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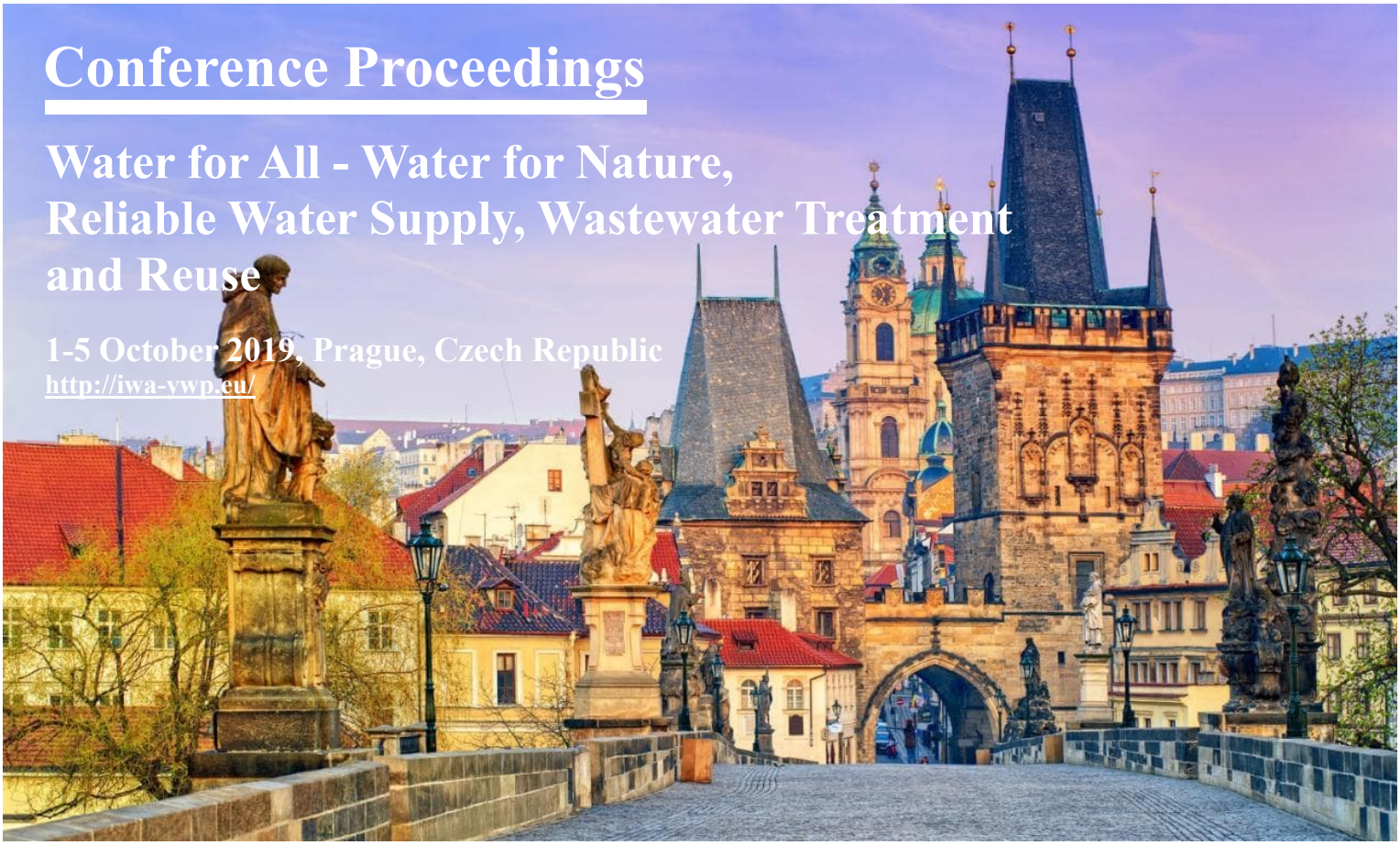

