UNESCO-IWRA ONLINE CONFERENCE
17-19 JANUARY 2023
3RD IN THE IWRA ONLINE CONFERENCE SERIES

Emerging Pollutants: Protecting Water Quality for the Health of People and the Environment

Occurrence and source of typical odor-causing compounds in drinking water of major cities across China

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18 January 2023, 12:20 CET

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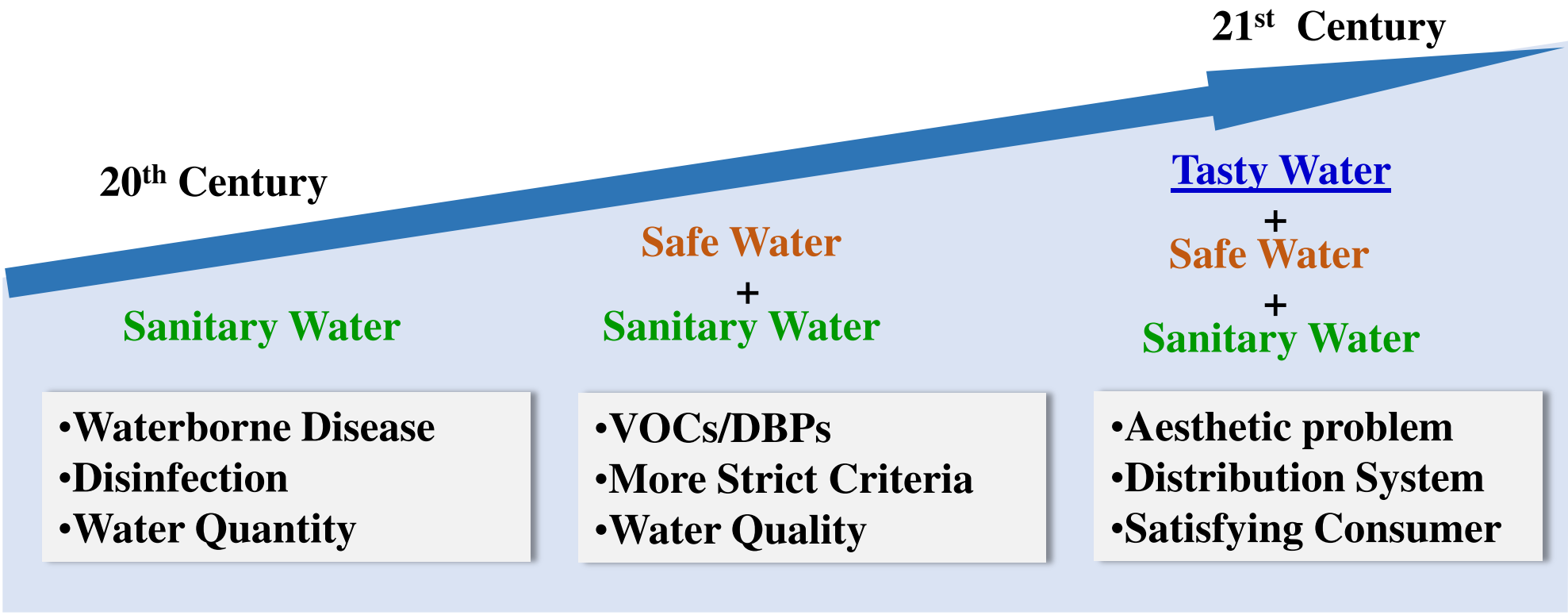
Backgrounds

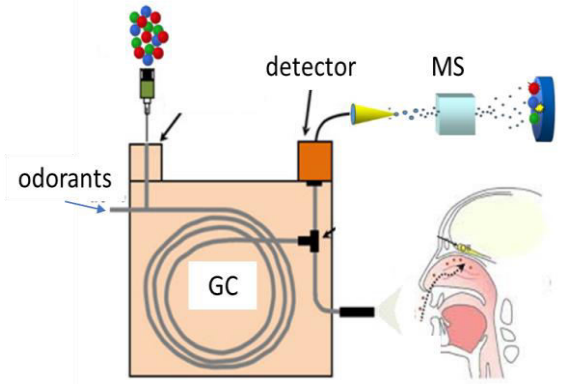


Backgrounds

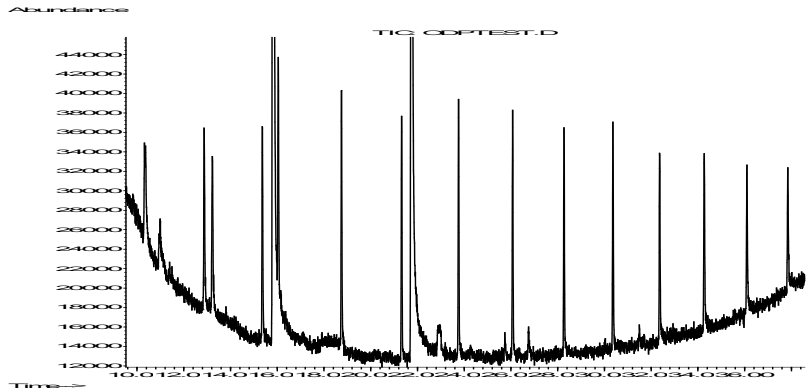
Odor incidents in drinking water of China

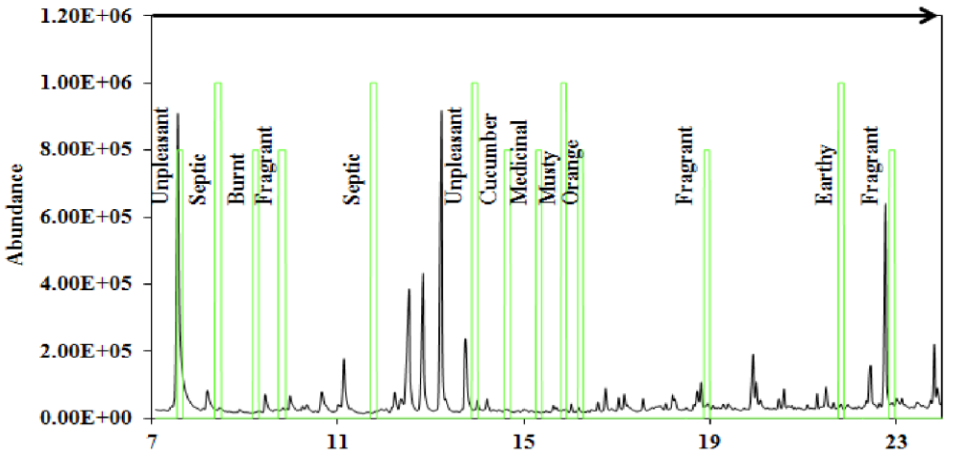
- MIB was main cause of earthy/musty odor in China, related to cyanobacteria metabolites.
- **Main odor-causing compounds for other odors? their sources?**

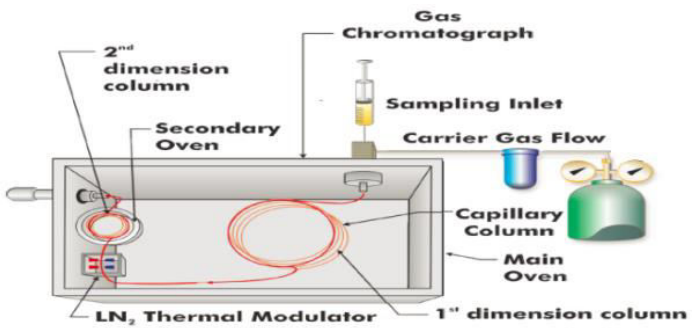
Identification major odorants for complex water samples by combining GC-O and GC×GC-MS



