations: **naproxen, ibuprofen and diclofenac, furosemide, metoprolol, oxazepam**
- **47% APIs** reduced **20-80%**; **47% APIs > 80%**
- **Diclofenac, furosemide, and naproxen** reduced **74–100%.**

Table 1. Measured concentrations of APIs in incoming and outgoing wastewater in the CWs. E- Eskilstuna, H- Hässleholm, N- Nynäshamn, T- Trosa och O- Oxelösund. I= Incoming, O= Outgoing. All concentrations in ng/L.

Active Ingredients	E_I	E_O	H_I	H_O	N_I	N_O	T_I	T_O	O_I	O_O
Amplodine	*	*	42	*	*	*	*	*	140	*
Atenolol	*	*	920	200	*	*	*	*	1200	*
Bisoprolol	*	**	130	89	**	*	3,8	*	530	92
Caffeine	*	*	16000	5400	*	*	*	*	*	*
Citalopram	*	*	600	210	*	*	*	*	620	**
Diclofenac	1000	150	700	98	1700	120	2500	200	1500	120
Fluoxetin	*	*	75	21	*	*	*	*	70	*
Furosemid	1300	*	640	*	2600	*	1900	*	2500	*
Hydrochlorothiazide	1200	140	1400	140	2400	160	3000	310	2600	380
Ibuprofen	**	**	6100	560	1300	**	2800	220	430	**
Carbamazepine	*	*	590	500	*	*	*	*	650	500
Ketoprofen	*	*	290	*	*	*	*	*	320	*
Metoprolol	12	**	2100	1400	34	**	31	**	2200	510
Naproxen	590	140	2400	410	1100	*	10000	220	1700	*
Oxazepam	*	*	4900	4300	*	*	*	*	3500	1900
Paracetamol	*	*	*	*	*	*	*	*	*	*
Propranolol	**	*	130	28	**	*	**	*	180	24
Ramipril	*	*	*	*	*	*	*	*	*	*
Ranitidine	*	*	21	*	**	*	3	*	26	*
Risperidone	*	*	*	*	*	*	*	*	*	*
Sertraline	*	*	160	9	*	*	*	*	81	*
Simvastatin	*	*	*	*	*	*	*	*	*	*
Terbutaline	*	*	*	*	*	*	*	*	*	*
Warfarin	3	4	9	11	6	7	12	9	9	6

*The ingredient was not detected; the concentration was under the detection limit.
**The ingredient has been detected but not quantified, the concentration is between the detection and the quantification limits.