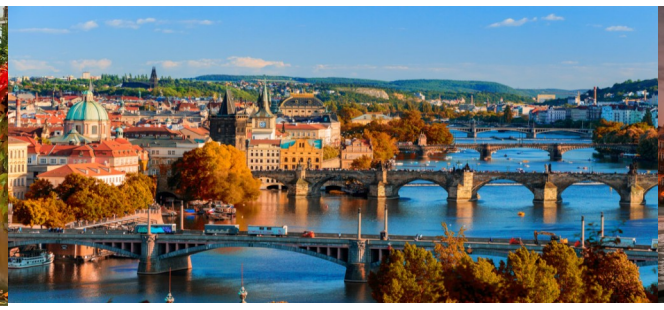

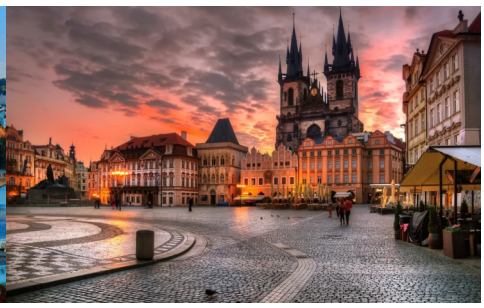

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CONTENTS

WATER MANAGEMENT

Characterization of Leachate from Non-sanitary Municipal Solid Waste Landfill in Novi Sad

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Abstract
Leachate is produced through complex chemical reactions, infiltration of the atmospheric water in the landfill body and the water contained in the waste, as well as through dissolution of waste pollutants. Due to its toxic composition, leachate pollutes soil and groundwater. It is very difficult to foresee real composition of landfill leachate due to dynamics of the processes occurring in the landfill body and the impact of a large number of variable factors. Qualitative composition of the leachate is characterized by pollutants that can be classified into four groups - *soluble organic components*, *inorganic macrocomponents*, *heavy metals* and *xenobiotic organic compounds*. The main objective of the conducted research was determination of the quality and organic profile of the leachate collected at non-sanitary municipal solid waste landfill in Novi Sad, by performing a screening analysis using GC-MS device.

Keywords
Landfill leachate; characterization of landfill leachate; municipal solid waste landfill; screening analysis using GC-MS device; organic compounds

INTRODUCTION

Leachate is the entity resulted from a several factors in both, the landfill body itself (landfill age, morphological waste composition, temperature and humidity, migration of fluid, pre-disposal waste treatment technology, thickness of the landfill body, waste decomposition stage), and outside of it (meteorological parameters, with focus on annual precipitation volume, as well as seasonal variations). The process of landfill filtrate forming includes decomposition of solid organic matter in the water drained through the landfill body and generating of new substances by biological processes and chemical reactions, which inevitably occur within the landfill body (Brennan et al., 2015).

Real composition of the landfill leachate is very difficult to foresee due to dynamics of the processes occurring in the landfill body and the impact of a large number of variable factors. Qualitative composition of leachate is characterized by pollutants that can be classified in four basic groups (Christensen et al., 1998; Kjeldsen et al., 2002): *soluble organic components* (volatile fatty acids, humic and fulvic acids), *inorganic macrocomponents* (ions of calcium, Ca^{2+}, magnesium, Mg^{2+}, sodium, Na^{+}, potassium, K^{+}, ammonium, NH_4^{+}, iron, Fe^{2+}, manganese, Mn^{2+}, chlorides, Cl^{-}, sulphates, SO_4^{2-}, carbohydrates, HCO^{3-}), *heavy metals* (ions of cadmium, Cd^{2+}, chromium, Cr^{3+}, copper, Cu^{2+}, lead, Pb^{2+}, nickel, Ni^{2+}, and zinc, Zn^{2+}), *xenobiotic organic compounds* (carbohydrates, phenols, chlorinated aliphatic compounds, pesticides, dioctyl phthalates). The toxic and hazardous matters previously registered and identified in landfill leachate, from the region of Vojvodina, are aromatic carbohydrates, halogenated compounds, phenols, pesticides, heavy metals and nutrients (Đogo et al., 2016).

The main objective of the conducted research was determination of the quality and organic profile of the leachate collected at non-sanitary municipal solid waste landfill in Novi Sad, by performing a

screening analysis using GC-MS device.

MATHERIALS AND METHODS

Leachate sampling campaigns were carried out during the winter and spring periods 2019 in 2 hours cycles at the landfill in Novi Sad (Figure 1.).

