

表 1 消毒処理水の全体毒性の評価に関する文献レビューの対象論文

対象論文No.	文献情報
1	Narotsky, M. G.; Klinefelter, G. R.; Goldman, J. M.; Best, D. S.; McDonald, A.; Strader, L. F.; Suarez, J. D.; Murr, A. S.; Thillainadarajah, I.; Hunter, E. S.; Richardson, S. D.; Speth, T. F.; Miltner, R. J.; Pressman, J. G.; Teuschler, L. K.; Rice, G. E.; Moser, V. C.; Luebke, R. W.; Simmons, J. E., Comprehensive assessment of a chlorinated drinking water concentrate in a rat multigenerational reproductive toxicity study. <i>Environ. Sci. Technol.</i> 2013 , <i>47</i> (18), 10653-10659.
2	Narotsky, M. G.; Pressman, J. G.; Miltner, R. J.; Speth, T. F.; Teuschler, L. K.; Rice, G. E.; Richardson, S. D.; Best, D. S.; McDonald, A.; Hunter Iii, E. S.; Simmons, J. E., Developmental Toxicity Evaluations of Whole Mixtures of Disinfection By-products using Concentrated Drinking Water in Rats: Gestational and Lactational Effects of Sulfate and Sodium. <i>Birth Defects Res., B</i> 2012 , <i>95</i> (3), 202-212.
3	Narotsky, M. G.; Best, D. S.; McDonald, A.; Godin, E. A.; Hunter, E. S.; Simmons, J. E., Pregnancy loss and eye malformations in offspring of F344 rats following gestational exposure to mixtures of regulated trihalomethanes and haloacetic acids. <i>Reprod. Toxicol.</i> 2011 , <i>31</i> (1), 59-65.
4	Dingus, C. A.; Teuschler, L. K.; Rice, G. E.; Simmons, J. E.; Narotsky, M. G., Prospective power calculations for the four lab study of a multigenerational reproductive/developmental toxicity rodent bioassay using a complex mixture of disinfection by-products in the low-response region. <i>Int. J. Environ. Res. Public Health</i> 2011 , <i>8</i> (10), 4082-4101.
5	Colman, J.; Rice, G. E.; Wright, J. M.; Hunter, E. S.; Teuschler, L. K.; Lipscomb, J. C.; Hertzberg, R. C.; Simmons, J. E.; Fransen, M.; Osier, M.; Narotsky, M. G., Identification of developmentally toxic drinking water disinfection byproducts and evaluation of data relevant to mode of action. <i>Toxicol. Appl. Pharmacol.</i> 2011 , <i>254</i> (2), 100-126.
6	Simmons, J. E.; Teuschler, L. K., Chemistry, Toxicity, and Health Risk Assessment of Drinking Water Disinfection By-Products. 2010; pp 401-419.
7	Pressman, J. G.; Richardson, S. D.; Speth, T. F.; Miltner, R. J.; Narotsky, M. G.; Hunter Iii, E. S.; Rice, G. E.; Teuschler, L. K.; McDonald, A.; Parvez, S.; Krasner, S. W.; Weinberg, H. S.; McKague, A. B.; Parrett, C. J.; Bodin, N.; Chinn, R.; Lee, C. F. T.; Simmons, J. E., Concentration, chlorination, and chemical analysis of drinking water for disinfection byproduct mixtures health effects research: U.S. EPAs four lab study. <i>Environ. Sci. Technol.</i> 2010 , <i>44</i> (19), 7184-7192.
8	Plewa, M. J.; Simmons, J. E.; Richardson, S. D.; Wagner, E. D., Mammalian cell cytotoxicity and genotoxicity of the haloacetic acids, a major class of drinking water disinfection by-products. <i>Environ. Mol. Mutagen.</i> 2010 , <i>51</i> (8-9), 871-878.
9	McDonald, A.; Killough, P.; Puckett, E.; Best, D. S.; Simmons, J. E.; Pressman, J. G.; Narotsky, M. G., A novel water delivery system for administering volatile chemicals while minimizing chemical waste in rodent toxicity studies. <i>Lab. Animals</i> 2010 , <i>44</i> (1), 66-68.
