BRNO UNIVERSITY OF TECHNOLOGY
FACULTY OF CIVIL ENGINEERING

THESSALONIKI 2021

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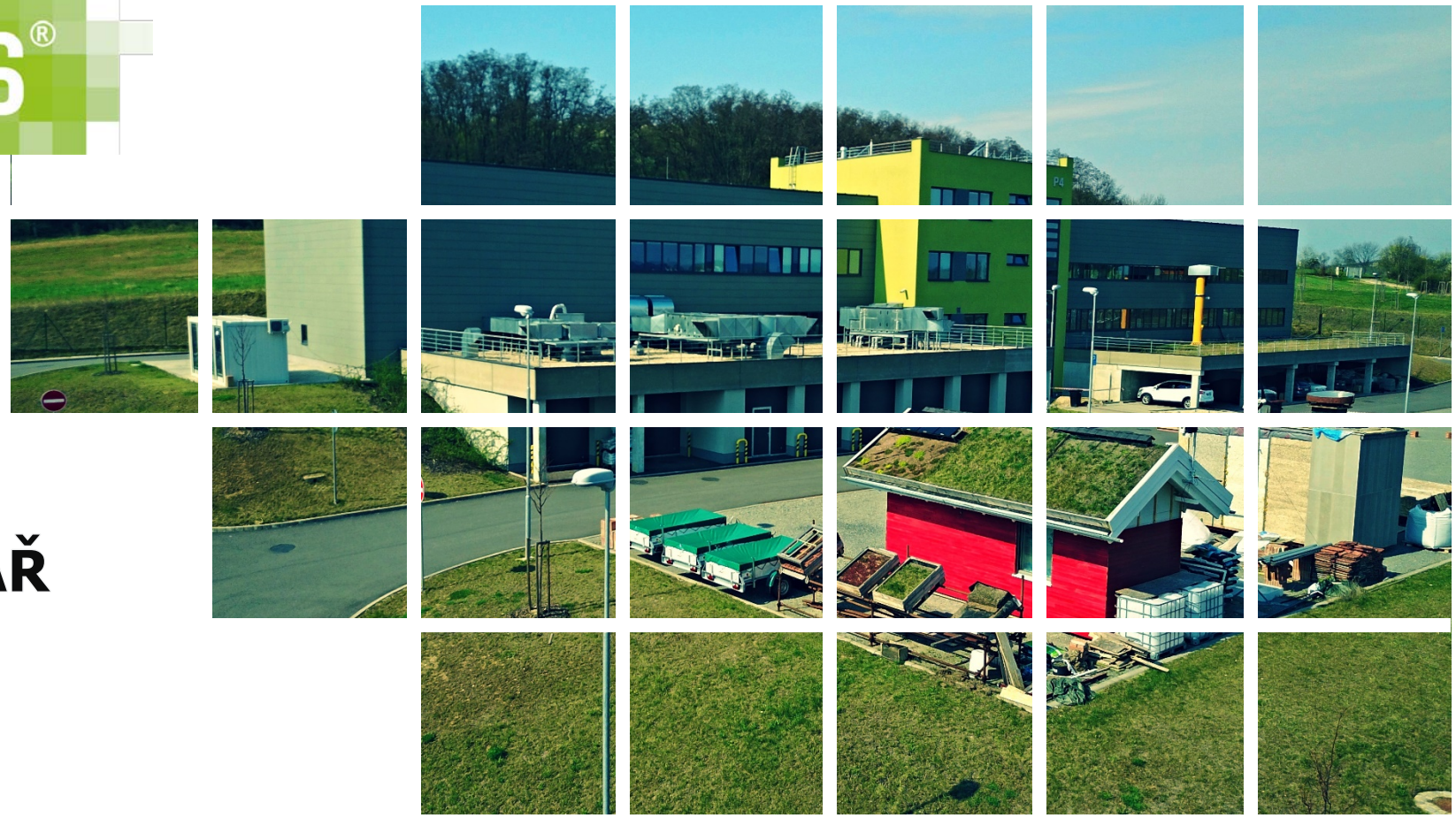


IVO KORYTÁŘ

CHARACTERISTICS OF WASTEWATER FROM TUNNEL WASHING: CASE STUDY FROM BRNO

Outline:

1. Introduction: affecting factors, origins of contaminant, TWW treating in EU;

2. Materials and Methods: tunnel wash water (TWW),road tunnel in Brno, activation of biochar, experiments;

3. Results and discussion: Glasses pre-tests – contact time (CT), and adsorbent concentration;

4. Conclusions and further development of research.

1. Introduction

Factors affecting quality of TWW

- Traffic loading;
- length of road tunnel;
- tunnel equipment settings;
- frequency of washing processes 2-12 times per year;
- volume of water 30 – 150 L per linear meter;
- amount of detergents 0,5 – 1 %;
- water pressure 6 – 160 bars.

