

CarbonCLEAN®

Demonstration pilot project for the removal of pharmaceuticals from wastewater r. č. 3213200007

Ing. Sylvie Kříženecká, Ph.D.
J. E. Purkyně University in Ústí nad Labem, Czech Republic
Faculty of Environment
Ing. Jan Káňa
AIVOTEK s.r.o., Kroměříž

CarbonCLEAN® (4073)

AIMS:

- Demonstrate **the removal effectiveness** of selected pharmaceuticals in real waste water and in real technological conditions of the WWTP in a demonstrative semi-operatio
- Determine the possible need for partial technological **modifications of the filter** equipment so that it can be used in normal operation.
- Technically, replaceable textile filters with CarbonCLEAN® sorbent will be used.



Gradual development

1. Testing of biochar (4073) on standard solutions and real wastewater
2. Preparation and testing of the first textile filter prototype on standard solutions and real wastewater
3. Preparation and testing of other types of textile filters
4. Selection of the most suitable type of filter and construction of a pilot unit

Textil filter development

Biochar 4073



First textile filter



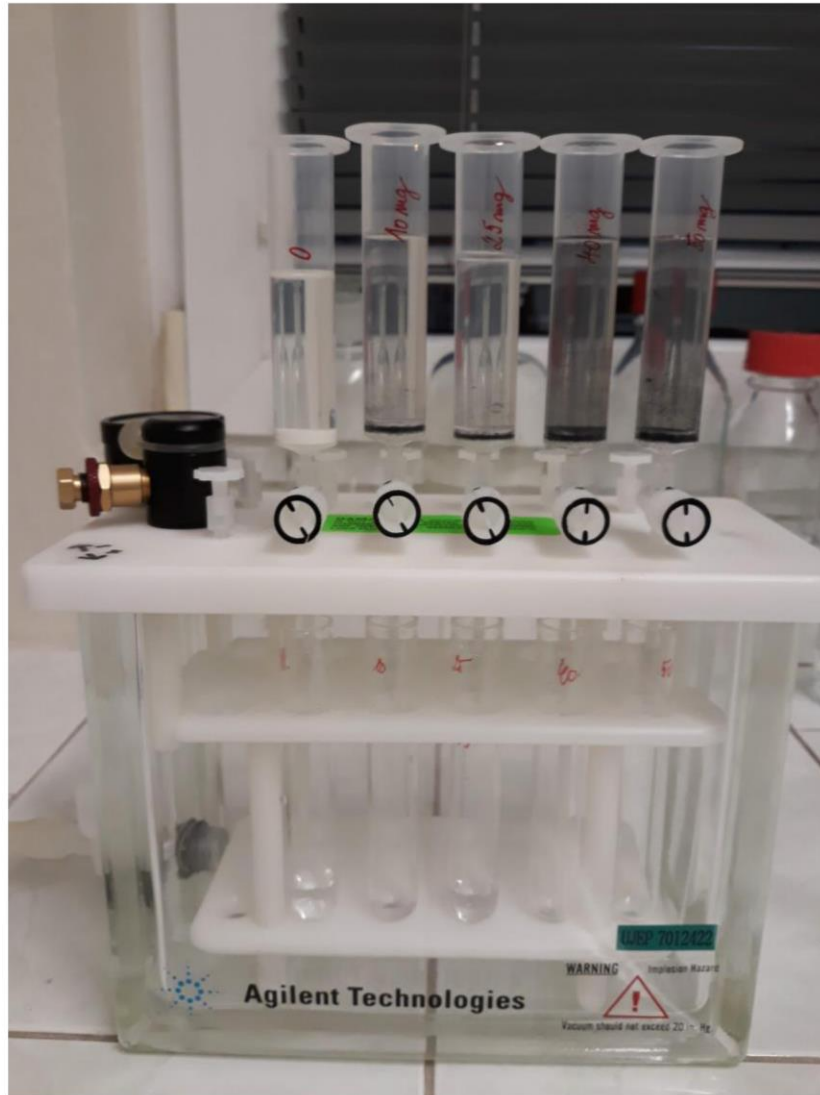
The best filter



Biochar (4073) characterization

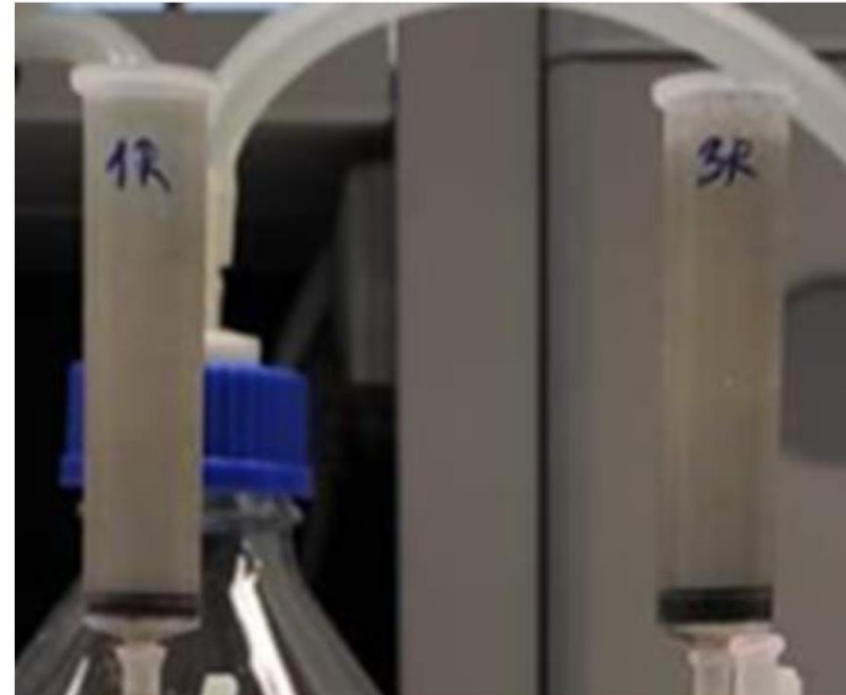
- Prepared by pyrolysis 470 °C for 25 minutes - digestate from wood and green maintenance (60%) and from corn separation (40%)
- Specific surface area of BET 571.6 ± 9.2 m²/g
- Grain size: 0.09 mm
- Content of -OH groups: 0.386 ± 0.02 mmol/g
- Elementar composition: 82.03% C, 0,74% H,
0.285% N, 16.95% O,
S ≤ LOQ

Biochar sorption test



- Different weight of biochar
- Sorption of pesticides, pharmaceuticals, $C_{10}-C_{40}$
- Sorption pollutants from real water

