Comparative Assessments of VOC Emission Rates and the Associated Health Risks from Wastewater Treatment Processes

Wen-Ben Yang[1], Wei-Hsiang Chen[1*], Chung-Shin Yuan[1, 2]*, Jun-Chen Yang[2], Qing-Liang Zhao[2]

Electronic Supplementary Information

(5 tables included)

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1. Institute of Environmental Engineering, National Sun Yat-Sen University, Kaohsiung 804, Taiwan, R.O.C.
2. State Key Laboratory of Urban Water Resources and Environments (SKLUWRE), Harbin Institute of Technology, Harbin 150090, China

***Corresponding author**: **Corresponding authors**: Wei-Hsiang Chen, Tel: +886 7 5252000 ext 4421; E-mail address: whchen@mail.nsysu.edu.tw Chung-Shin Yuan, Tel.: +886 7 5252000 ext 4417; E-mail address: ycsngi@mail.nsysu.edu.tw

Table S1. Selected physicochemical properties of the VOCs considered in this study

Chemical	Melting points (^{o}C)	Boiling point (^{o}C)	Water solubility (g/L)	Octanol-water partition coefficient (dimensionless)
Benzene	6	80	1.8	2.13
Toluene	-93	111	0.53	2.69
Xylene	-34	137-140	< 0.1	3.12
Carbon tetrachloride	-23	77	0.8	2.64
Chloroform	-64	61	8	1.97
Trichloroethylene	-73	87	1	2.42
Perchloroethylene	-19	121	0.15	3.4

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Table S2. The VOC species identified in different treatment processes of the wastewater treatment plant investigated in this study

Processes	The VOC species	
	General[1]	Additional[1]
Bar screen	C1-C12, Aromatic and chlorinated hydrocarbons	Indole, Dimethyl disulphide
Aerated grit chamber		Methylene chloride, Naphthalene
Primary sedimentation basins		2-chloro-1,3-butadiene
Anaerobic sludge treatment process		Vinyl chloride
Aerobic sludge treatment process (forepart)		1-aminopentylane, volatile fatty acids, phthalic acid
Aerobic sludge treatment process (rear part)		1-aminopentylane, nitropentylane, volatile fatty acids, phthalic acid
Secondary sedimentation basins		1-aminopentylane, nitropentylane phthalic acid

1. General and additional denote the VOC species observed in all processes and those found in each specific treatment processes, respectively.

Table S3. Estimated dimensionless Henry's constants of the VOCs of interest in this study

Substance	Spring	Summer	Fall	Winter
Benzene	4.18	4.33	9.80	9.59
Toluene	3.25	3.36	7.62	7.46
Xylene	3.25	3.36	7.62	7.46
Carbon tetrachloride	5.80	6.01	13.61	13.32
Chloroform	0.81	0.84	1.91	1.87
Trichloroethylene	2.32	2.40	5.44	5.33
Perchloroethylene	1.28	1.32	2.99	2.93

Table S4. The concentrations of VOCs (mg/L) measured in the gas phase of different treatment processes in the wastewater treatment plant in this study

