POLITECHNIKA GDAŃSKA
WYDZIAŁ INŻYNIERII LĄDOWEJ I ŚRODOWISKA

Gdańskie Wody

Pilot installation for stormwater treatment

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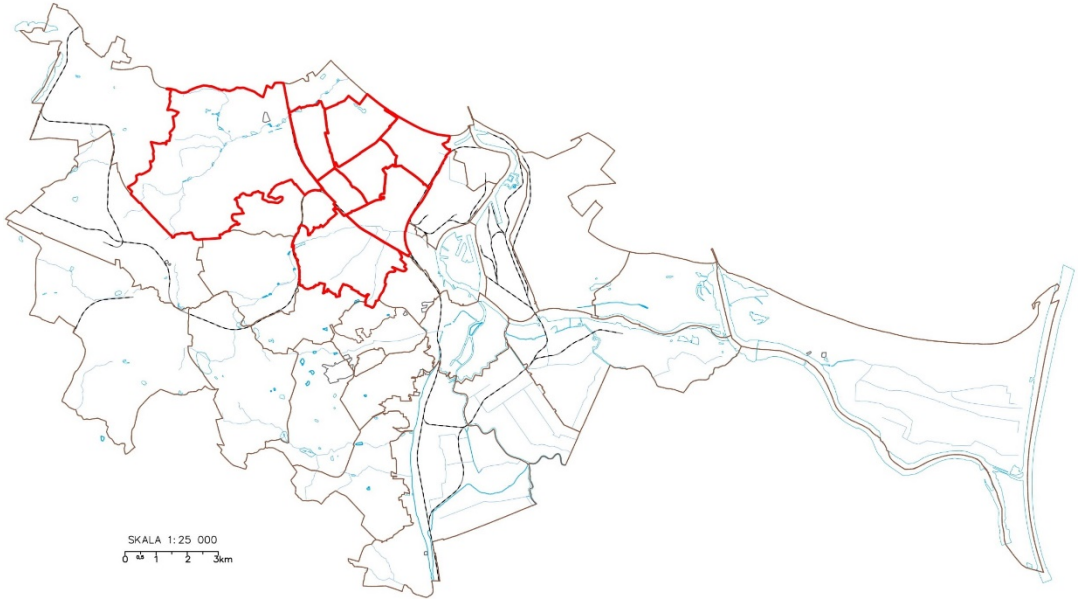
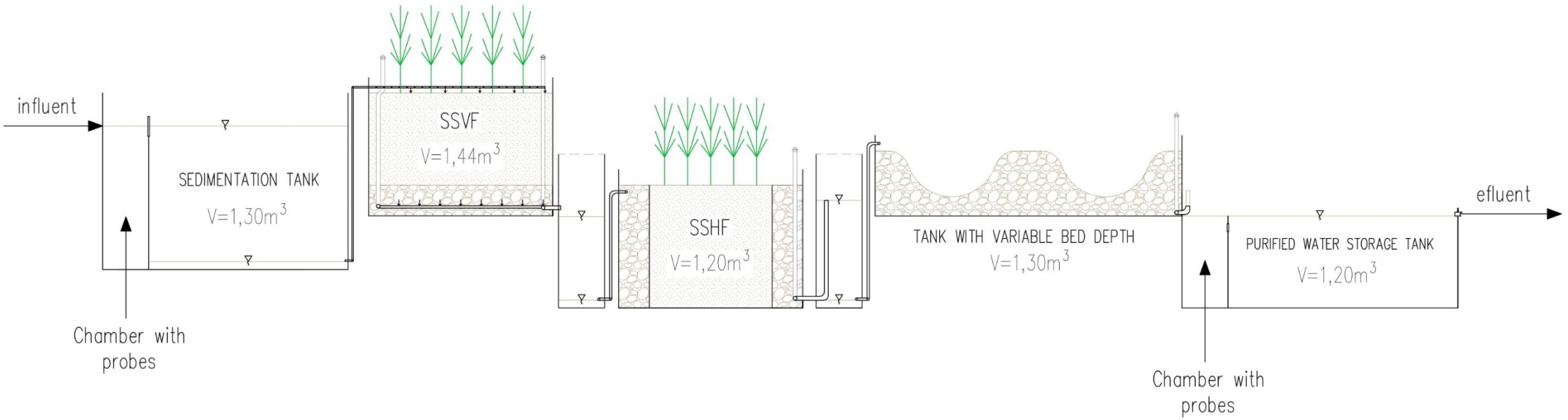
General information about the station