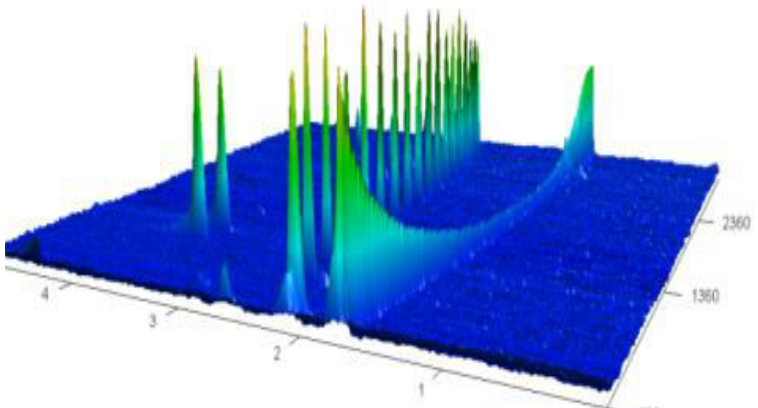
GC-O/MS



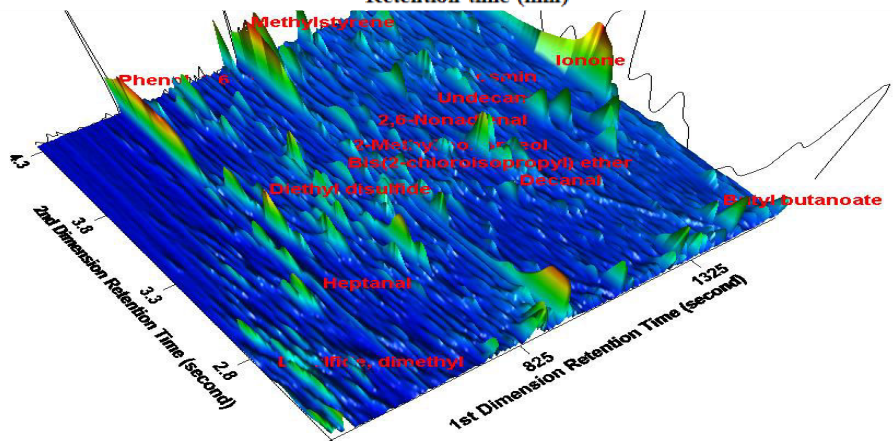




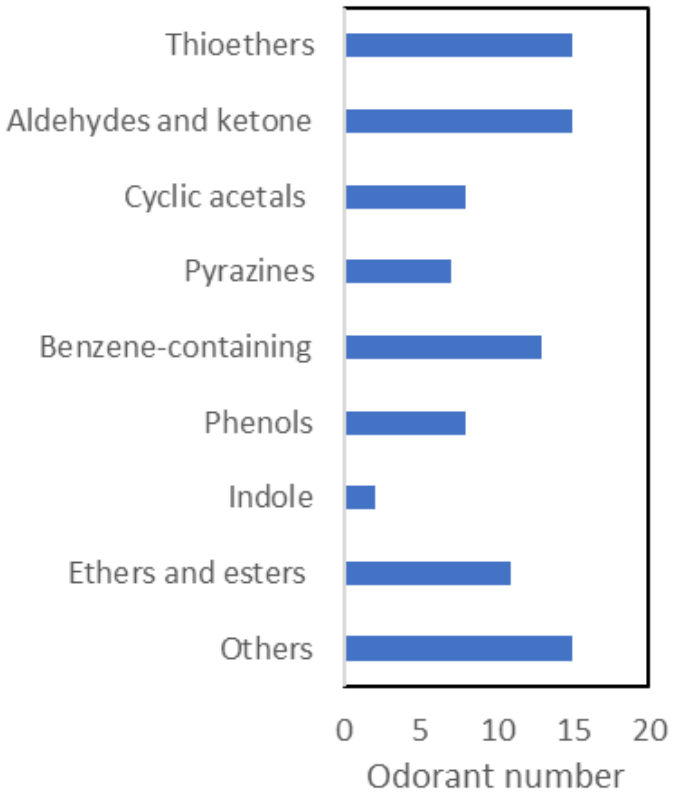
GC×GC-TOFMS

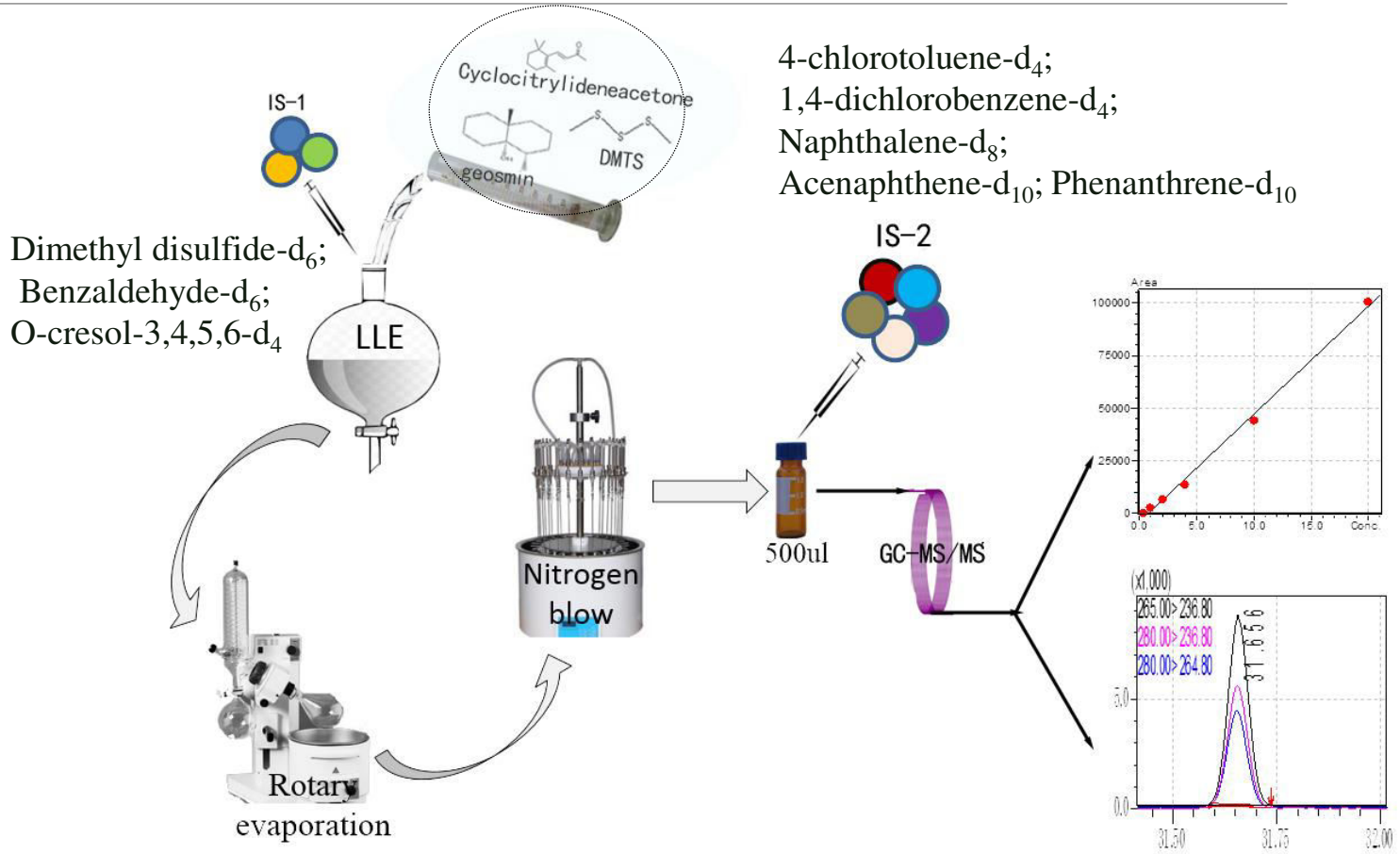


N-alkanes (C7-C30)