API concentrations: IN-OUT

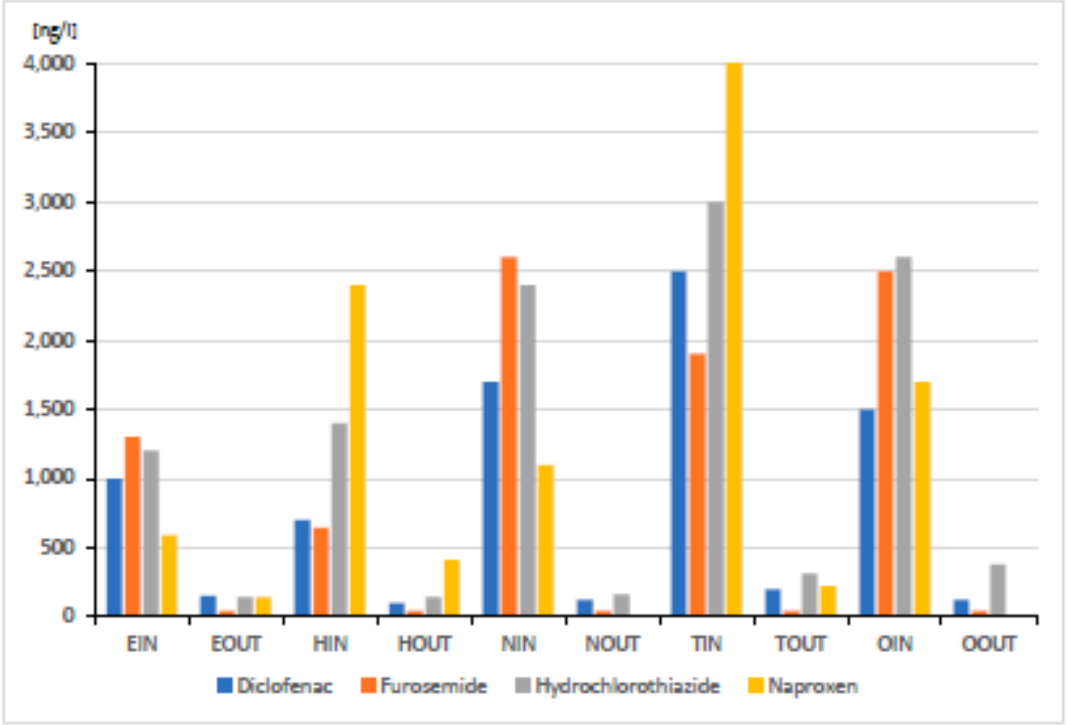


Figure 4. Four APIs in incoming (IN) and outgoing (OUT) wastewater of the five CWs (E = Eskilstuna, H = Hässleholm, N = Nynäshamn, T = Trosa and O = Oxelösund).

Table 2. Removal efficiencies for Eskilstuna, Hässleholm, Nynäshamn, Trosa, Oxelösund wetland. E- Eskilstuna, H- Hässleholm, N- Nynäshamn, T- Trosa and O- Oxelösund.

APIs	E [%]	H [%]	N [%]	T [%]	O [%]
Amplodine	*	**84	*	*	**99
Atenolol	*	82	*	*	100
Bisoprolol	*	44	*	**75	98
Citalopram	*	71	*	*	**99
Caffeine	*	72	*	*	*
Carbamazepine	*	31	*	*	89
Diclofenac	84	89	95	92	99
Fluoxetine	*	77	*	*	100
Furosemide	**97	**95	**99	**98	100
Hydrochlorothiazide	87	92	96	90	98
Ibuprofen	*	92	**98	92	**99
Ketoprofen	*	**94	*	*	**99
Metoprolol	**10	45	80	**69	97
Naproxen	74	86	**99	98	100
Oxazepam	*	28	*	*	92
Paracetamol	*	*	*	*	*
Propranolol	*	82	*	*	98
Ramipril	*	*	*	*	*
Ranitidine	*	**96	*	**68	**99
Risperidone	*	*	*	*	*
Sertraline	*	96	*	*	100
Simvastatin	*	*	*	*	*
Terbutaline	*	*	*	*	*
Warfarin	-27	1	14	28	90

**The removal efficiency has not been possible to determine as the influent or effluent concentrations were below the quantification or detection limit*

***The removal efficiency is greater than*

API removal efficiency

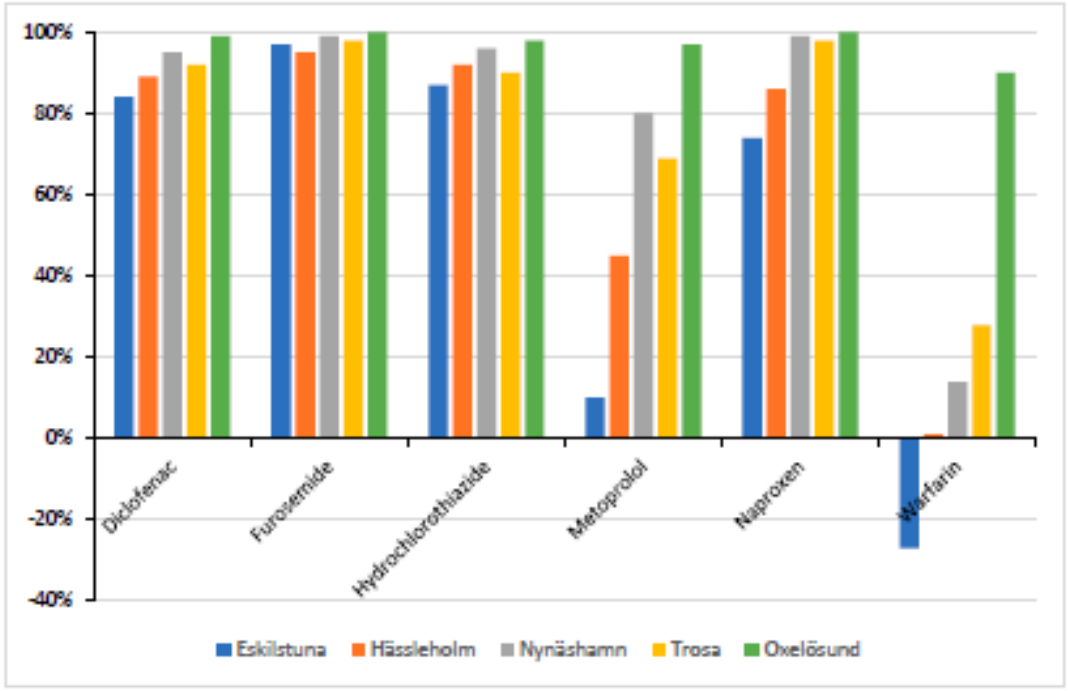


Figure 5. Removal efficiency (%) of six API in the five studied CWs.