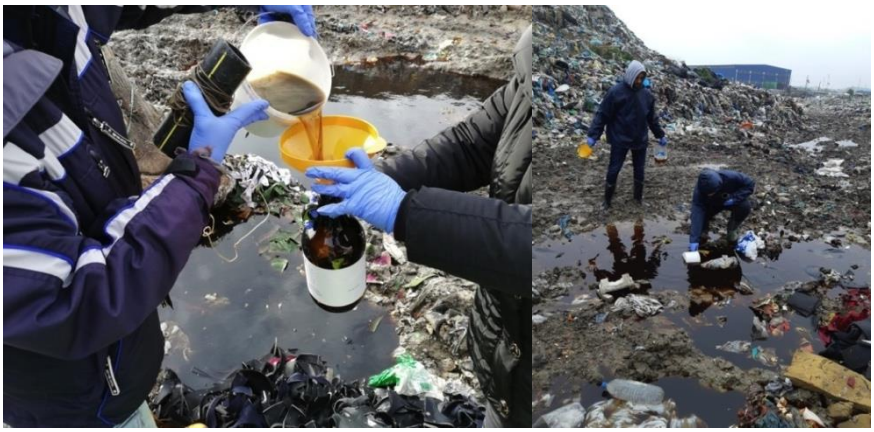

Figure 1. Collecting of leachate at a non-sanitary municipal solid waste landfill in Novi Sad in winter (left) and spring (right) 2019

Total of 2 L of leachate were collected for the purpose of the screening analysis.The samples were transported and stored at the temperature of 4 ^{o}C until the preparation for the analysis. Samples were prepared by liquid-liquid extraction and concentrated in the Kuderna-Danish device. Previously prepared internal standard Fenantren D10, concentration of 15 ppm in methanol, was applied, while dichloromethane was used as a solvent agent. QP2010-Ultra GC-MS, Shimadzu, and Agilent HP – 5ms column (30 m·0,25 mm·0,25 μm) were used for the analysis. The screening analysis was conducted in the Laboratory for monitoring landfills, wastewater and air of the Department of Environmental Engineering and Occupational Safety and Health, Faculty of Technical Sciences in Novi Sad.

RESULTS

The organic profile of the analysed leachate is result of the morphological composition of the disposed waste and its seasonal variations, age of the landfill, as well as of the meteorological parameter variations, i.e. temperature, precipitation and humidity. The organic profile of the leachate from the non-sanitary municipal solid waste landfill in Novi Sad in winter and spring periods 2019 is presented in Table 1.

Table 1. The organic profile of the leachate from the non-sanitary municipal solid waste landfill in Novi Sad in winter and spring periods 2019

Group of compounds	**Winter period**	**Spring period**
Carbohydrates	5	7
Organic acids, esters, and salts of organic acids	12	16
Phthalates	/	/
Alcohols, ketones and aldehydes	7	10
Phenols	3	1
Heterocyclic compounds	5	2
Organonitrogen compounds	5	5
Total detected	38	41

The obtained results indicate the dominant presence of two groups of organic compounds: *organic acids, esters and salts of organic acids* and *alcohols, ketones and aldehydes*. The specified groups of organic compounds are usually presentin the organic fraction of waste and products of degradation (fruit, animal waste, food products) and in industrial waste as well (pharmaceuticals, synthetic polymers, industrial solvents, essential oils).

Table 2, Table 3, Table 4, Table 5, Table 6. and Table 7 show identified organic compounds within the groups of *carbohydrates, organic acids, esters and organic acid salts, phthalates, alcohols, ketones and aldehydes, phenols, heterocyclic compounds* and *organonitrogen compounds* in winter and spring periods.

Table 2. Identified compounds within the group of *carbohydrates* during the winter and spring periods 2019

Winter period			
Group of compounds	**CAS Number**	**Molecular weight [g mol^{-1}]**	**Retention time**
Z,Z,Z-1,4,6,9-Nonadecatetraene	82970-94-3	260.46	16.383
(Cyclopropyl)trivinylsilane	959074-89-6	150.30	51.688
Longipinane, (E)-	/	206.37	53.108
3.5-Decadiyne, 2.2-dimethyl-	55682-73-0	162.27	58.790
cis-Z-.alpha.-Bisabolene epoxide	/	220.35	70.930
Spring period			
Group of compounds	**CAS Number**	**Molecular weight [g mol^{-1}]**	**Retention time**
Cyclopentane, 1-methyl-3-(2-methylpropyl)-	29053-04-1	140.26	13.785
Cyclohexasiloxane, dodecamethyl-	540-97-6	444.92	44.528
Benzene, 1,3-diisocyanato-2-methyl-	91-08-7	174.16	44.905
Benzene, 2,4-diisocyanato-2-methyl-	584-84-9	174.16	45.065
Diphenyl sulphide	139-66-2	186.27	59.485
Phenanthrene-D10	1517-22-2	188.29	69.545
Oxirane, 2,2'-[(1-methylethylidene)bis(4,1-phenyleneoxymethylene)]bis-	1675-54-3	340.41	188.593