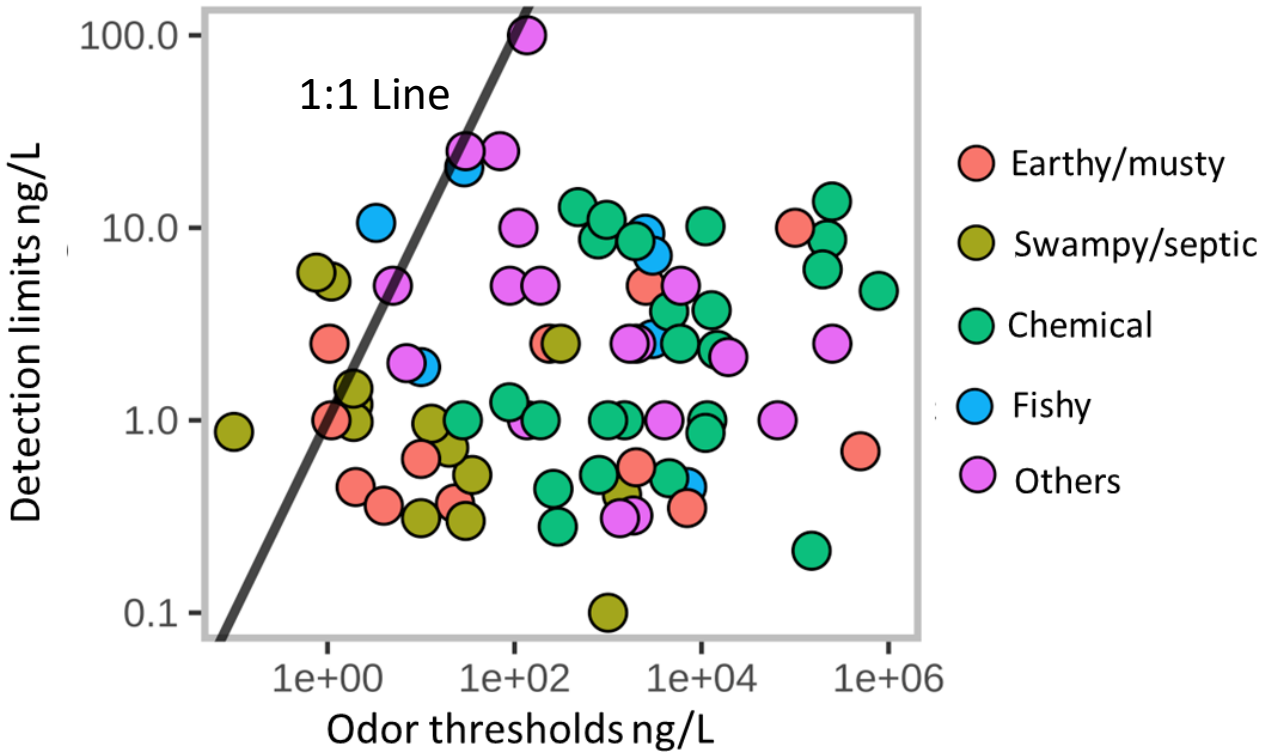


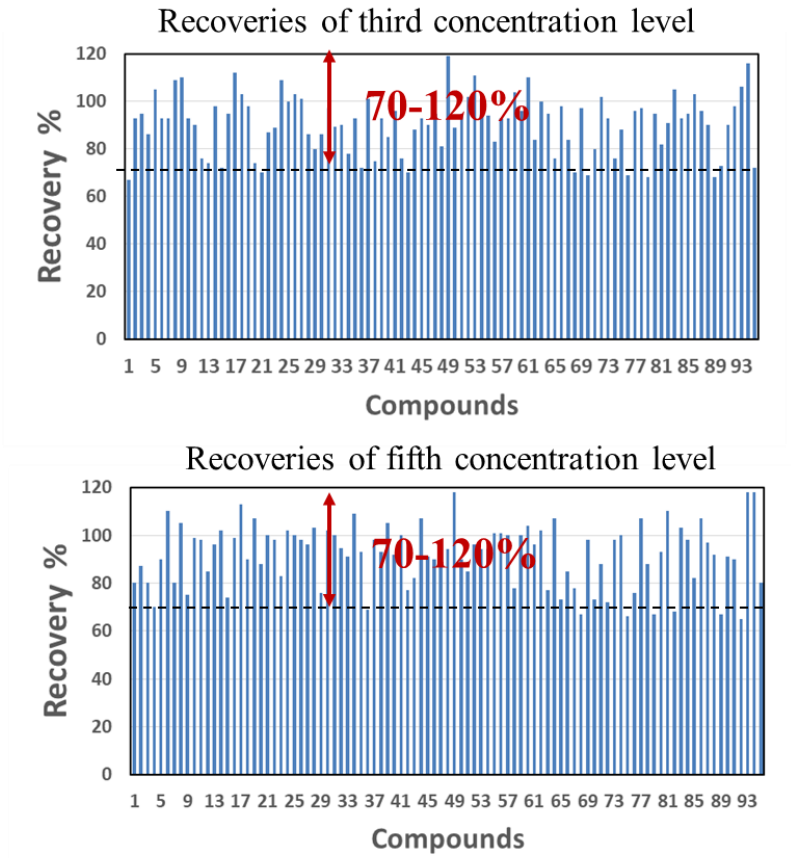
Quantitative method for simultaneous determination of 95 odorants based on liquid-liquid extraction combined with GC-MS/MS





Performance of the method





- Linearity: > 0.999; Detection limits: 0.01-100 ng/L, < their individual OTC; Recoveries: 70%-120%.

Wang et al., J. Environ Sci, 2019

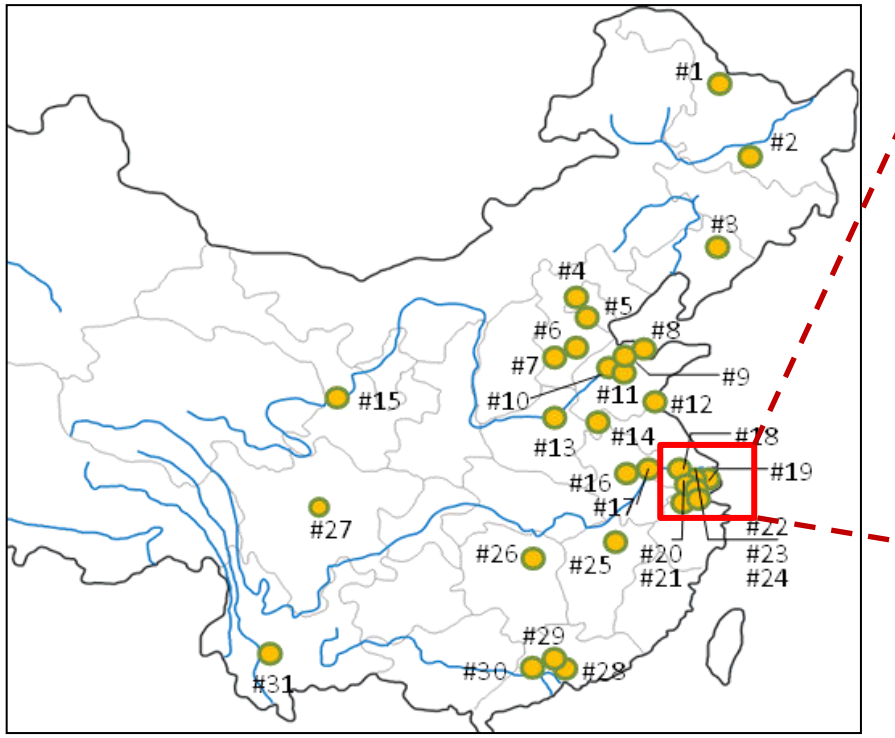
Establishment of odorant quick screening database

