Screening level risk assessment for phenols in surface water of three rivers in Tianjin, China [1]

Wenjue ZHONG, Donghong WANG, Zijian WANG *
Research Center for Eco-Environmental Sciences，Chinese Academy of Sciences，
Beijing 100085, e-mail of the corresponding author: wangzj@rcees.ac.cn

Wenjue ZHONG, Lingyan ZHU
College of Environmental Science and Engineering, Nankai University, Key Laboratory of Pollution Processes and Environmental Criteria, Ministry of Education, Tianjin Key Laboratory of Remediation & Pollution Control for Urban Ecological Environment, Tianjin 300071, China

Abstract: The purpose of this paper was to identify the phenols in surface water of three rivers in Tianjin and assess the ecological risk. Using technology of retention time lock (RTL) and deconvolution reporting software (DRS), a contaminants list including all the phenols which were identified in the samples was obtained and all identified phenols were quantified. The concentration levels of total phenols in three rivers accorded with the patterns that Dagu river>Beitang river>Yongdingxinhe river, and June samples>October samples. Risk quotients (RQ) were used to assess the environmental risk of identified phenols. As a result, 5, 6 and 2 phenols were determined as potential ecological risk stressors in surface water of Beitang river, Dagu river and Yongdingxinhe river, respectively.

Keywords: phenols, ecological risk, screening level, DRS

1. Introduction

Phenols exist widely in environment. They can pose many adverse effects to aquatic organisms because of their toxicity, persistence and bioaccumulative potential. In the past decades, many papers have been devoted to the occurrences of phenols in natural waters (House *et al.* 1997; Staples *et al.* 2000; Belfroid *et al.* 2002). However, little information is available for their concentration levels in Chinese rivers. Therefore, it is necessary to screen broad-spectrum phenols in the environment and assess their full-scale ecological risk in order to improve risk control.

Tianjin is the third largest industrial center in China. With intense industrial and commercial activities in the coastal area, rivers in the Tianjin are severely polluted with high loads of persistent organic pollutants and these bring risks to the water environment. Dagu river, Beitang river and Yongdingxinhe river are three main sewage-received rivers. Industrial, agricultural and domestic wastewaters from Tianjin area are directly or indirectly discharged into the three rivers (Song *et al.* 2006). It is important and urgent, therefore, to evaluate the occurrence and ecological risk of phenols in the three rivers.

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The objectives of this study are to: 1) determine the concentration levels of phenols in surface water of three rivers, consequently, the ecological risks of the idenfied phenols were characterized; 2) select the potential ecological risk stressors as priorities for further ecological risk assessment based on the risk quotients.

2. Materials and Methods

2.1.Chemicals and materials

All the phenolic standards were purchased from Sigma-Aldrich (USA) and the detailed information of phenolic standards were listed in the Table 1.

Compound	Abbr.	Compound	Abbr.	Compound	Abbr.
2,4-dinitrophenol	2,4-DNP	4-Nitrophenol	4-NP	Dichlorophene	
Phenol	-	2,3,5-Trichlorophenol	2,3,5-TCP	Hexanoestrol	
2-cresol	-	2,4,5-Trichlorophenol	2,4,5-TCP	Bithionol	
3-cresol	-	2,3,6-Trichlorophenol	2,3,6-TCP	Hexachlorophene	
4-cresol	-	4-Chlororesorcinol	-	Pyrocatechol	-
2-chlororphenol	2-CP	4-chloro-2-nitrophenol	4-C-2-NP	2-naphthol	-
2,4- Xylenol	-	2-Chlorohydroquinone	-	2-Biphenylol	-
4-chlorophenol	4-CP	3,4,5-Trichlorophenol	3,4,5-TCP	Resorcinol	-
4-Chloro-3-methylphenol	4-C-3-MP	2-Chloro-4-nitrophenol	2-C-4-NP	2-Nitrophenol	2-NP
2,5-Dichlorophenol	2,5-DCP	2,3,5,6-Tetrachlorophenol	2,3,5,6-TeCP	Hydroquinone	-
2,6-dichlorophenol	2,6-DCP	2,3,4,6-Tetrachlorophenol	2,3,4,6-TeCP	2,6-Xylenol	-
2,3,6-Trimethylphenol	2,3,6-TMP	2,3,4,5-Tetrachlorophenol	2,3,4,5-TeCP	2-Isopropylphenol	-
2,4-dichlorophenol	2,4-DCP	2,4-dichloro-3-ethyl-6-nitrophenol	-	2-sec-Butylphenol	-
2,6-Diisopropylphenol	-	Pentachlorophenol	PCP	4,4'-Biphenyldiol	-
p-chloro-m-xylenol	PCMX	Ortho-benzyl-para-chlorophenol	-	Biphenol A	BPA
3,5,6-trichloro-2-pyridinol	-	2-chloro-4-phenylphenol	-	6-chlorothymol	-
2,4,6-Trichlorophenol	2,4,6-TCP	Tetrachlorohydroquinone	-		

--Abbr.: Abbreviation; "-": no abbreviation available

Table 1: The detailed information of 50 phenols

2.2 Sampling and preparation

39 and 31 surface water samples (2 L) were collected in Tianjin, China with aid of a global positioning system (GPS; Fig. 1) in June and October, 2007, respectively. b1-b7 were sampled in Beitang river, d1-d19 were sampled in Dagu river and y1-y15 were sampled in Yongdingxinhe river. The method for sample conservation and preparation and analytical procedures could see in literatures published before(Zhong *et al.* 2010; Zhong *et al.* 2011).