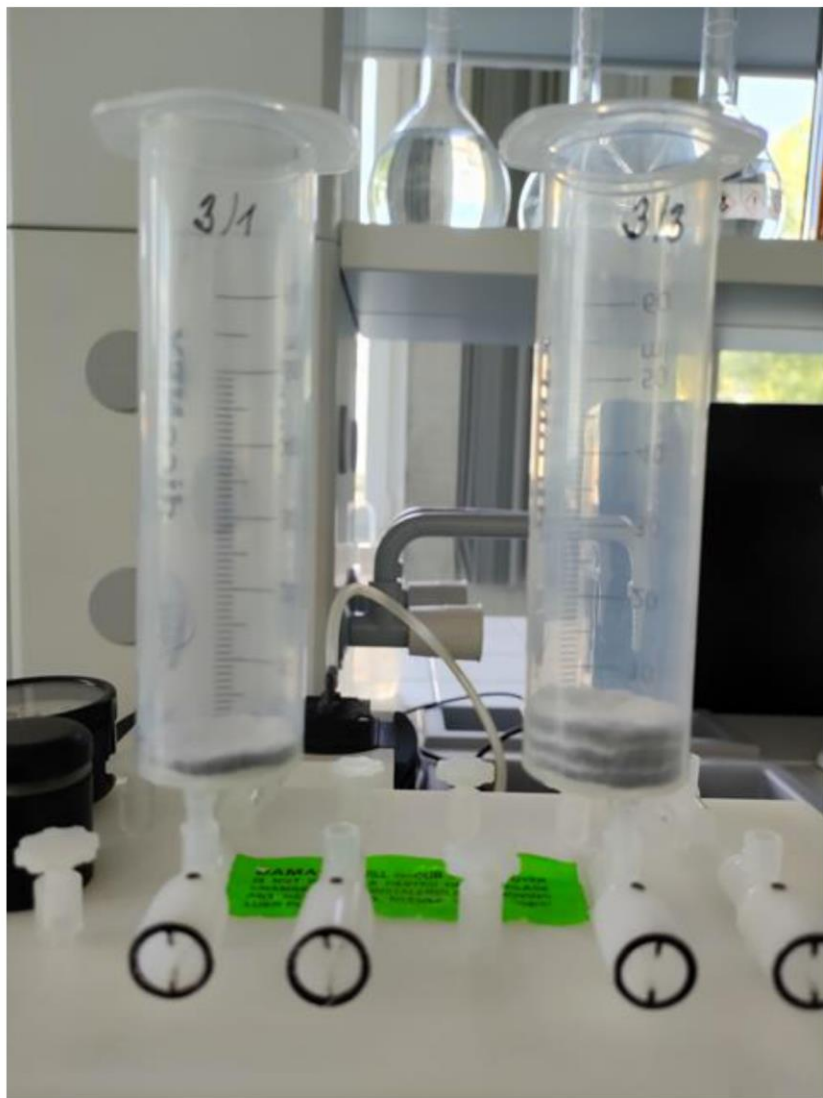
First textile filter



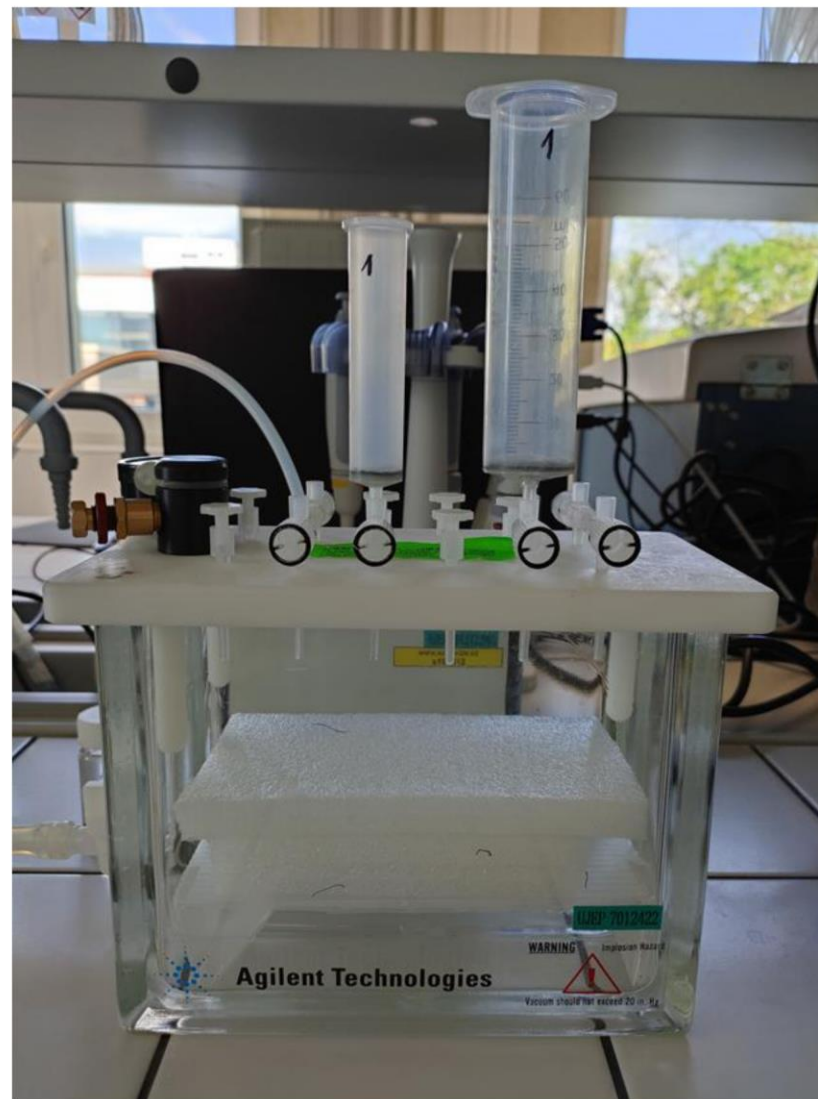
Results of sorption tests

Analytes	Conc 1 ug/L (%)/1 layer	Conc 100 ug/L (%)/1 layer	Conc 1 ug/L (%)/3 layers	Conc 100 ug/L (%)/3 layers
3-hydroxykarbamazepin	92,4 ± 9,2	48,0 ± 4,8	98,9 ± 9,9	92,2 ± 9,2
4-hydroxydiklofenac	90,8 ± 9,1	49,4 ± 4,9	96,6 ± 9,7	82,9 ± 8,3
Acebutolol	100 ± 10	74,8 ± 7,5	100 ± 10	98,0 ± 9,8
Acetylsulfadiazin	77,9 ± 7,8	24,7 ± 2,5	97,2 ± 9,7	39,7 ± 4,0