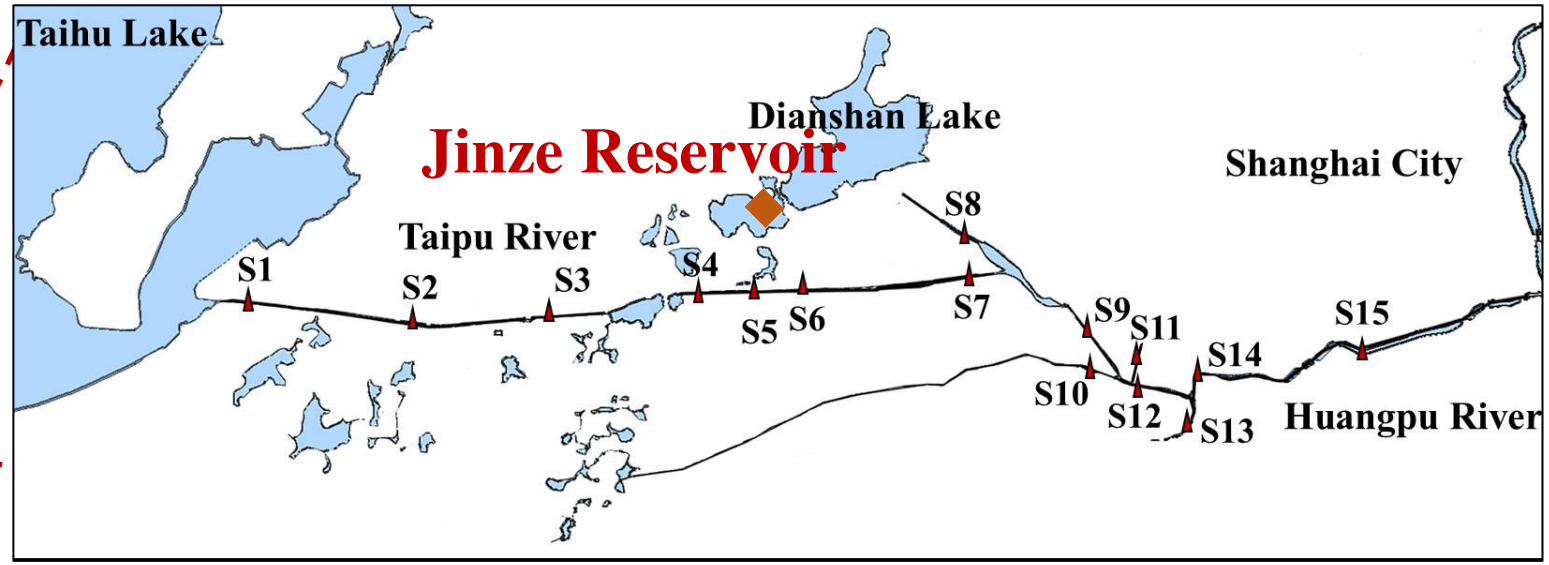
Basic information				Odor characteristics			MS information						
							MRM				SIM		
No.	Category	Odorant	CAS	Retention indice	Odor	OTC	Type	m/z	CE	Ratio	Type	m/z	Ratio
3	Thioether	dimethyl disulfide	624-92-0	723	Swampy/septic	30	T	94>57	6	100	T	94	100
4	Thioether	diethyl disulfide	110-81-6	923	Swampy/septic	20	T	122>101	21	100	T	122	100
5	Thioether	dimethyl trisulfide	365-80-8	943	Swampy/septic	10	T	126>111	6	100	T	126	100

- Semiquantitative analysis without odorant standards; **transferred to Shimadzu Corporation (China).**

Investigation of odor problems in source and drinking water

Quantitative method: Liquid-liquid extraction-GC-MS/MS; Sensory test：Flavor profile analysis.

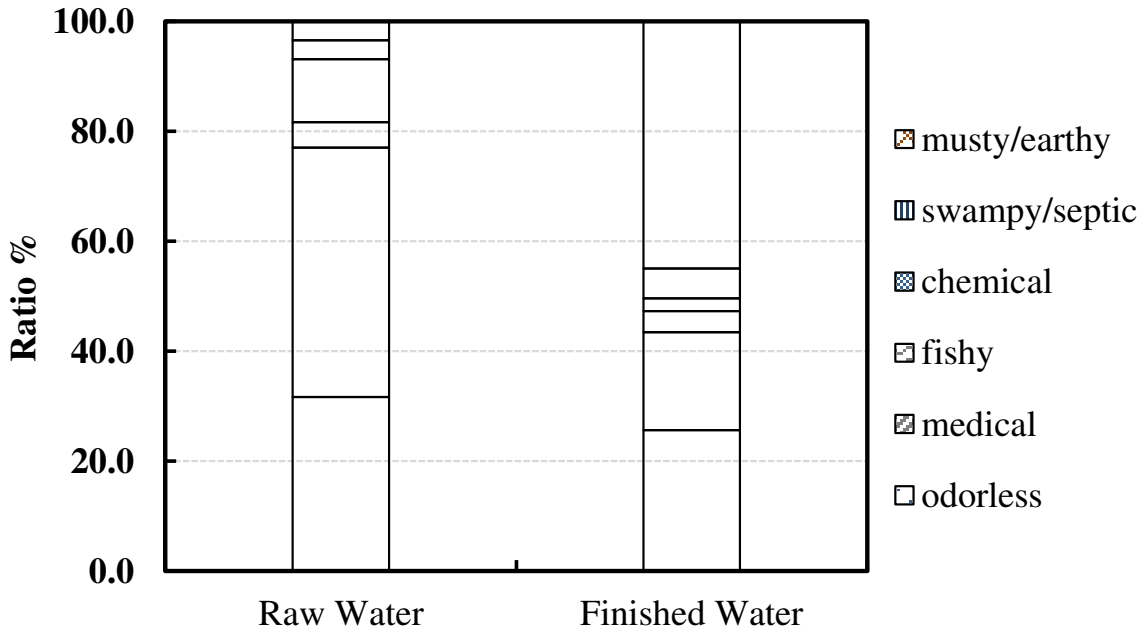




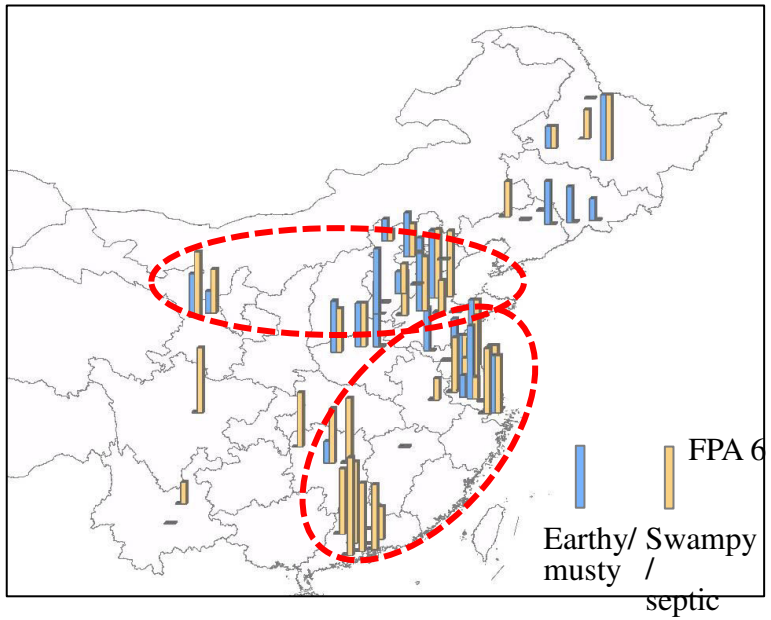
Sampling sites in Huangpu River watershed

- Source/finished water samples from 98 waterworks in 31cities across China (n = 300)
- Samples from Huangpu River source water (n = 216), monthly for one year).