The pilot station is located in the seaside district in Gdansk, close to the outlet of the „Kołobrzeska” stormwater collector to the Bay of Gdansk.



The „Kołobrzeska” collector discharges stormwater from the catchment area of approximately 1,735.2 hectare (i.e. 17.35 square kilometers). **It’s a highly urbanized catchment area**.

Technological scheme of the station



Technological scheme of the wetland system (fractional-pilot installation). **1** - sedimentation tank. **2** - 1st stage bed with subsurface vertical flow (SSVF). **3** - 2nd stage bed with subsurface horizontal flow (SSHF). **4** - reservoir with variable bed depth. **5** - purified water storage tank.

Water quality parameters tested at the pilot station

Stormwater is **continuously** (24/h) monitored by probes before and after treatment:

1. pH
2. Temperature
3. Redox
4. Conductivity
5. Turbidity and solids content
6. dissolved oxygen

Additional laboratory analyses: **microplastics**, total nitrogen and forms of nitrogen, total phosphorus, BOD5, COD, TOC, general suspensions, **heavy metals** (Zinc, Cadmium, Copper, Nickel, Lead, Mercury), polycyclic aromatic hydrocarbons, phthalates, **bacteria** (Escherichia coli, Enterococci).

Research results – additional parameters

	Inlet concentration [mg/L]	Outlet concentration [mg/L]	Removal effectiveness [%]	Load removal rate [g/m²/d]
Total suspended solids - TSS	1.28 ÷ 5.66	0.31 ÷ 0.55	72 ÷ 96	0.09 ÷ 0.59
Chemical oxygen demand - COD	7 ÷ 39	6 ÷ 18	8 ÷ 75	0.03 ÷ 3.48
Biochemical oxygen demand - BOD_5	3	< 3	100	0.42
Total nitrogen TN	1.51 ÷ 2.13	0 ÷ 1.32	62 ÷ 100	0.1 ÷ 0.21
Ammonium-nitrogen N-NH_4	0.5 ÷ 0.56	< 0,5	100	0.003 ÷ 0.038
Nitrite-nitrogen N-NO_2	0.003 ÷ 0.12	< 0,003	100	0.002 ÷ 0.009
Nitrate-nitrogen N-NO_3	0.1 ÷ 0.5	0 ÷ 0.2	54 ÷ 100	0.006 ÷ 0.03
Total phosphorus TP	0.14 ÷ 0.35	0.02 ÷ 0.03	82 ÷ 96	0.01 ÷ 0.025
Total organic carbon - TOC	3.37 ÷ 9.81	2.04 ÷ 7.9	24 ÷ 66	0.09 ÷ 0.90

	Heavy metals			
	Inlet concentration [mg/m3]	**Outlet concentration** [mg/m3]	**Removal effectiveness** [%]	**Load removal rate** [mg/m²/d]
Zinc	158 ÷ 252	52 ÷ 63	62 ÷ 88	11.14 ÷ 17.39
Copper	24 ÷ 83	0 ÷ 44	26 ÷ 100	1.85 ÷ 4.25
Nickel	3 ÷ 8	2 ÷ 4	36 ÷ 66	0.12 ÷ 0.30
Lead	0 ÷ 18	0 ÷ 9	0 ÷ 100	0 ÷ 1.36
Mercury	0.15 ÷ 0.4	0.01 ÷ 0.07	56 ÷ 98	0.01 ÷ 0.02