10	Rice, G. E.; Teuschler, L. K.; Bull, R. J.; Simmons, J. E.; Feder, P. I., Evaluating the similarity of complex drinking-water disinfection by-product mixtures: Overview of the issues. <i>J. Toxicol. Environ. Health, A</i> 2009 , <i>72</i> (7), 429-436.
11	Feder, P. I.; Ma, Z. J.; Bull, R. J.; Teuschler, L. K.; Schenck, K. M.; Simmons, J. E.; Rice, G., Evaluating sufficient similarity for disinfection by-product (DBP) mixtures: Multivariate statistical procedures. <i>J. Toxicol. Environ. Health, A</i> 2009 , <i>72</i> (7), 468-481.
12	Speth, T. F.; Miltner, R. J.; Richardson, S. D.; Simmons, J. E., Integrated disinfection by-products mixtures research: Concentration by reverse osmosis membrane techniques of disinfection by-products from water disinfected by chlorination and ozonation/postchlorination. <i>J. Toxicol. Environ. Health, A</i> 2008 , <i>71</i> (17), 1149-1164.
13	Simmons, J. E.; Richardson, S. D.; Teuschler, L. K.; Miltner, R. J.; Speth, T. F.; Schenck, K. M.; Hunter Iii, E. S.; Rice, G., Research issues underlying the four-lab study: Integrated disinfection by-products mixtures research. <i>J. Toxicol. Environ. Health, A</i> 2008 , <i>71</i> (17), 1125-1132.
14	Richardson, S. D.; Thruston Jr, A. D.; Krasner, S. W.; Weinberg, H. S.; Miltner, R. J.; Schenck, K. M.; Narotsky, M. G.; McKague, A. B.; Simmons, J. E., Integrated disinfection by-products mixtures research: Comprehensive characterization of water concentrates prepared from chlorinated and ozonated/postchlorinated drinking water. <i>J. Toxicol. Environ. Health, A</i> 2008 , <i>71</i> (17), 1165-1186.
15	Rice, G.; Teuschler, L. K.; Speth, T. F.; Richardson, S. D.; Miltner, R. J.; Schenck, K. M.; Gennings, C.; Hunter Iii, E. S.; Narotsky, M. G.; Simmons, J. E., Integrated disinfection by-products research: Assessing reproductive and developmental risks posed by complex disinfection by-product mixtures. <i>J. Toxicol. Environ. Health, A</i> 2008 , <i>71</i> (17), 1222-1234.
16	Narotsky, M. G.; Best, D. S.; Rogers, E. H.; McDonald, A.; Sey, Y. M.; Simmons, J. E., Integrated disinfection by-products mixtures research: Assessment of developmental toxicity in Sprague-Dawley rats exposed to concentrates of water disinfected by chlorination and ozonation/postchlorination. <i>J. Toxicol. Environ. Health, A</i> 2008 , <i>71</i> (17), 1216-1221.
17	Miltner, R. J.; Speth, T. F.; Richardson, S. D.; Krasner, S. W.; Weinberg, H. S.; Simmons, J. E., Integrated disinfection by-products mixtures research: Disinfection of drinking waters by chlorination and ozonation/postchlorination treatment scenarios. <i>J. Toxicol. Environ. Health, A</i> 2008 , <i>71</i> (17), 1133-1148.
18	Crosby, L. M.; Simmons, J. E.; Ward, W. O.; Moore, T. M.; Morgan, K. T.; DeAngelo, A. B., Integrated disinfection by-products (DBP) mixtures research: Gene expression alterations in primary rat hepatocyte cultures exposed to DBP mixtures formed by chlorination and ozonation/postchlorination. <i>J. Toxicol. Environ. Health, A</i> 2008 , <i>71</i> (17), 1195-1215.
19	Claxton, L. D.; Pegram, R.; Schenck, K. M.; Simmons, J. E.; Warren, S. H., Integrated disinfection by-products research: Salmonella mutagenicity of water concentrates disinfected by chlorination and ozonation/postchlorination. <i>J. Toxicol. Environ. Health, A</i> 2008 , <i>71</i> (17), 1187-1194.