Odor characteristics



Odor problems in source and finished water



Occurrence of odor problems in source water

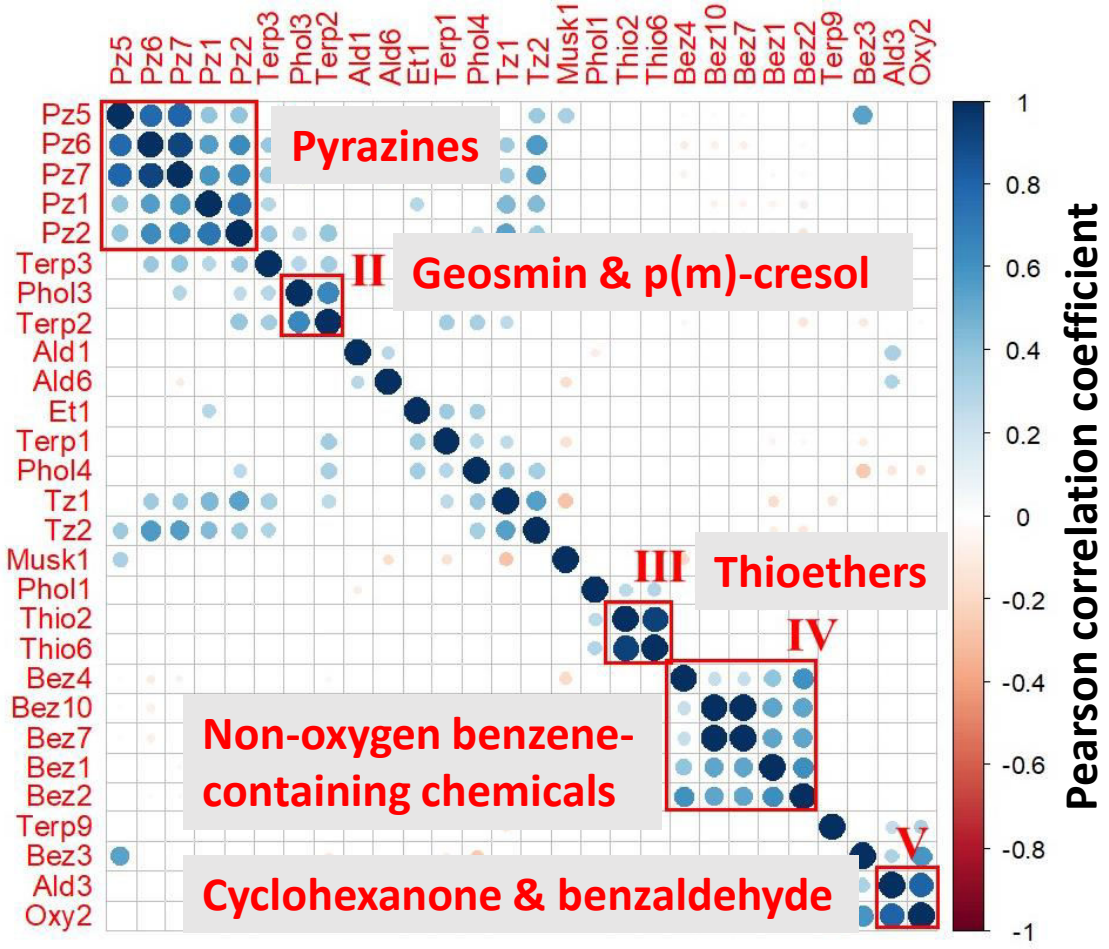
- 90% source water samples and 50% finished water samples exhibited odor problems, and earthy/musty (31.8%) and swampy/septic (45.4%) odors were dominant odor descriptors.
- Swampy/septic odor was the major odor types in Yangtze River, Taihu Lake and Pearl River, while swampy/septic odors and earthy/musty odors in Yellow River.

Occurrence of typical odor-causing compounds

Odor-causing compounds	OTC ng/L	Raw water ng/L			Finished water ng/L		
		Max	Mean	Detection rate %	Max	Mean	Detection rate %
2-MIB	**10**	**251**	**9.8**	**53.8**	**576**	**7.4**	**35.4**
Dimethyl disulfide	**30**	**714**	**15**	**85.5**	**8.7**	**0.83**	**45.1**
Dimethyl trisulfide	**10**	**84.4**	**2.1**	**60**	**3.3**	**0.29**	**25**
bis(2-Chloro-1-methylethyl) ether (DCIP)	**197**	**1280**	**35.8**	**42.1**	**1191**	**33.3**	**36.1**
Geosmin	**4**	**10.8**	**0.9**	**55.9**	**10**	**0.75**	**50**
Hexanal	300-14,000	211	12.8	53.8	243	28.8	78.5
Benzaldehyde	4,500	351	12.6	70.3	592	62.4	92.4
1,4-Dichlorobenzene	4,500	125	11.9	60.7	177	5	54.9
Indan	1,860	11.4	1.3	65.5	11.3	1.8	72.9
o-Nitrophenol	11,000	422	95.4	66.9	202	32.3	38.9
Pyrazine	n.a.	32.7	9.6	93.8	38	8.52	98

- 77 (raw water) / 75 (finished water) odorants were detected;
- 19 (raw water) / 12 (finished water) odorants could be frequently detected (> 50%).

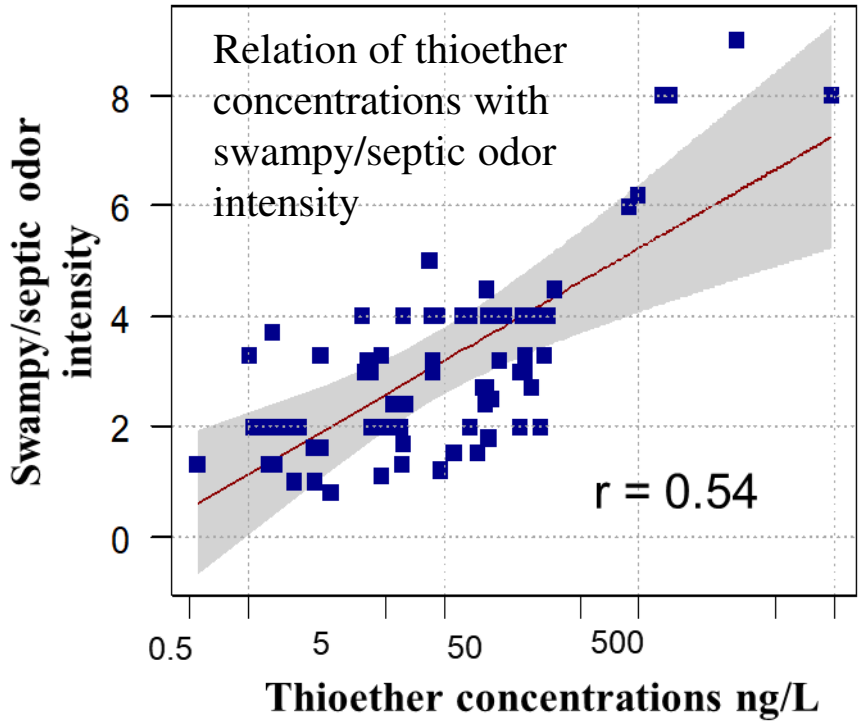
Co-occurrence of odorants in raw water and their possible sources