PAHs – completly removed

Microbial contamination (E.coli, Enterococci) – over 90 % removal effectiveness

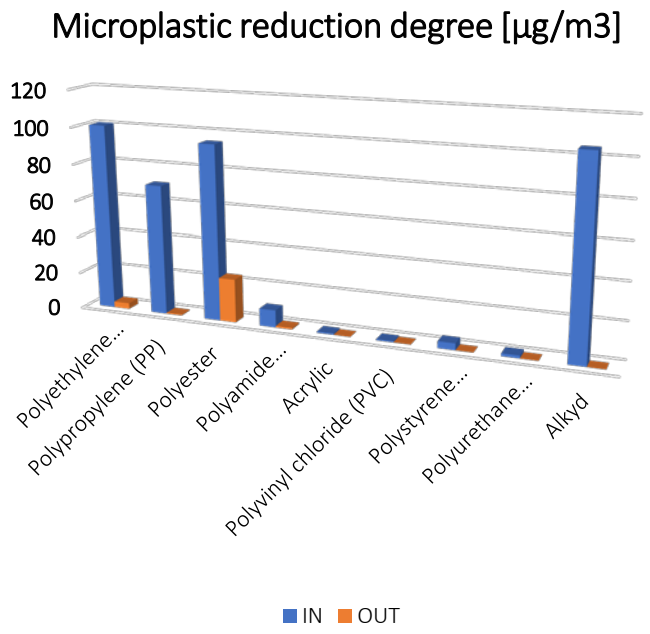
Research results – microplastics

	microplastics [µg/m3]								
	Polyethylene (PE)	**Polypropylene (PP)**	**Polyester**	Polyamide (PA)	Acrylic	Polyvinyl chloride (PVC)	Polystyrene (PS)	Polyurethane (PU)	**Alkyd**
IN	100,72	70,47	94,87	9,37	0,65	0,56	3,65	1,54	104,77
OUT	3,17	0,45	23,61	0,84	0	0	0	0,08	0

The largest weight share in the total mass of microplastics is attributed to: polyethylene, polypropylene, polyester and alkyd.

The reduction (%) results are very promising:

1. **Polyethylene**: (IN) = 100,72 µg/m^3, (OUT) = 3,17 µg/m^3 **(96,8%)**
2. **Polypropylene**: (IN) = 70,47 µg/m^3, (OUT) = 0,45 µg/m^3 **(99,4%)**
3. **Polyester**: (IN) = 94,87 µg/m^3, (OUT) = 23,61 µg/m^3 **(75,1%)**
4. **Alkyd**: (IN) = 104,77 µg/m^3, (OUT) = 0 µg/m^3 **(100%)**



Pilot installation for wastewater treatment

Constructed wetland technology
for microplastics removal and prevention
at the WWTP in Gdansk

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Gdansk Water Utilities
(GIWK)