Season	Species	Bar Screen	Primary sedimentation	Anaerobic sludge	Aerobic sludge		Secondary sedimentation
					Forepart	Rear	
Spring	Benzene	64	79	65	55	42	36
	Toluene	72	96	22	17	ND	ND
	Xylene	117	167	ND	ND	ND	ND
	$CHCl_3$[1]	17.0	19.6	13.0	16.0	17.0	15.8
	CCl_4[1]	11.0	9.8	8.8	8.9	10.2	ND
	TCE[1]	0.4	0.5	0.2	0.3	0.3	0.5
	PCE[1]	ND	ND	ND	ND	ND	ND
Summer	Benzene	69	83	70	57	48	34
	Toluene	75	99	25	19	ND	ND
	Xylene	117	112	99	ND	ND	ND
	$CHCl_3$[1]	18.5	23.4	14.6	16.8	17.7	16.4
	CCl_4[1]	13.2	11.2	7.8	10.3	10.2	11.1
	TCE[1]	0.4	0.5	0.2	0.3	0.4	0.6
	PCE[1]	ND	ND	ND	ND	ND	ND
Fall	Benzene	59	77	59	51	40	35
	Toluene	71	88	21	13	ND	ND
	Xylene	112	141	ND	ND	ND	ND
	$CHCl_3$[1]	15.5	16.4	11.7	14.0	15.0	15.2
	CCl_4[1]	8.9	8.7	5.6	7.7	7.8	8.9
	TCE[1]	0.4	0.4	0.2	0.3	0.3	0.5
	PCE[1]	ND	ND	ND	ND	ND	ND
Winter	Benzene	56	70	56	49	38	33
	Toluene	70	86	20	10	ND	ND
	Xylene	99	149	ND	ND	ND	N
	$CHCl_3$[1]	14.9	16.1	8.9	13.0	13.5	12.5
	CCl_4[1]	8.2	7.9	4.9	7.4	7.6	7.5
	TCE[1]	0.4	0.4	0.2	0.2	0.2	0.4
	PCE[1]	ND	ND	ND	ND	ND	ND

1. $CHCl_3$, CCl_4, TCE, and PCE represent chloroform, carbon tetrachloride, trichloroethylene, and perchloroethylene, respectively.
2. ND denotes non-detected.

Table S5. The concentrations of VOCs (mg/L) measured in the water phase of different treatment processes

Season	Species	Bar Screen	Primary sedimentation	Anaerobic sludge	Aerobic sludge		Secondary sedimentation
					Forepart	Rear	
Spring	Benzene	0.16	0.22	0.20	0.16	0.07	0.05
	Toluene	0.12	0.10	0.07	ND	ND	ND
	Xylene	0.50	0.70	0.18	0.02	ND	ND
	$CHCl_3$[1]	0.04	0.04	0.03	0.02	0.02	0.02
	CCl_4[1]	0.42	0.34	0.29	0.25	0.26	0.23
	TCE[1]	2.10	1.75	1.65	1.10	1.30	1.20
	PCE[1]	0.67	0.75	0.65	0.58	0.56	0.53
Summer	Benzene	0.15	0.25	0.17	0.13	ND	ND
	Toluene	0.10	0.06	0.05	ND[1]	ND	ND
	Xylene	0.44	0.66	0.14	ND[1]	ND	ND
	$CHCl_3$[1]	0.04	0.04	0.03	0.02	0.02	0.02
	CCl_4[1]	0.40	0.32	0.25	0.23	0.20	0.20
	TCE[1]	1.80	1.60	1.50	1.00	1.10	1.10
	PCE[1]	0.61	0.60	0.58	0.56	0.54	0.51
Fall	Benzene	0.19	0.28	0.22	0.18	0.08	0.07
	Toluene	0.14	0.13	0.04	0.03	0.10	ND
	Xylene	0.52	0.72	0.16	0.02	0.02	ND
	$CHCl_3$[1]	0.04	0.04	0.04	0.02	0.03	0.02
	CCl_4[1]	0.45	0.37	0.31	0.27	0.26	0.24
	TCE[1]	2.35	2.00	1.75	1.15	1.40	1.30
	PCE[1]	0.79	0.78	0.70	0.61	0.58	0.56
Winter	Benzene	0.20	0.30	0.27	0.20	0.13	0.08
	Toluene	0.16	0.14	0.08	0.04	0.02	ND
	Xylene	0.62	0.82	0.17	0.04	0.03	ND
	$CHCl_3$[1]	0.05	0.05	0.04	0.02	0.02	0.03
	CCl_4[1]	0.05	0.38	0.33	0.29	0.28	0.27
	TCE[1]	2.45	2.20	1.90	1.23	1.50	1.40
	PCE[1]	0.85	0.80	0.75	0.64	0.64	0.57

1. $CHCl_3$, CCl_4, TCE, and PCE represent chloroform, carbon tetrachloride, trichloroethylene, and perchloroethylene, respectively.
2. ND denotes non-detected.