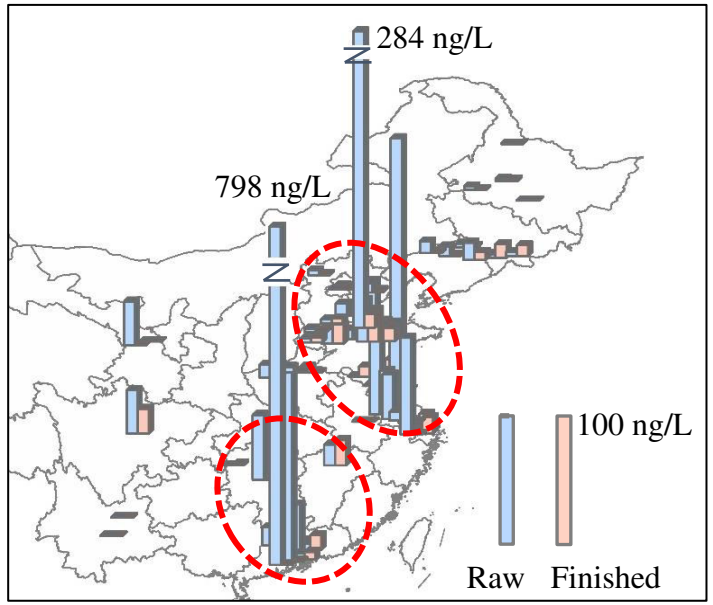


- Pyrazines: foods & beverages/waste water;
- Geosmin & p(m)-cresol, thioethers: biological production;
- Non-oxygen benzene-containing chemicals : petrochemicals industries;
- Cyclohexanone & benzaldehyde: fine chemical industries.

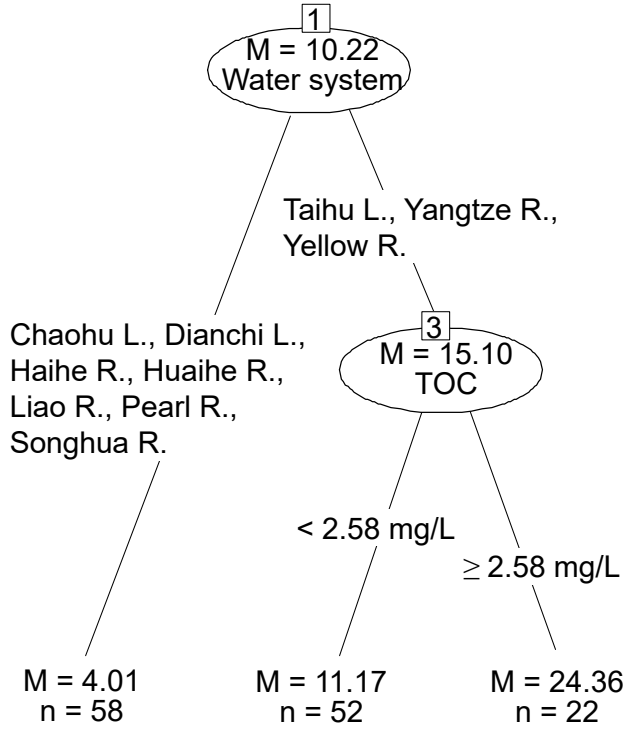
Wang et al., ES&T, 2021

Odorants related with swampy/septic odor





Regional distribution

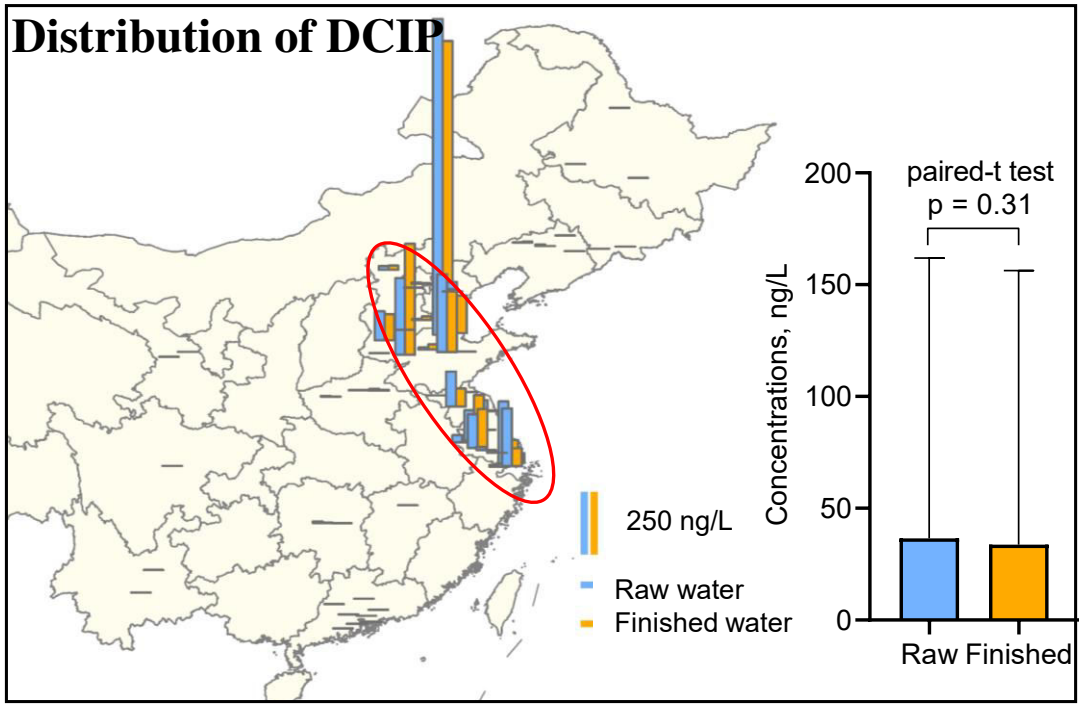


(a)