Fanplesstic-sea

GIWK

Fanplesstic-sea

Interreg
Baltic Sea Region

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

Constructed wetland pilot station

Location – Gdansk WWTP

A – WWTP effluent channel B – pilot station

Gdansk WWTP general numbers

mechanical-biological WWTP with enhanced nutrients removal

average flow: 100 000 m^3/d

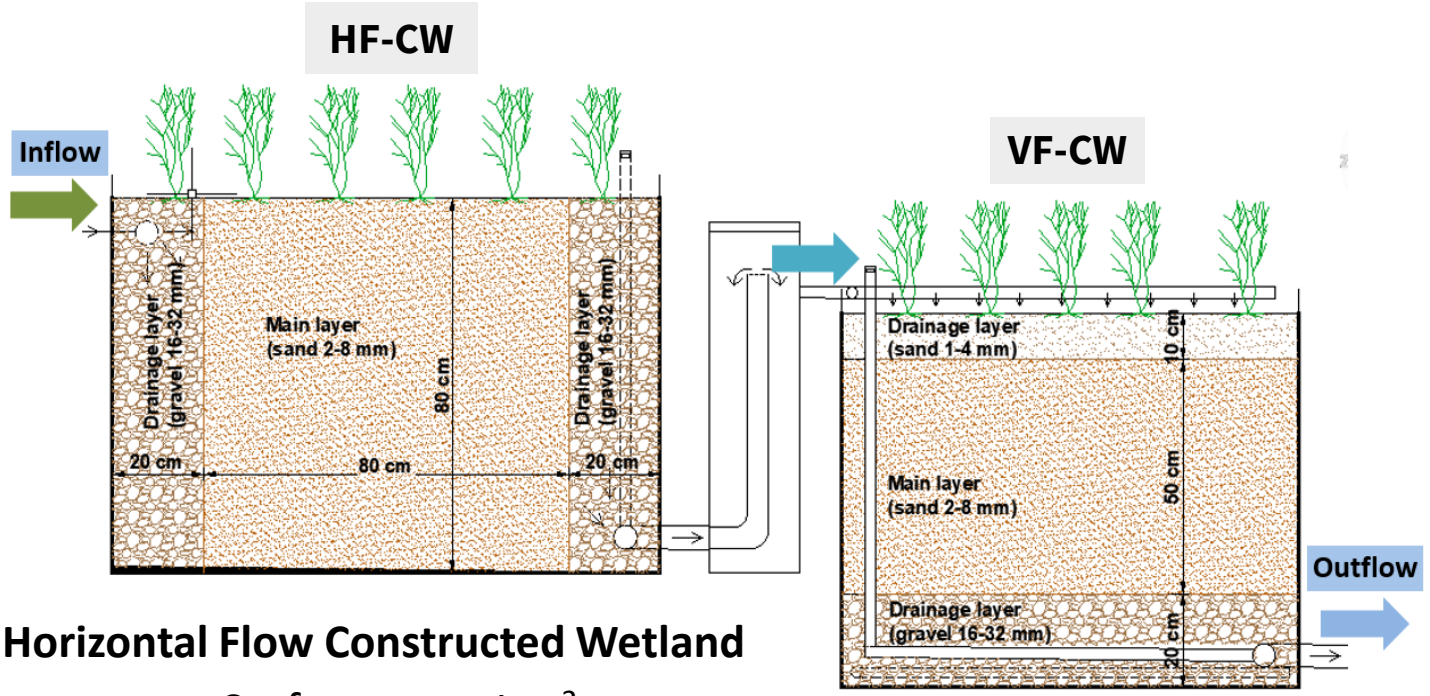
effluent receiver: Baltic Sea

capacity: 790 000 PE

Pilot station for **microplastics** removal
Hybrid (two-stage) **constructed wetland** system:

Testing the effectiveness of constructed wetland treatment method for microplastics removal from the final effluent of WWTP, before it is discharged to the Gulf of Gdansk.

Design and operation



Horizontal Flow Constructed Wetland

Surface area: 1 m^2

Depth: 0.8 m

Flow rate: 15–20 L/h ≈ 400 L/day

Vertical Flow Constructed Wetland

Surface area: 1 m^2

Depth: 0.8 m

Parameters in the inlet:

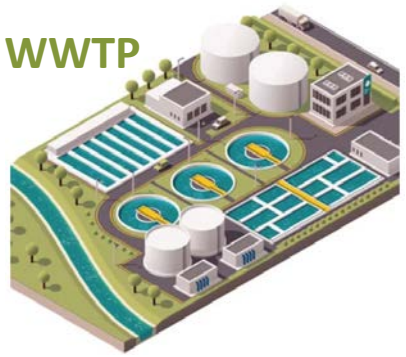
	Concentration [g/m^3]	Loading rates [$g/m^2/d$]
TSS	12.0	4.9
COD	34.9	14.2
TN	8.8	3.6
TP	0.34	0.14

Microplastics removal

WP (2.2) S5: **Inlet to the WWTP**
WP (3.2) M2: **Outlet of the WWTP**
WP (3.2) M3_8: **Outlet of the pilot**