1. Introduction: origins of contaminant

Contaminant	Origin of pollution
Suspended solids	Weather-beaten surface material, tire
Pb	Tire, petroleum
Al	Tire, road surface (asphalt, bitumen)
Zn	Tire, oil drip, used lubricant oil
Fe	Breaks, vehicle body, road surface (asphalt, bitumen)
Cu	Brakes, fungicides
Cd	Tire, insecticides
Cr	Vehicle body, breaks
Ni	Oil and petroleum spill, metals, asphalt
Mn	Vehicle body, tire
Ti	Road surface (asphalt, bitumen)
Cl, cyanide, Na, Ca	Winter operating, de-icing
Hydrocarbons	Oil and petroleum spill, oil drip, used lubricant oil

1. Introduction

- Circular Economy Strategy search for new ways of reusing carbon waste and minimizing water pollution;
- the aim of the AdMaS research:
  - the transformation of carbon waste into new product (biochar);
  - reusing biochar for minimizing water pollution.

1. Introduction

TWW from road tunnels in EU

- Switzerland, Austria – not allowed;
- Norway, Sweden – not mandatory;
- CR 29 - road tunnels;
  - total length 43,5 km;
  - sedimentation tank.

2. Materials and Methods

Road tunnel in Brno – case study

- Road tunnel in Brno 2.495 m;
- annual average daily traffic 30 000;
- the average water consumption 160,3 L per linear metre;
- sedimentation tank.

2. Materials and Methods:biochar activation

Biochar → Milling → Fraction 0,5-2 mm → Activation

HCl

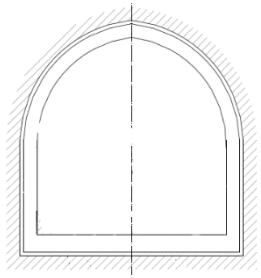
Neutralization
- 200 mL demi water
- 5.0 g activated biochar
- 40 °C constant temperature
- 24-hour mixing

Drying
- Activated neutralized biochar
- 80 °C constant temperature
- 24 hour drying

Adsorbtion

2. Materials and Methods

Road tunnel washing



TWW

Adsorbent

- GAC
- FWB
- AFWB
- WB

Stirring

- Determined CT
- Determined concentration

Filter paper

Chemical determination

- Heavy metals
- C10-C40
- Chlorides
- Sulfates
- Chemical elements

2. Materials and Methods

Sample preparation

- Glasses pre-tests – CT;
  - CT: 0-7-24-46 h;
  - concentration of adsorbent: 2,5 $g \cdot L^{-1}$;
  - adsorbents: GAC, FWB, AFWB;
- glasses pre-tests – adsorbent concentration;
  - CT: 1 h;
  - concentration of adsorbent: 1,0 - 2,5 - 4,0 $g \cdot L^{-1}$;
  - adsorbents: GAC, WB, AFWB;

3. Results and discussion

Glasses pre-tests – CT

Adsorbent	Time	Weight	Cu	Ni	Cr	As	Zn	Na	Ca	Mg
	[h]	[g·L^{-1}]	[µg·L^{-1}]	[µg·L^{-1}]	[µg·L^{-1}]	[µg·L^{-1}]	[µg·L^{-1}]	[mg·L^{-1}]	[mg·L^{-1}]	[mg·L^{-1}]
GAC	0	0	4.45 ± 0.07	35.25 ± 1.05	0.98 ± 0.05	5.76 ± 1.08	21.36 ± 0.65	293.33 ± 5.77	67.00 ± 0.00	6.78 ± 0.04
	7	2.5	8.97 ± 0.49	34.85 ± 0.39	<LOD	<LOD	10.97 ± 0.32	253.33 ± 5.77	61.67 ± 0.58	8.79 ± 0.17
	24	2.5	4.01 ± 0.03	36.73 ± 0.15	<LOD	<LOD	4.10 ± 0.28	270.00 ± 0.00	54.67 ± 0.58	11.24 ± 0.06
	46	2.5	3.98 ± 0.25	32.53 ± 0.05	<LOD	<LOD	9.32 ± 0.34	260.00 ± 0.00	55.33 ± 0.58	10.45 ± 0.13
FWB	0	0	8.99 ± 0.18	39.85 ± 0.39	<LOD	<LOD	141.82 ± 1.53	270.00 ± 0.00	56.00 ± 0.00	7.77 ± 0.18
	7	2.5	7.05 ± 0.29	40.10 ± 1.05	<LOD	<LOD	8.55 ± 0.39	310.00 ± 0.00	69.67 ± 0.58	7.91 ± 0.19
	24	2.5	3.44 ± 0.30	38.86 ± 0.13	<LOD	<LOD	11.95 ± 0.46	333.33 ± 5.77	70.00 ± 0.00	9.94 ± 0.22
	46	2.5	7.75 ± 0.04	35.10 ± 0.21	<LOD	<LOD	13.06 ± 0.11	366.67 ± 5.77	68.00 ± 0.00	9.54 ± 0.23
AFWB	0	0	8.99 ± 0.18	39.85 ± 0.39	<LOD	<LOD	141.82 ± 1.53	270.00 ± 0.00	56.00 ± 0.00	7.77 ± 0.18
	7	2.5	6.14 ± 0.22	33.47 ± 0.01	<LOD	<LOD	27.57 ± 0.65	280.00 ± 0.00	63.00 ± 0.00	8.64 ± 0.13
	25	2.5	2.65 ± 0.10	35.25 ± 0.08	<LOD	<LOD	16.76 ± 0.44	280.00 ± 0.00	62.00 ± 0.00	9.44 ± 0.30
	46	2.5	5.03 ± 0.24	36.39 ± 0.30	<LOD	<LOD	25.11 ± 0.34	286.67 ± 5.77	67.00 ± 0.00	9.11 ± 0.21

