Constructed wetlands for small communities: 25 years of experience in the Czech Republic

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The first constructed wetland was built in the Czech Republic in 1991.

At present, there are about 300 constructed wetlands treating sewage from small communities.

The largest system treats 1400 PE, but the most common size is between 100 and 500 PE.

Until about 2013, all constructed wetlands were designed as subsurface horizontal systems.

There are no legal limits for discharge of ammonia for wastewater treatment plants up to 500 PE, therefore vertical flow systems are not used.

Recently, hybrid constructed wetlands have been used when limits for ammonia discharge were imposed.

Objectives

To evaluate treatment performance of constructed wetlands in the Czech Republic.

Reliable data from 114 systems are available for evaluation

The results included in the evaluation were obtained from the constructed wetlands that has been in operation < 5 years (n=44), 6-10 years (n=26), 11-15 years (n=8), 16-20 years (n=18) and > 20 years (n=18).

Treatment performance of constructed wetlands treating municipal sewage in the Czech Republic. n = number of annual means, N = number of constructed wetlands. *Means with medians in parentheses.

	n	N	Inflow* (mg/L)	Outflow* (mg/L)	Removal* (%)
BOD_5 (mg/L)	1080	114	166 (112)	12.8 (8.8)	87.2 (91.2)
COD (mg/L)	1043	111	364 (244)	48.8 (40.0)	77.9 (81.9)
TSS (mg/L)	1059	114	179 (94)	11.1 (8.3)	85.3 (90.8)
TP (mg/L)	509	81	6.3 (5.0)	3.5 (2.8)	39.8 (41.7)
NH_4-N (mg/L)	667	92	34.1 (26.8)	17.1 (13.4)	40.2 (40.8)

Design parametrs of HF CWs in operation for more than 20 years.

	Start of operation	PE	Area (m^2)	Filtration material	Vegetation*
Ondřejov	1991	333	806	gravel, 3-15 mm	PG
Chmelná	1992	150	706	rock, 5-10 mm	PG + PH
Sp. Poříčí	1992	1400	5000	rock, 16-32 mm	PG + PH
Jimlíkov	1993	100	520	gravel, 8-16 mm	PG
Lipka	1993	300	1890	gravel, 4-8 mm	PG
Onšov	1993	420	2100	gravel, 4-8 mm	PG
Osová Bitýška	1993	1000	4471	gravel, 8-16 mm	PG + TL
Kořenec	1994	360	2527	gravel, 4-8 mm	PG
Zásada	1994	400	1892	gravel, 8-16 mm	PH
Čistá	1995	800	3 040	rock, 8-16 mm	PG + PH
Nučice	1995	650	3224	rock, 8-16 mm	PG + PH
Olší	1995	262	2160	gravel, 4-8 mm	PG
Zdíkov	1995	150	750	gravel, 4-8 mm	PG + TL
Hostětín	1995	240	1400	gravel, 8-16 mm	PG
Zbenice	1996	200	1000	rock, 8-16 mm	PG + PH
Ptenín	1998	290	1450	rock, 4-16 mm	PG + PH
Křoví	1998	500	2045	gravel, 8-16 mm	PG

*PG = *Phragmites australis*, PH = *Phalaris arundinacea*, TL = *Typha latifolia*

Average outflow concentrations of BOD_5, COD and TSS from 17 CWs with at least 20 years of operation.The first number for each parameter is the average for operation years 1-5, the second number is the average for the period indicated in the column*.

	Years of operation*	BOD_5		COD		TSS	
Ondřejov	23-27	21.7	8.8	63	43	8.2	4.5
Chmelná	22-26	6.0	4.9	37	22	6.2	4.3
Sp. Poříčí	22-26	4.4	10.3	26	45	8.0	3.3
Jimlíkov	21-25	3.3	3.5	28	34	7.8	12.2
Lipka	21-25	3.9	3.1	15	25	9.5	5.6
Onšov	21-25	4.9	5.7	18	29	4.9	6.1
Osová Bitýška	21-25	12.1	3.4	51	26	10.4	2.5
Kořenec	20-24	4.5	5.3	27	35	4.1	8.6
Zásada	20-24	12.8	13.6	46	48	16.6	9.0
Čistá	19-23	6.8	5.7	35	27	3.0	3.3
Nučice	19-23	13.7	4.7	43	19	20.3	10.6
Olší	19-23	3.4	2.2	29	19	6.3	3.5
Zdíkov	19-23	3.5	3.5	37	43	4.8	8.8
Hostětín	19-23	11.3	8.9	34	37	15.4	8.4
Zbenice	18-22	7,5	6.3	51	33	14.8	5.5
Ptenín	16-20	8.1	5.0	46	28	18.7	14.1
Křoví	16-20	2.7	2.5	23	12	3.6	5.0