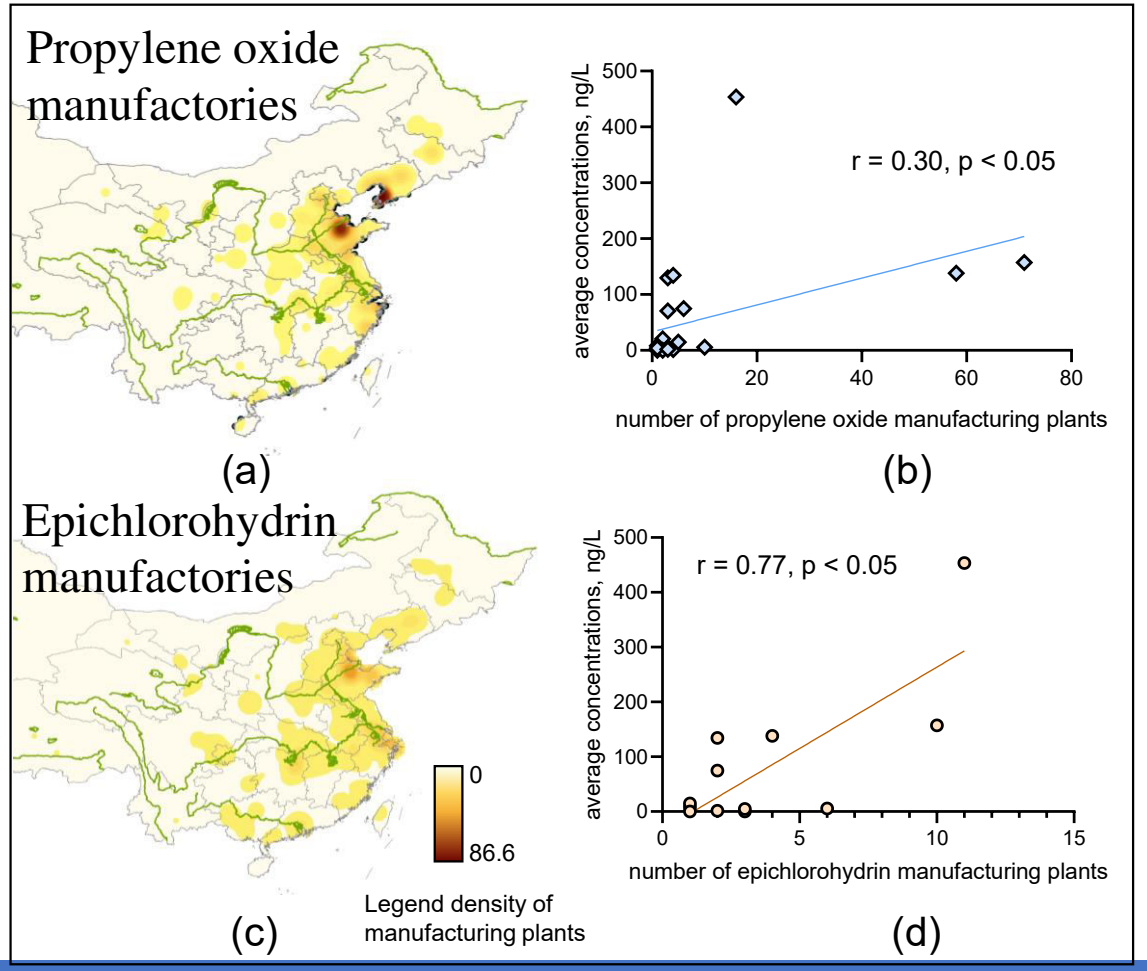
- Thioethers were the main cause of swampy/septic odor in source water of China.
- Thioethers were distributed widely with higher concentrations in the east and south parts of China.
- TOC was major factor affecting the concentrations of thioethers.

Wang et al., ES&T, 2021; Environ Pollut., 2019.

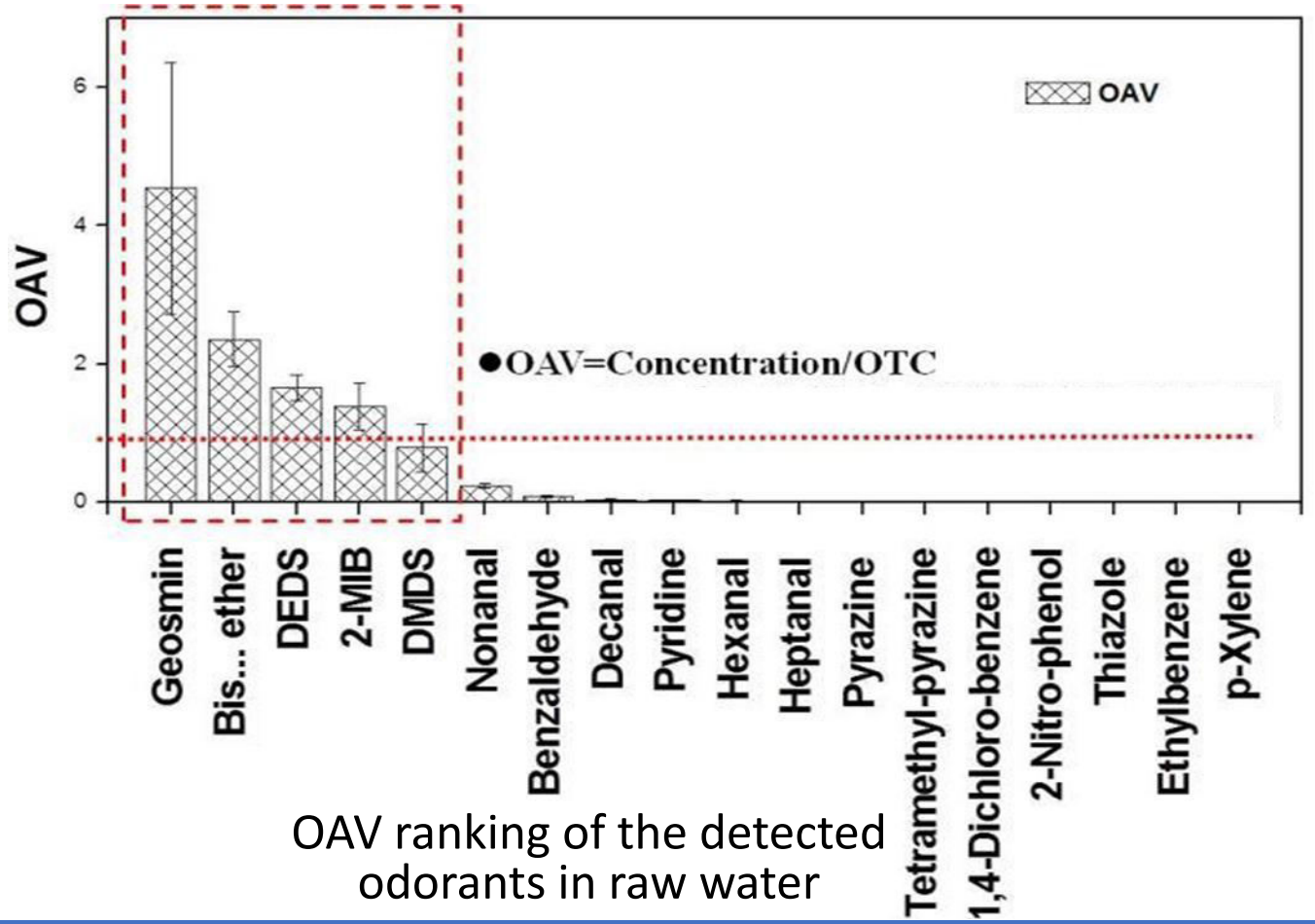
Odorants related to industrial pollutions-bis(2-chloro-1-methylethyl) ether (DCIP)