Table 3. Identified compounds within the group of *organic acids, esters and salts of organic acids* during the winter and spring periods 2019

Winter period			
Group of compounds	**CAS Number**	**Molecular weight [g mol^{-1}]**	**Retention time**
Carbamic acid, methyl-, phenyl ester	2603-10-3	151.16	17.770
Triisopropylphosphate	513-02-0	224.23	35.017
N,N-Dimethylsuccinamic acid	2564-95-6	145.16	49.518
3,7-Dimethyl-6-nonen-1-ol acetate	/	212.33	54.545
Methyl (4S,5R)-2,2,5-trimethyl-1,3-dioxolane-4-carboxylate	38410-80-9	174.19	56.063
Tributyl phosphate	126-73-8	266.32	56.628
4-Oxo-4-(para-tolyl)-butyric acid	4619-20-9	307.40	59.698
Decanoic acid, decyl ester	1654-86-0	312.53	62.870
2-Dodecen-1-yl(-)succinic anhydride	19780-11-1	266.37	64.240
[1,1'-Bicyclopropyl]-2-octanoic acid, 2'-hexyl-, methyl ester	56687-68-4	322.50	66.915
Phthalic acid, monoethyl ester	2306-33-4	194.18	76.093
Cyclohexanecarboxylic acid, hexyl ester	27948-10-3	212.33	77.115
Spring period			
Group of compounds	**CAS Number**	**Molecular weight [g mol^{-1}]**	**Retention time**
3-Trifluoroacetoxypentadecane	/	324.23	11.300
2-Propenoic acid, 1-methylundecyl ester	51443-73-3	240.38	13.738
Propylene Carbonate	108-32-7	102.09	17.615
Pterin-6-carboxylic acid	948-60-7	207.15	28.060
2-Oxepanone	502-44-3	114.14	29.628
5-(Prop-2-enoyloxy)pentadecane	/	282.46	30.003
5-Cyclopropylcarbonyloxypentadecane	/	296.49	30.283
3-(Prop-2-enoyloxy)tetradecane	/	282.50	43.013
3-Trifluoroacetoxy-6-ethyldecane	/	282.35	58.235
Hydracrylic acid, monoanhydride with 1-butaneboronic acid, cyclic ester	33823-94-8	155.99	62.565
2-Propanol, 1-chloro-, phosphate (3:1)	13674-84-5	327.57	72.288
Phthalic acid, isobutyl octadecyl ester	/	474.70	75.685
7,9-Di-tert-butyl-1-oxaspiro(4,5)deca-6,9-diene-2,8-dione	82304-66-3	276.37	78.140
Hexadecanoic acid, methyl ester	112-39-0	270.45	78.848
Nor-diazepam, 3-[[N-hydroxymethyl]aminocarbonyloxy]-	/	373.80	78.877
Isopropyl Palmitate	142-91-6	298.50	83.773

Table 4. Identified compounds within the group of *alcohols, ketones and aldehydes* during the winter and spring periods 2019

Winter period			
Group of compounds	**CAS Number**	**Molecular weight [g mol^{-1}]**	**Retention time**
Cycloundecanone	878-13-7	168.27	46.352
Bicyclo[2.2.1]heptan-2-one, 5-hydroxy-4,7,7-trimethyl-	114529-11-2	168.23	48.390
2,4,7,9-Tetramethyl-5-decyn-4,7-diol	126-86-3	226.36	50.005
7-Hexadecenal, (Z)-	56797-40-1	238.41	52.485
Bicyclo[4.1.0]heptan-3-ol, 4,7,7-trimethyl-, [1R-(1.alpha.,3.beta.,4.alpha.,6.alpha.)]-	54750-09-3	154.25	66.915
s-Trioxane, 2,4,6-triethyl-	2396-42-1	174.24	68.275
1-Heptadec-1-ynyl-cyclohexanol	/	334.58	69.660
Spring period			
Group of compounds	**CAS Number**	**Molecular weight [g mol^{-1}]**	**Retention time**
2-Nonyn-1-ol	5921-73-3	140.22	10.268
7-Hexadecenal, (Z)-	56797-40-1	238.41	10.433
2-n-Butylacrolein	1070-66-2	112.17	13.845
1,6-Anhydro-2,4-dideoxy-.beta.-D-ribo-hexopyranose	/	130.14	17.905
9-Oxabicyclo[6.1.0]nonan-4-ol	2616-81-1	142.19	37.435
Azacyclodecan-5-ol	/	157.25	40.600
9-Oxabicyclo[4.2.1]nonan-2-ol	/	142.20	47.720
2,4,7,9-Tetramethyl-5-decyn-4,7-diol	126-86-3	226.36	49.850
Heptanal	111-71-7	114.18	51.653
2(3H)-Benzofuranone, hexahydro-4,4,7a-trimethyl-	16778-27-1	182.26	58.285