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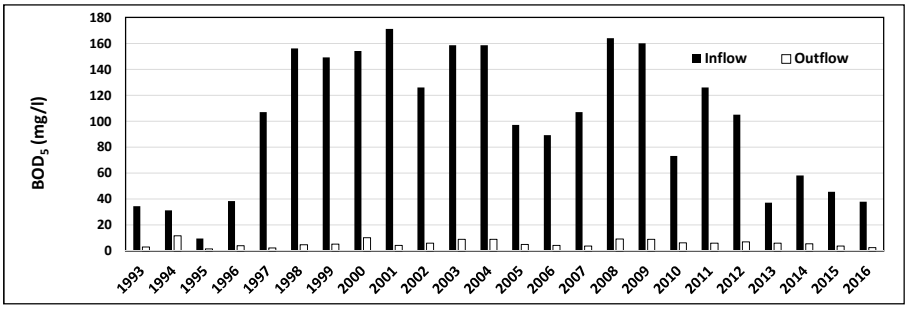
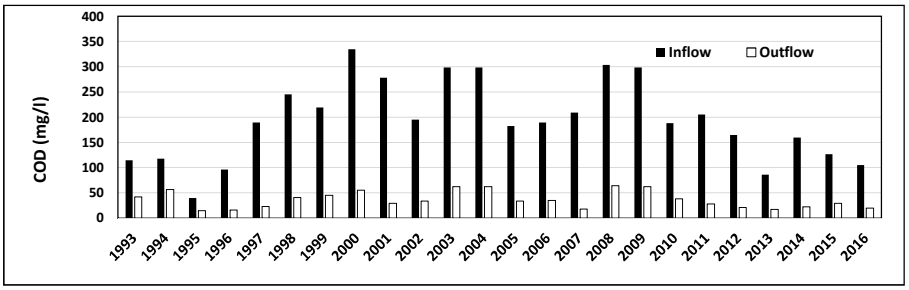
HF CW Chmenlá 2005

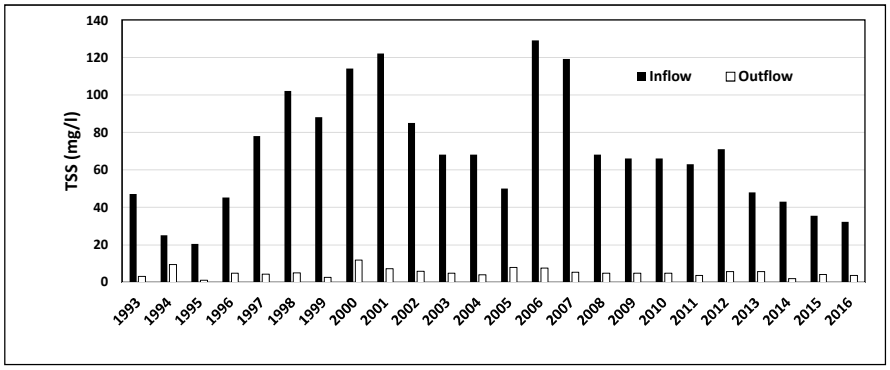

HF CW Chmelná 2017

Average annual concentrations of BOD_5 and COD at CW Chmelná between 1993 and 2016



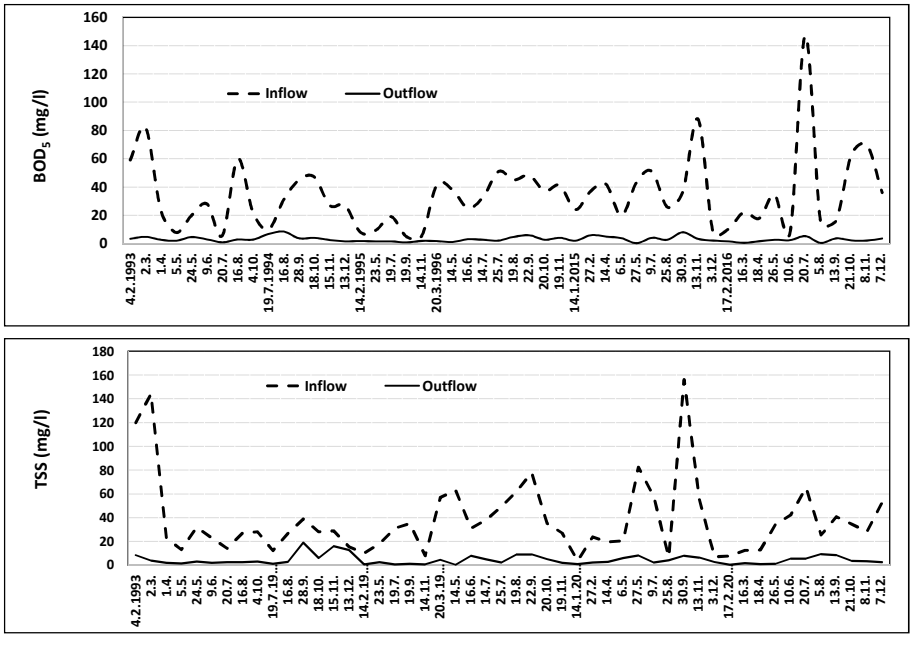


Average annual concentrations of TSS at CW Chmelná between 1993 and 2016



Average inflow loads: **7.7 g BOD_5/m^2 d**
16.2 g COD /m^2 d
8.5 g TSS/m^2 d

More detailed evaluation of inflow/outflow concentrations of BOD_5 and TSS in periods 1993-1996 and 2015-2016 at CW Chmelná



Average outflow concentrations of BOD_5, COD and TSS from 17 CWs with at least 20 years of operation.The first number for each parameter is the average for operation years 1-5, the second number is the average for the period indicated in the column*.