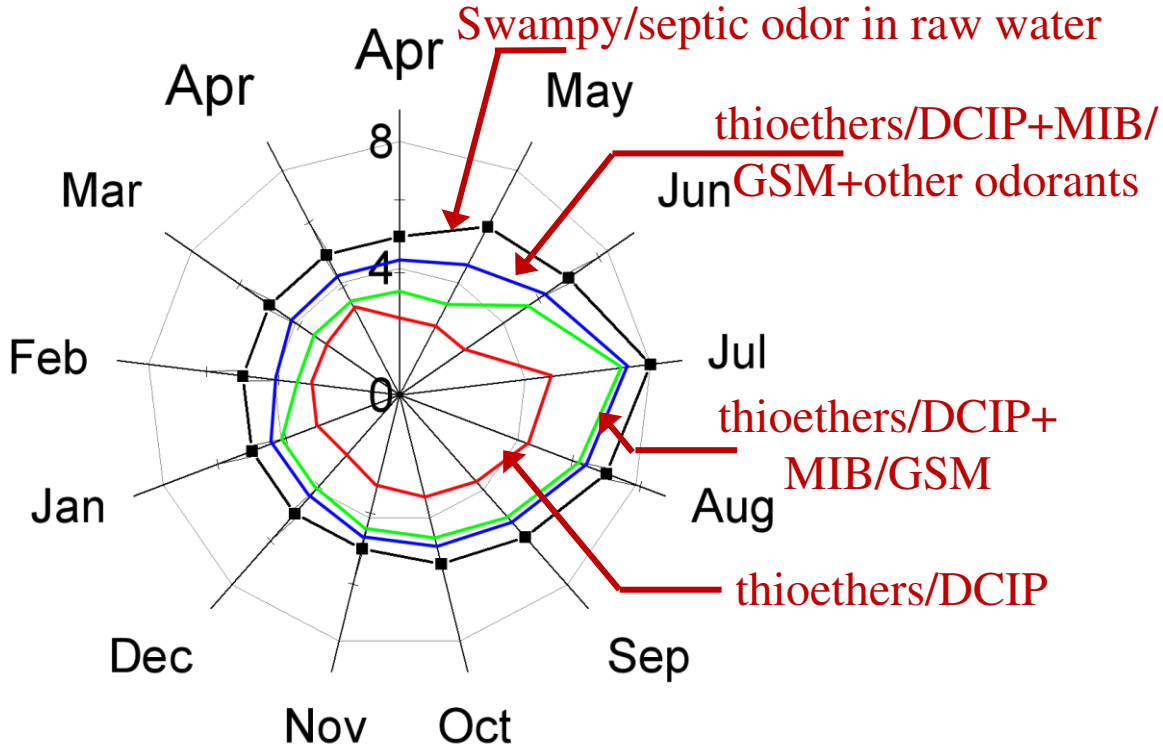
- Mainly distributed at eastern area in major watersheds;
- Limited removal using conventional treatment process;
- By-product of industrial activities related to epichlorohydrin/propylene oxide.



Identification of typical odorants in Huangpu River based on reconstitution test



OAV ranking of the detected odorants in raw water

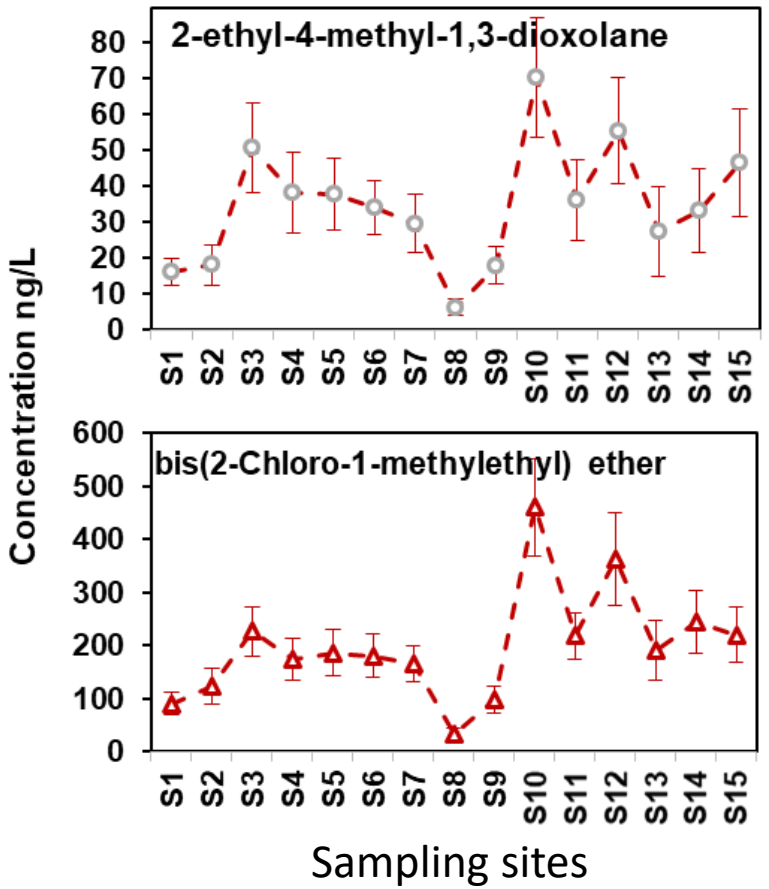


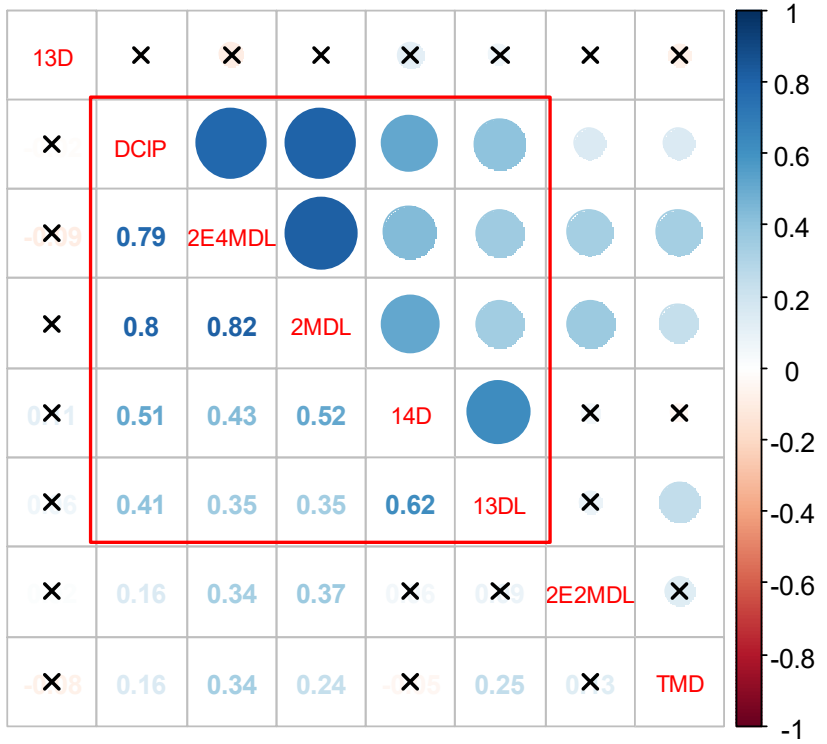
FPA intensity for swampy/septic odor and reconstituted samples in odorless finished water

☐ **Swampy/septic odor was strengthen with addition of major earthy/musty odorants.**

Guo et al., Water Res. 2016; Sci Total Environ. 2019

New class of odorants in Huangpu River-Cyclic acetals





Co-occurrence of bis(2-chloro-1-methylethyl) ether (DCIP) with cyclic acetals

- Three major pollution sources at S2-S3, S10 and S11, might be associated with resin-related industrial pollution.
- Suggestions on the setting of industrial wastewater discharge standards to control source water pollution (Shanghai Water authority)

Conclusion

- Odorant identification and quantitative methods were developed for complex water samples.
- 77 odor-causing compounds were detected in source water samples, thioethers were the major swampy/septic odor-causing compounds in drinking water of China; bis(2-chloro-1-methylethyl) was by-product of industrial activities related to epichlorohydrin/propylene oxide.
- Swampy/septic odor was strengthen with addition of major musty odorants.
- Cyclic acetals were first detected in Huangpu River source water, which could be associated with resin-related industrial pollution.

Thanks for your attentions!

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