Carbamazepin	94,0 ± 9,4	45,1 ± 4,5	98,4 ± 9,8	89,3 ± 8,9
Clarithromycin	97,4 ± 9,7	87,8 ± 8,8	97,4 ± 9,7	95,2 ± 9,5
Diclofenac	91,4 ± 9,1	56,2 ± 5,6	100 ± 10	95,7 ± 9,6
Ketoprofen	95,7 ± 9,6	33,2 ± 3,3	100 ± 10	76,6 ± 7,7
N-acetylsulfamethoxazol	94,2 ± 9,4	50,4 ± 5,0	98,6 ± 9,9	90,2 ± 9,0
N-acetylsulfapyridin	90,1 ± 9,0	38,6 ± 3,9	98,8 ± 9,9	85,0 ± 8,5
Propranolol	98,4 ± 9,8	86,6 ± 8,7	98,5 ± 9,9	100 ± 10
Roxithromycin	97,2 ± 9,7	82,7 ± 8,3	97,3 ± 9,7	92,3 ± 9,2
Sotalol	86,3 ± 8,6	29,0 ± 2,9	97,4 ± 9,7	78,8 ± 7,9
Sulfamethoxazol	35,4 ± 3,5	5,60 ± 0,56	73,7 ± 7,4	9,80 ± 1,0
Sulfapyridin	75,2 ± 7,5	24,1 ± 2,4	96,0 ± 9,6	58,5 ± 5,9
Tramadol	95,2 ± 9,5	30,6 ± 3,1	98,4 ± 9,8	88,1 ± 8,8
Venlafaxin	96,1 ± 9,6	39,0 ± 3,9	97,9 ± 9,8	90,9 ± 9,1

Next filters, increasing volume



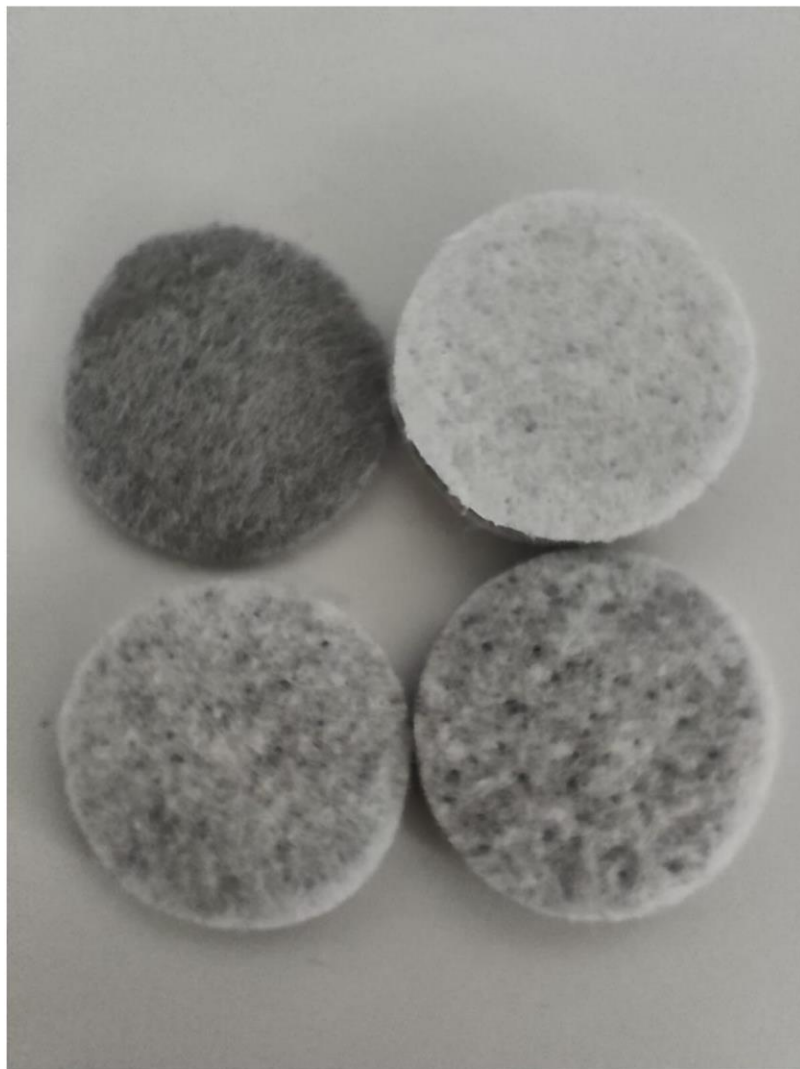
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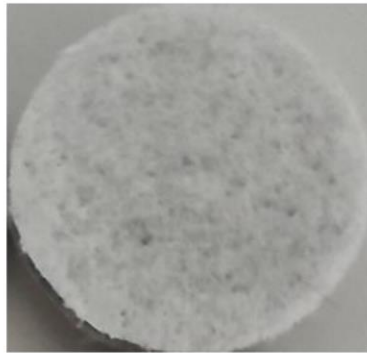
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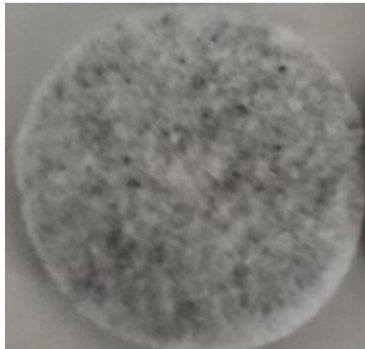
3 types of textile filters