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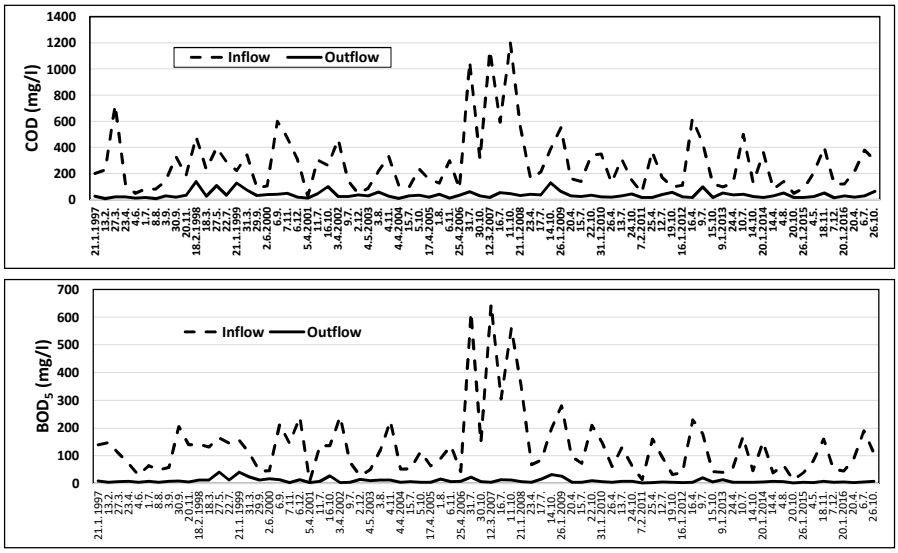
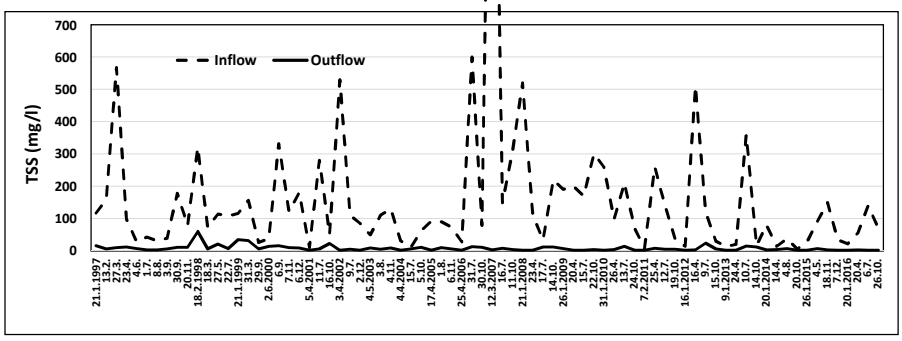
HF CW Zbenice in 2004, after 7 years of operation


HF CW Zbenice, after 20 years of operation
(spring)


summer

Inflow and outflow COD and BOD_5 concentrations at HF CW Zbenice during the period 1997-2016.





Clogging?

Inevitable process because of:

- **Sedimentation and filtration of suspended solids not trapped in pretreatment**
- **Growth of biofilms on filtration material**
- **Formation of preciates (Fe-precipitates in aerobic conditions, sulphides, carbonates under anaerobic conditions)**
- **Undecomposed belowground biomass**


Inflow gravel


Outflow gravel


HF CW Libníč, 11 years of operation


HF CW Spálené Poříčí, 20 years of operation

Conclusions

The HF constructed wetlands included in the survey sustainably provide outflow concentrations below 15 mg l^{-1} BOD_5, 60 mg l^{-1} COD and 15 mg l^{-1} TSS.

The results revealed that HF constructed wetlands provide a very stable removal of organics (BOD_5 and COD) and suspended solids if the inflow loadings are < 5 (8) g BOD_5 m^{-2} d^{-1}, < 15 g COD m^{-2} d^{-1} and < 10 g TSS m^{-2} d^{-1}.

If the inflow loadings are < 10 g BOD_5 m^{-2} d^{-1}, < 20 g COD m^{-2} d^{-1} and < 10 g TSS m^{-2} d^{-1} the partial ponding may occur after about 15 years of operation. However, the sustainable treatment efficiency occurs for at least 5 (10) more years.