Glasses pre-tests – adsorbent concentration

Adsorbent	Weight	pH	US	Tenside	C10-C40	Chlorides	Sulfates
	[g·L^{-1}]	-	[g·L^{-1}]	[mg·L^{-1}]	[g·L^{-1}]	[mg·L^{-1}]	[mg·L^{-1}]
-	0.0		0.62 (UF)	0.44	0.02 (UF)	4400.00	71.00
WB	0.0	8.397	0.45 (UF)	0.14	0.13 (UF)	220.00	62.00
	1.0	8.435	-	0.18	0.01	185.00	55.00
	2.5	8.522	-	0.16	0.02	155.00	56.00
	4.0	8.574	-	0.22	0.17	145.00	66.00
AFWB	0.0	8.395	0.42 (UF)	0.31	0.64 (UF)	185.00	73.00
	1.0	8.398	-	0.36	0.17	150.00	64.00
	2.5	8.306	-	0.17	0.22	170.00	79.00
	4.0	8.274	-	0.16	0.15	185.00	83.00
GAC	0.0	8.288	0.16 (UF)	0.25	0.05 (UF)	225.00	63.00
	1.0	8.421	-	0.27	0.11	190.00	84.00
	2.5	8.546	-	0.24	0.26	180.00	80.00
	4.0	8.658	-	0.26	0.32	210.00	78.00

Glasses pre-tests – adsorbent concentration

Adsorbent	Weight	Cu	Ni	Cr	Zn	Na	Ca	Mg	Fe
	[g·L^{-1}]	[µg·L^{-1}]	[µg·L^{-1}]	[µg·L^{-1}]	[µg·L^{-1}]	[mg·L^{-1}]	[mg·L^{-1}]	[mg·L^{-1}]	[µg·L^{-1}]
-	0.00	29.16 ± 0.23	42.17 ± 3.00	3.16 ± 0.09	139.98 ± 3.87	130.00 ± 0.00	79.33 ± 0.58	11.12 ± 0.27	311.44 ± 9.16
WB	0.0	1.78 ± 0.15	<LOD	<LOD	48.27 ± 4.96	113.33 ± 5.77	57.33 ± 2.08	8.81 ± 0.19	254.36 ± 8.71
	1.0	<LOQ	<LOD	<LOD	8.77 ± 0.18	186.67 ± 5.77	58.67 ± 0.58	9.26 ± 0.18	<LOD
	2.5	2.39 ± 0.12	<LOD	<LOD	29.49 ± 1.13	186.67 ± 5.77	57.33 ± 1.53	10.32 ± 0.14	<LOD
	4.0	2.07 ± 0.07	<LOD	<LOD	17.89 ± 0.14	96.67 ± 5.77	57.67 ± 1.15	10.95 ± 0.25	<LOD
AFWB	0.0	1.51 ± 0.11	<LOD	<LOD	29.59 ± 5.10	66.67 ± 5.77	60.33 ± 1.15	9.31 ± 0.25	130.84 ± 12.98
	1.0	<LOQ	<LOD	<LOD	9.29 ± 0.37	110.00 ± 0.00	59.00 ± 1.00	9.06 ± 0.20	<LOD
	2.5	1.08 ± 0.22	<LOD	<LOD	9.66 ± 0.25	76.67 ± 5.77	60.00 ± 1.73	8.55 ± 0.09	<LOD
	4.0	1.57 ± 0.12	<LOD	<LOD	21.14 ± 0.95	96.67 ± 5.77	63.00 ± 0.00	9.18 ± 0.20	<LOD
GAC	0.0	1.38 ± 0.42	<LOD	<LOD	29.50 ± 1.46	100.00 ± 10.00	58.00 ± 1.00	8.80 ± 0.14	234.12 ± 5.89
	1.0	0.92 ± 0.03	<LOD	<LOD	<LOD	123.33 ± 5.77	54.00 ± 0.00	9.30 ± 0.19	<LOD
	2.5	0.93 ± 0.05	<LOD	<LOD	<LOD	60.00 ± 0.00	53.67 ± 0.58	9.08 ± 0.22	<LOD
	4.0	1.17 ± 0.00	<LOD	<LOD	<LOD	116.67 ± 15.28	52.67 ± 1.53	9.48 ± 0.25	<LOD

4. Conclusion

- Our tests have proved that biochar as adsorbent could reduce chosen pollutants from TWW;
- biochar could have similar reduction effectivity as granulated active carbon;
- pre-tests have showed applicable contact time and concentration of adsorbents;
- future research: glasses tests focused on another adsorbents with CT 1 hour and concentration of adsorbent 1,0 $g \cdot L^{-1}$.

Thank you for your attention

Questions??

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