3 types of textile filters



- **2.1.0** – 200 g/m², 100% **PES** calendered (core), impregnation in a bath of 300 ml water + 3 g 4073, flow rate 0.717 ml/s



- **2.1.1** – 200 g/m², 100% **VS** (core), impregnation in a bath of 300 ml water + 3 g 4073, flow rate 0.719 ml/s



- **2.1.2** – 200 g/m², 100% **VS** (core), impregnation in a bath of 300 ml water + 3 ml PAL + 3 g 4073, flow rate 0.712 ml/s

Results – 3 types of filters

Standards (%)	core /1	2.1.0/1	2.1.1/1	2.1.2/1	core /3	2.1.0/3	2.1.1/3	2.1.2/3
Acebutolol	98.6	100	100	98.8	95.3	97.4	96.3	96.0
Atenolol	89.1	92.0	97.0	100	94.7	94.2	94.5	100
Azithromycin	100	100	100	100	100	100	100	100
Clarithromycin	100	100	100	100	100	100	100	100
Clofibric acid	0	44.2	2.5	1.1	0	0	3.8	0
Erythromycin	93.6	9.1	93.7	94.0	89.4	84.5	90.7	90.7
Gabapentin	37.5	82.0	53.7	100	18.6	37.5	16.7	54.1
Hydrochlorothiazide	21.4	39.6	0	29.8	3.8	25.6	7.3	15.7
Ketoprofen	55.8	95.7	67.4	82.8	29.7	84.4	25.8	59.8
Metoprolol	100	100	100	100	95.3	100	96.0	95.9
Pentoxifyllin	58.3	100	71.3	88.4	18.2	82.9	14.0	66.0
Phenazone	26.4	100	44.9	81.1	24.8	89.6	25.2	46.6
Propranolol	94.5	94.5	94.5	94.5	92.7	92.9	92.8	92.9
Propyphenazone	16.8	96.1	43.4	66.7	38.8	74.4	40.0	50.3
Sotalol	70.3	83.4	86.3	96.6	89.8	88.6	89.3	93.2
Tramadol	100	100	100	100	94.0	100	95.0	94.6
Trimethoprim	100	100	100	100	94.0	95.4	95.4	96.2
Venlafaxine	100	100	100	100	100	100	100	100