Table 5. Identified compounds within the group of *phenols* during the winter and spring periods 2019

Winter period			
Group of compounds	**CAS Number**	**Molecular weight [g mol^{-1}]**	**Retention time**
Phenol	108-95-2	94.11	17.468
Phenol, 4-methyl-	106-44-5	108.14	25.145
Phenol, 4,4'-(1-methylethylidene)bis-	80-05-7	228.29	90.153
Spring period			
Group of compounds	**CAS Number**	**Molecular weight [g mol^{-1}]**	**Retention time**
Phenol, 4,4'-(1-methylethylidene)bis-	80-05-7	228.29	90.068

Table 6. Identified compounds within the group of *heterocyclic compounds* during the winter and spring periods 2019

Winter period			
Group of compounds	**CAS Number**	**Molecular weight [g mol^{-1}]**	**Retention time**
Guanosine	118-00-3	283.24	11.570
3-Methyl-4-(phenylthio)-2-prop-2-enyl-2,5-dihydrothiophene 1,1-dioxide	/	280.40	12.273
Spiro[androst-5-ene-17,1'-cyclobutan]-2'-one, 3-hydroxy-, (3.beta.,17.beta.)-	/	328.49	14.828
Indole	120-72-9	117.15	40.948
Cyclic octaatomic sulfur	10544-50-0	256.52	81.868
Spring period			
Group of compounds	**CAS Number**	**Molecular weight [g mol^{-1}]**	**Retention time**
3-Methyl-4-(phenylthio)-2-prop-2-enyl-2,5-dihydrothiophene 1,1-dioxide	/	280.40	10.018
Imidazole, 2-amino-5-[(2-carboxy)vinyl]-	1330014-65-7	153.14	42.703

Table 7. Identified compounds within the group of *organonitrogen compounds* during the winter and spring periods 2019

Winter period			
Group of compounds	**CAS Number**	**Molecular weight [g mol^{-1}]**	**Retention time**
2,6-Dimethylphenyl isocyanate	28556-81-2	147.17	58.196
Propyphenazone	479-92-5	230.31	80.120
L-Glutamine, N2-[(phenylmethoxy)carbonyl]-	2650-64-8	280.28	45.005
8H-Pyrano[3,4-b]pyrimido[5,4-d]furane, 5,6-dihydro-4-hydrazino-6,6-dimethyl-2-methylthio-	/	280.35	108.665
Oxirane, 2,2-dimethyl-3-(3,7,12,16,20-pentamethyl-3,7,11,15,19-heneicosapentaenyl)-, (all-E)-	7200-26-2	426.72	116.663
Spring period			
Group of compounds	**CAS Number**	**Molecular weight [g mol^{-1}]**	**Retention time**
1,4-Piperazinediethanol, .alpha.,.alpha.'-bis(phenoxymethyl)-	34972-10-6	386.48	10.143
2-Piperidinone, 6-methyl-	1558-58-3	113.16	29.713
3-Azabicyclo[3.2.2]nonane	283-24-9	125.21	47.640
Glucopyranuronamide, 1-(4-amino-2-oxo-1(2H)-pyrimidinyl)-1,4-dideoxy-4-(D-2-(2-(methylamino)acetamido)hydracrylamido)-, .beta.-	2096-42-6	443.41	48.110
Piperidine, 3-isopropyl-	13603-18-4	127.23	48.788

CONCLUSION

Considering that the leachate from the non-sanitary municipal solid waste landfill in Novi Sad is not treated, the identification of specific pollutants is important from the aspect of environmental and health risk assessment. In addition, it is necessary to be aware of the presence and content of these pollutants in the landfill leachate, as well as their possible synergistic effects when developing, selecting and optimizing future treatments.

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