Environmental Research 146 (2016) 235–244

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

Hazardous and odorous pollutants released from sewer manholes and stormwater catch basins in urban areas

Sudhir Kumar Pandey [a], Ki-Hyun Kim [b,*], Eilhann E. Kwon [c,*], Yong-Hyun Kim [b]

[a] Dept. of Botany, Guru Ghasidas Central University, Bilaspur (C.G.) 495009, India
[b] Department of Civil and Environmental Engineering, Hanyang University, 222 Wangsimni-ro, Seoul 04763, Republic of Korea
[c] Dept. of Environment and Energy, Sejong University, Seoul 05006, Republic of Korea

ARTICLE INFO

Article history:
Received 16 October 2015
Received in revised form
28 December 2015
Accepted 29 December 2015

Keywords:
Sewer
Manhole
Offensive odorants
Stormwater catch basin
Sulfur
Nitrogenous

ABSTRACT

To learn more about the emission characteristics of odorants released from sewer manholes and stormwater catch basins (SCBs) in an urban environment, we measured the emission concentrations of major odorants including 22 target compounds designated as offensive odorants by the Korean Ministry of Environment (KMOE). All of our measurements were made from urban sewer manholes and SCBs in a highly commercialized location in Seoul, Korea. The results of our study were analyzed to identify the major odorants from such sources and to assess their contribution to odor intensity. The malodor strengths at both types of underground sources were considerably higher in the afternoon than in the morning. The assessment of odor intensity (OI) and odor activity value (OAV) confirmed the dominance of key odorants like H_2S, CH_3SH, and ammonia along with various volatile fatty acids (VFAs) and phenol. The concentration of these major odorants (H_2S, CH_3SH, and NH_3) exceeded the maximum permissible limit given as the odor prevention law in Korea. As such, significantly high levels of odorants released from these underground sources were greatly distinguished from those seen at above ground locations.

1. Introduction

The recognition of offensive odorants and the resulting nuisance is considered one of the most serious issues triggering public complaints in urban environments. Community odors remain one of the top complaints to air quality regulators and government bodies in many different countries. For instance, odor related complaints were amongst top complaints in air pollution related issues to the Environmental Protection Agency (EPA) in North America (McGinley and McGinley, 2014). Although many research efforts have been devoted to the assessment and control of odor pollution in urban environments, the qualitative and quantitative information regarding such pollution phenomenon is not yet fully understood (Curren, 2012).

Manhole structures are one of the basic building blocks of sanitary sewer collection systems, defining much of the underground infrastructure by linking sewer pipes together. Emissions of odor from municipal sewers have often been subjected to inadequate emission estimation procedures or ignored from hazardous air pollutant (HAPs) emission inventories which may lead to underestimation of their emission impact (Jones et al., 1996). There have been efforts to develop and improve estimation methods for the VOCs from sewer junction boxes and drop structures (e.g., Corsi and Quigley, 1996; Koziel et al., 2001). In combined sewer systems and storm water systems, catch basins also served as connect points for system components (United states Environmental Protection agency (US EPA), 2014). Hence, a stormwater catch basin (SCB) implies underground space for draining excess rain and surface water from paved streets, parking lots, sidewalks, and roofs (FDEP, 2004). As the exchange of gas through sewer manholes and catch basins is uncontrolled, they are recognized as the most common sources of pollutants and odorants in the urban environments (United states Environmental Protection Agency (US EPA), 1999). Volatile organic compounds (VOCs) derived from solvents, petroleum derivatives, and other wastes can also be released directly or indirectly from effluents with highly degradable organic materials or high sulfur content to cause odor nuisance and associated health problems (Vincent and Hobson, 1998; Sivret and Stuetz, 2012; Wang et al., 2015).

In this study, we investigated the emission of target volatile odorants and hazardous compounds from urban sewer manholes and SCB from a major urban area in Wangsimni station in Seoul, South Korea to help characterize odor pollution in an urban environment. To this end, ambient air samples were collected from underground source environments such as two manholes and

* Corresponding authors.
E-mail addresses: kkim61@hanyang.ac.kr (K.-H. Kim), ekwon74@sejong.ac.kr (E.E. Kwon).

http://dx.doi.org/10.1016/j.envres.2015.12.033
0013-9351/

Table 1
List of target offensive odorants investigated in this study and their relevant information (designated by KMOE, Korea).

Order	Group	Group No.	Full name	Short name	Chemical formula	CAS No.	Molecular weight ($g\ mol^{-1}$)	Odor threshold[a] (ppb)	Permissible emission standard[b] (ppb)
1	Aromatic	1	Toluene	TOL	$C_6H_5CH_3$	108–88–3	92.1	330	10,000
2			para-Xylene	p-X	$C_6H_4(CH_3)_2$	106–42–3	106	58.0	1,000
3			Styrene	STR	$C_6H_5CHCH_2$	100–42–5	104	35.0	400
4	Ketone	2	Methyl ethyl ketone	MEK	$CH_3COCH_2CH_3$	78–93–3	72.1	440	13,000
5			Methyl isobutyl ketone	MIBK	$(CH_3)_2CHCH_2COCH_3$	108–10–1	100	170	1,000
6	Ester	3	Butyl acetate	BuAc	$CH_3COO(CH_2)_3CH_3$	123–86–4	116	16.0	1,000
7	Alcohol	4	Isobutyl alcohol	i-BuAl	$(CH_3)_2CHCH_2OH$	78–83–1	74.1	11.0	900
8	Volatile fatty acids	5	Propionic acid	PPA	CH_3CH_2COOH	79–09–4	74.1	5.70	30
9			Butyric acid	BTA	$CH_3(CH_2)_2COOH$	107–92–6	88.1	0.19	1
10			Isovaleric acid	IVA	$(CH_3)_2CHCH_2COOH$	503–74–2	102	0.078	1
11			Valeric acid	VLA	$CH_3(CH_2)_3COOH$	109–52–4	102	0.037	0.9
12	Nitrogenous	6	Ammonia	NH_3	NH_3	7664–41–7	17.0	1,500	1,000
13			Trimethylamine	TMA	$(CH_3)_3N$	75–50–3	59.1	0.032	5
14	Sulfur	7	Hydrogen sulfide	H_2S	H_2S	7783–06–4	34.1	0.41	20
15			Methanethiol	CH_3SH	CH_3SH	74–93–1	48.1	0.07	2
16			Dimethyl sulfide	DMS	$(CH_3)_2S$	75–18–3	62.1	3.00	10
17			Dimethyl disulfide	DMDS	$(CH_3)_2S_2$	624–92–0	94.2	2.20	9
18	Aldehyde	8	Acetaldehyde	AA	CH_3CHO	75–07–0	44.1	1.50	50
19			Propionaldehyde	PA	CH_3CH_2CHO	123–38–6	58.1	1.00	50
20			Butyraldehyde	BA	$CH_3(CH_2)_2CHO$	123–72–8	72.1	0.67	29
21			Isovaleraldehyde	IA	$(CH_3)_2CHCH_2CHO$	590–86–3	86.1	0.10	3
22			Valeraldehyde	VA	$CH_3(CH_2)_3CHO$	110–62–3	86.1	0.41	9

[a] Refer to (Nagata, 2003).
[b] Odor Prevention Law in Korea (KMOE, 2011).