Table 3. Compilation of removal efficiencies for Eskilstuna, Nynäshamn, Trosa and Oxelösund wetlands summer conditions (this study) in 2019 and in winter conditions (Näslund, 2010). (E_W = Eskilstuna winter, E_S = Eskilstuna summer, N_W = Nynäshamn winter, N_S = Nynäshamn summer, T_W = Trosa winter, T_S = Trosa summer, O_W = Oxelösund winter, O_S = Oxelösund summer).

	Es	Ew	Ns	Nw	Ts	Tw	Os	Ow
Atenolol	*	27	*	53	*	53	100	53
Bisoprolol	*	26	*	22	75	36	98	29
Citalopram	*	45	*	84	*	97	99	63
Diclofenac	84	31	95	24	92	30	99	36
Ibuprofen	*	38	98	80	92	5	99	88
Carbamazepine	*	12	*	11	*	-19	89	21
Ketoprofen	*	56	*	3	*	19	99	32
Metoprolol	10	-3	80	30	69	27	97	18
Naproxen	74	34	99	46	90	50	100	75
Oxazepam	*	*	*	21	*	-26	92	48
Ranitidine	*	-39	*	92	68	56	99	88
Sertraline	*	0	*	*	*	*	100	94

**Removal efficiency not available.*

Summer vs. winter removal

- **Summer** - significantly higher
- **Winter** - low water temperatures, low biological activity, low incoming sunshine and poor oxygen conditions.
- **Optimal**, T 15-25° C
- **Longer retention time** could benefit the removal process in summer conditions

Time to re-think personal medical footprint?

Medicine	daily, g	days	consumed, g	rate, %	excreted, g	Could be reduced, g
Amlodipine	0,005	140	0,7	0,6	0,42	0,036
Metoprolol	0,1	91	9,1	0,95	8,645	3,458
Eliquis	0,01	91	0,91	0,52	0,4732	?
Paracetamol	4,0	70	280	0,9	252	?

Recommendation 1

- **Constructed wetlands**
  - ✓**are an economically and environmentally suitable compliment** for treatment of wastewater **from small and medium-sized** municipalities.
  - ✓have shown to **reduce the flux of pharmaceuticals and other micro-pollutants substantially** to the water recipient.

Recommendation 2

- When constructing wetlands, it is important to **pay attention to the design, type and retention time**.

  Removal efficiency increases:

  ✓ **with retention** time,

  ✓ **when water flow is filled and emptied alternately** rather than flowing continuously.

  This characteristic can be designed into constructed wetlands.

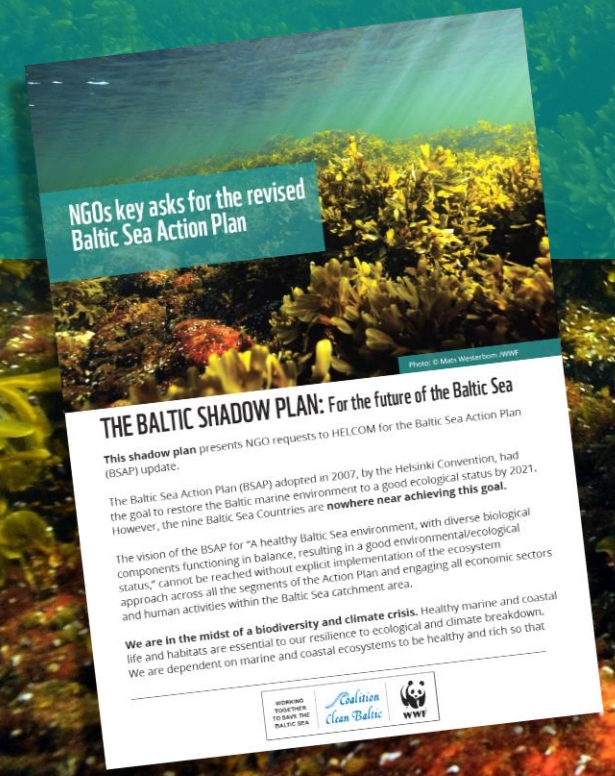
Recommendation 3

- In order to improve the performance of the wetlands, it is important to **emphasize optimal management, incorporating improved monitoring systems** covering micro plastics, pharmaceuticals and other emerging pollutants.

Download the Shadow Plan at:

balticwwf.org

ccb.se



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