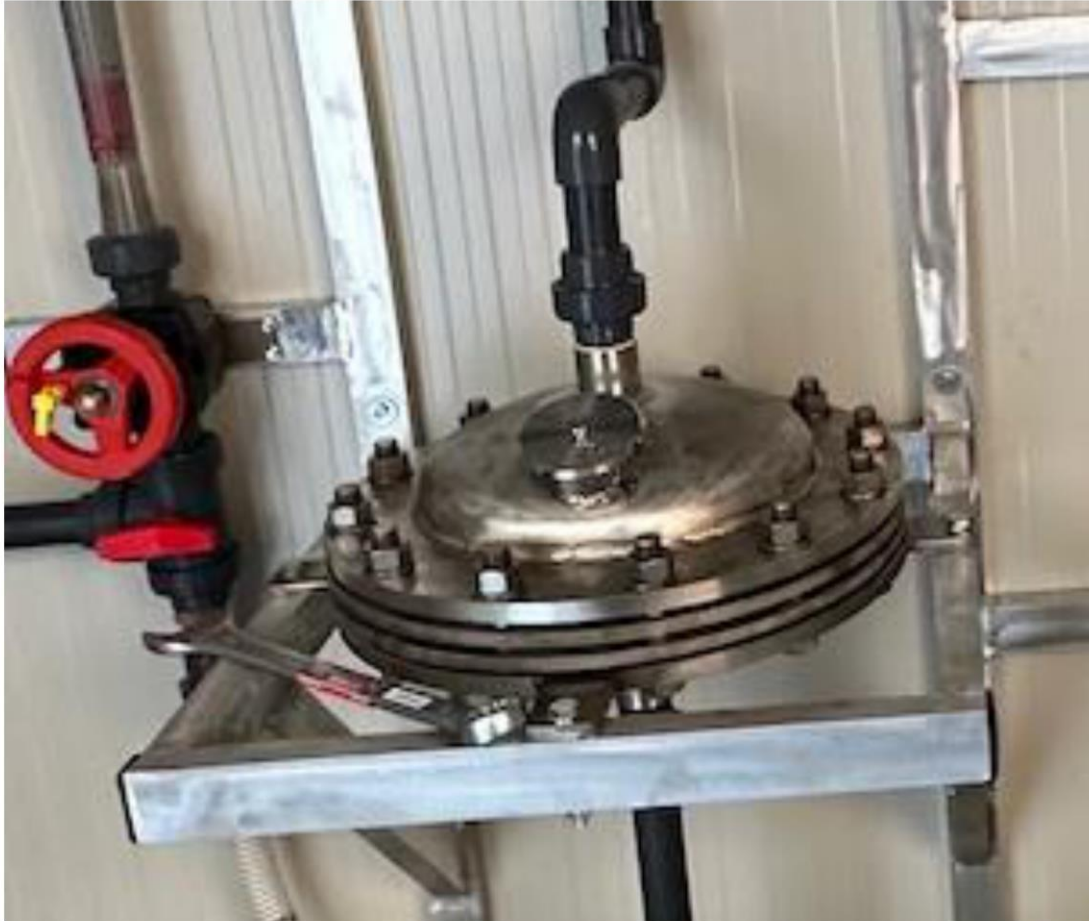


The best filter is 2.1.0

Pilot technology



Cloth filters

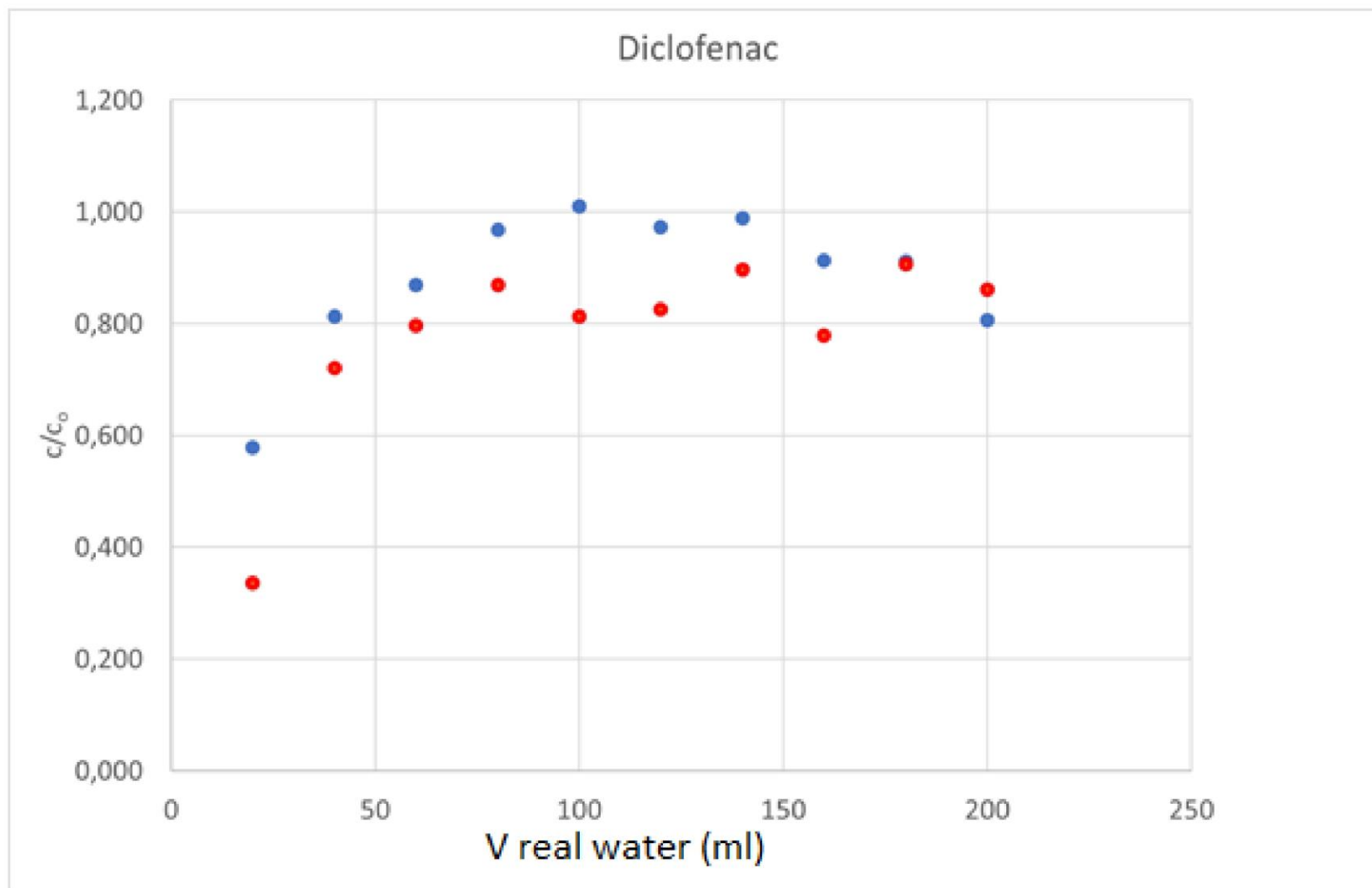


- 3 layers of textile filter
- First test - 3 x 200 g/m² biochar
- Second test – 2 x 200 g/m² and 1x 300 g/ m² biochar
- Test on real waste water in Zlín and Ostrava

Results – real wastewater

	Ostrava (%)	Zlín (%)
Acebutolol	94.5	89.4
Acetaminophen	96.1	88.1
Atenolol	95.3	90.9
Caffeine	89.1	79.3
Carbamazepine	90.2	93.5
Clofibric acid	99.3	95.5
Diclofenac	72.6	87.8
Hydrochlorothiazide	83.0	88.0
Ketoprofen	94.6	91.1
Metoprolol	90.9	89.4
Pentoxifyllin	98.1	92.4
Primidon	95.1	92.1
Propranolol	99.4	93.7
Propyphenazone	99.3	96.3
Sulfamethoxazole	90.0	86.3
Tramadol	78.2	97.3
Trimethoprim	91.8	91.9
Venlafaxine	91.2	90.8
Efficiency average	91.6	90.8

Breakthrough curves



SPE extraction (RWW)



LC-MS/MS

- Luna Omega C18 PS (100x2.1 mm)
- MF: A – H₂O with 0.5 mM NH₄F + 0.01% FA
B – ACN + MeOH (1+1)
- UHPLC 1290 Infinity II (Agilent Technologies)
- 6495 QQQ (Agilent Technologies)

Thanks to.....

CADORAN
Centre for Advanced Organic Analyses

Ing. Kateřina Klubalová

Petra Veronesi Dáňová

Management and staff WWT Ostrava



STATE ENVIRONMENTAL
FUND OF THE
CZECH REPUBLIC

Working together for a green Europe

Supported by grant from the people
of Norway.