~ 766.5 µg/L

72.8 kg/day



~ 1.21 µg/L

0.11 kg/day

Results soon

Raw WW: 2774 MPs/L

Polyester – 53%
Polyurethane – 16%
Polyurethane paint – 6%
Polyvinyl chloride – 6%
Acrylates – 4%
Polyethylene – 3%
Polypropylene – 3%
Polyamide – 3%
Polyvinyl acetate – 3%
Polystyrene – 2%
Alkyd – 1%

Treated WW: 6.7 MPs/L

Polyester – 30%
Polyurethane – 28%
Polyurethane paint – 2%
Polyvinyl chloride – 4%
Acrylates – 3%
Polyethylene – 6%
Polypropylene – 12%
Polyamide – 4%
Polyvinyl acetate – 2%
Polystyrene – 3%
Alkyd – 2%
Cellulose acetate – 5%

Transportation fate of microplastic pollution

sewage sludge

sewage sludge incineration plant

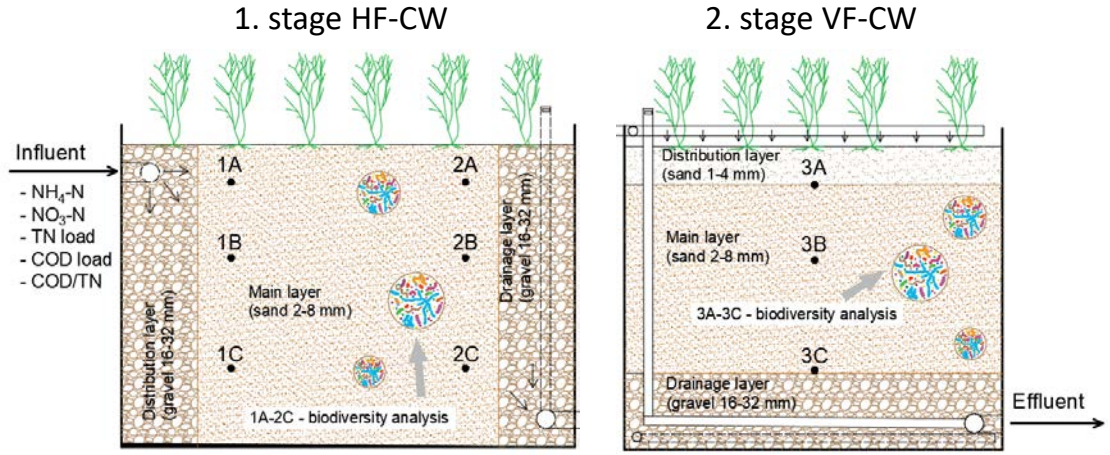
treated effluent

Additional studies at the pilot station

Parameter	Inlet concentration	Outlet concentration	Removal effectiveness	Load removal rate
	[mg/L]	[mg/L]	[%]	[g/m²/d]
Total suspended solids - TSS	**12.00**	**5.32**	**53.9**	**2.871**
Organic suspended solids	8.08	2.18	69.9	2.550
Chemical oxygen demand - COD	**34.92**	**21.40**	**37.9**	**5.679**
Biochemical oxygen demand - BOD_5	**2.40**	**0.48**	**80.0**	**0.776**
Total nitrogen TN	**8.76**	**4.76**	**52.7**	**1.512**
Ammonium-nitrogen $N\text{-}NH_4$	< 0.5*	< 0.5*	-	-
Nitrite-nitrogen $N\text{-}NO_2$	0.041	0.014	71.6	0.012
Nitrate-nitrogen $N\text{-}NO_3$	6.63	3.47	57.0	1.181
Total phosphorus TP	**0.34**	**0.19**	**43.2**	**0.065**

* concentration below detection limit

On-going microbiological studies to identify the microbial composition:



(1A-3C – sampling points of wetland matrix)

Thank you!

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