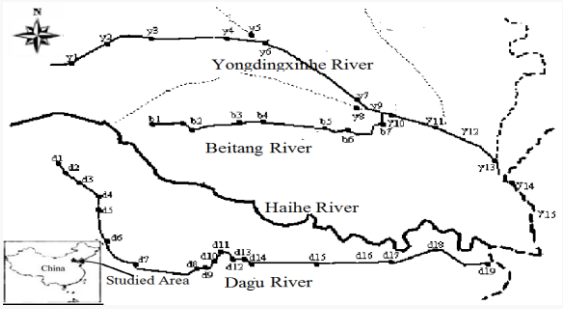

Fig 1: Sampling sites

2.3 Approach for screening level ecological risk assessment

The quotient method was used to characterize risk. Risk quotient (RQ) was defined as the ratio of predict environmental concentration (PEC) and predict no effect concentration (PNEC). Chemicals of potential concerns (COPCs) with RQ exceeding 1.0 were selected as potential stressors.

Using spectral deconvolution technology, a contaminants list including all the phenols which were identified in the samples was obtained. All phenols identified in samples were quantified and their concentration levels were used as PEC.

Chronic Value (Chv) were collected from PBT Profiler (USEPA 2010). As the recommendation of OECD, ten was taken as the assessment factor (AF). So tenth of Chvs were used as PNEC (USEPA 1985; OECD 1995).

3. Results

3.1 Identification and quantification of phenols in surface water of three rivers

The qualitative and quantitative results are listed in Table 2. The concentration levels of total phenols in three rivers accorded with the patterns that Dagu river> Beitang river> Yongdingxinhe river, and June samples> October samples.

chemicals	Beitang river		Dagu river		Yongdingxin river		PNEC
	June	October	June	October	June	October	
Phenol	nd-10.3	nd -10.9	nd -520	nd -15.1	nd -0.1	nd -1.05	19
2- cresol	nd-52.6	nd -15.6	nd -45.3	nd -3.09	nd -1.35	nd -0.2	12
3- cresol	nd-18.7	nd -16.4	nd -386	nd -1.06	nd -0.51	nd -0.11	12
2,4-xylenol	nd-32.8	nd -20.5	nd -90.6	nd -0.33	nd -6.61	nd -3.74	7.8
4-CP	nd-0.44	nd -1.63		nd -0.11		nd -0.05	13
2-CP						nd -0.07	13
2,5-DCP	nd-2.43	nd -4.63	nd -1.23		nd -0.29		8.5
2,6-DCP			nd -0.16				8.5
2,4,6-TCP				nd -0.16	nd -0.32	nd -0.99	5.3
4-NP	nd-1.77			nd -1.75	nd -0.18		18
2,3,6-TMP	nd-1.92	nd -1.35					5
PCMX	nd-3.7	nd -1.36	nd -157				5.2
2-naphthol	0.34-16.4			nd -167	nd -4.58	nd -0.15	8.5
Resorcinol		nd -0.35	nd -0.69		nd -0.17		36
Pyrocatechol			nd -0.04				36
2-Biphenylol	nd-0.51	nd -0.25	nd 0.95	nd -0.09			5.4
2-sec-Butylphenol	nd-11.1	nd -6.59		nd -1.98		nd -0.04	4
2,4-dichloro-3-ethyl-6-nitrophenol	nd-0.99						2.8

--nd: not detected;

Table 2: The results of identifying and quantifying phenols in three rivers and PNEC (μg/L)

3.2 Ecological risk assessment

Chv were collected from PBT Profiler (USEPA 2010) (last accessed February, 2010) and tenth of Chvs were used as PNEC (Table 2).

Using quotient method, phenols whose RQ exceed 1.0 were picked out. These phenols were considered as potential stressors to aquatic environment of three rivers. Furthermore, the risk levels of each potential stressors were sorted by RQs. Five kinds of phenols were selected as priority phenols in Beitang river, and the order of risk level was 2-cresol>2-sec-butylphenol>2,4-xylenol>2-naphthol>3-cresol. Six kinds of phenols were selected as priority phenols in Dagu river, and the order of risk level was 3-

cresol>PCMX>phenol>2-naphthol>2,4-xylenol>2-cresol. For Yongdingxinhe river, all RQs were less than 1.0. Although only COPCs with RQ exceeding 1.0 present a clear risk potential, any COPCs with the quotient greater than 0.3 are subjected to more rigorous risk assessment (WERF 1996), because chemical interactions and cumulative toxicity must also be considered. So 2-naphthol and 2,4-xylenol with RQ > 0.3 were selected as priority phenols for Yongdingxinhe river.

4. Concluding remarks

DRS was used to identify broad-spectrum phenols in three rivers of Tianjin, China. The result indicated that phenols exist widely in three rivers. Using quotient method to assess ecological risk of identified phenols, 5, 6 and 2 phenols were determined as potential ecological risk stressors in surface water of Beitang river, Dagu river and Yongdingxinhe river, respectively.

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