表2 本研究で用いた SPAC の物理化学的性状

	D ₅₀	BET	ミクロ孔	メソ孔	ミクロ孔	メソ孔			
	μm	m ² /g	m ² /g	m ² /g	mL/g	mL/g			
木質炭1	0.62	1130	922	116	0.388	0.392			
木質炭2	0.47	1111	953	131	0.450	0.252			
木質炭3	0.53	1174	918	88	0.405	0.136			
木質炭4	0.52	1145	919	138	0.395	0.223			
ヤシ殻炭1	0.57	978	824	103	0.302	0.310			
ヤシ殻炭2	0.62	1215	1023	79	0.432	0.133			
石炭系炭1	0.49	884	637	55	0.281	0.314			

	官能基当量, μeq/m ²		元素含有率, %				ゼータ電位	IEP	pHpzc
	塩基性	酸性	C	N	S	O	mV		
木質炭1	0.66	0.30	81.9	0.20	0.15	8.24	-46	2.8	7.40
木質炭2	0.64	0.17	84.6	0.15	0.11	9.06	-39	3.3	8.69
木質炭3	0.69	0.31	85.3	0.14	0.10	8.90	-42	4.2	8.88
木質炭4	0.62	0.49	83.3	0.22	0.13	8.90	-46	2.9	7.72
ヤシ殻炭1	0.34	0.43	88.1	0.16	0.11	6.10	-42	3.9	6.44
ヤシ殻炭2	0.48	0.36	89.1	0.18	0.06	6.06	-48	3.3	7.28
石炭系炭1	0.41	0.86	79.2	0.38	0.55	11.02	-38	4.2	6.32

IEP: isoelectric point, pHpzc: point of zero charge

表3 オゾン処理性調査結果

物質名	中オゾン流入水			中オゾン処理水			調査対象物質除去率 (%)	FA-FP低下率 (%)
	物質濃度	FA濃度	FA-FP	物質濃度	FA濃度	FA-FP		
	μM	μM	μM	μM	μM	μM		
HMT	2.2	0.52	7.6	<LOQ	0.51	1.6	100	79
TMA	2.0	<LOQ	2.3	0.15	0.13	0.26	93	89
DMEA	2.0	0.08	1.7	0.54	0.21	0.26	72	84
DMAE	1.6	<LOQ	2.1	<LOQ	0.24	0.41	100	80
DMGu	1.8	0.19	0.95	1.8	0.21	0.87	0	7.6
DMH	1.8	0.12	1.7	<LOQ	0.76	0.26	100	85
DMAN	2.0	<LOQ	1.7	<LOQ	0.35	0.10	100	94
TMED	-	<LOQ	3.6	-	0.17	0.25	-	93

表4 急速砂ろ過処理性調査結果

物質名	砂ろ過流入水			砂ろ過処理水			調査対象物質除去率 (%)	FA-FP低下率 (%)
	物質濃度	FA濃度	FA-FP	物質濃度	FA濃度	FA-FP		
	μM	μM	μM	μM	μM	μM		
HMT	2.5	0.45	7.8	2.5	0.43	7.5	2.1	3.2
TMA	1.9	<LOQ	2.4	1.7	<LOQ	2.2	11	6.4
DMEA	2.0	0.16	1.6	1.8	0.07	1.6	9.3	0
DMAE	1.7	<LOQ	1.8	1.4	<LOQ	1.5	16	18
DMGu	1.7	<LOQ	0.95	1.7	0.08	0.83	3.1	13
DMH	1.9	0.09	1.7	0.32	0.15	0.60	83	65
DMAN	2.1	<LOQ	1.8	1.7	<LOQ	1.5	19	18
TMED	-	<LOQ	3.4	-	<LOQ	3.3	-	4.6

表5 GAC 処理性調査結果

物質名	GAC流入水			GAC処理水			調査対象物質除去率 (%)	FA-FP低下率 (%)
	物質濃度	FA濃度	FA-FP	物質濃度	FA濃度	FA-FP		
	μM	μM	μM	μM	μM	μM		
HMT	1.9	0.64	8.0	1.3	0.49	6.5	33	19
TMA	2.2	<LOQ	2.7	1.1	0.07	0.96	52	64
DMEA	2.1	<LOQ	1.8	0.89	<LOQ	0.76	58	57
DMAE	1.7	<LOQ	2.1	<LOQ	<LOQ	0.07	100	97
DMGu	2.0	<LOQ	0.95	0.12	<LOQ	0.08	94	92
DMH	1.9	0.11	2.0	<LOQ	<LOQ	0.07	100	96
DMAN	2.2	<LOQ	2.2	<LOQ	<LOQ	0.13	100	94
TMED	-	<LOQ	3.6	-	<LOQ	<LOQ	-	100

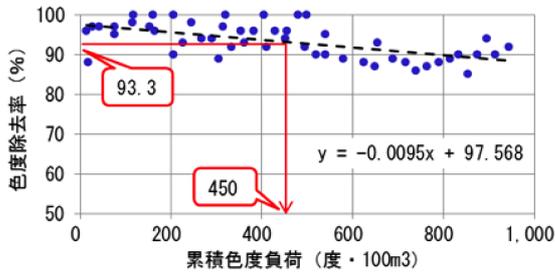


図3 ろ過水色度推定近似式

表6 算出結果まとめ

原水ピークカット色度(計器値)(度)	15
ろ過水色度上限目標(度)	1.2
必要除去率(%)	93.3
原水色度累積負荷上限(度・100m³)	450
色度負荷(度・100m³/日)	3.6
運用可能日数(日)	125

表7 E250の管理値

水温	0 ~ 10	10 ~ 20	20 ~ 30
E250 値	0.083	0.067	0.056

(セル長: 50mm)

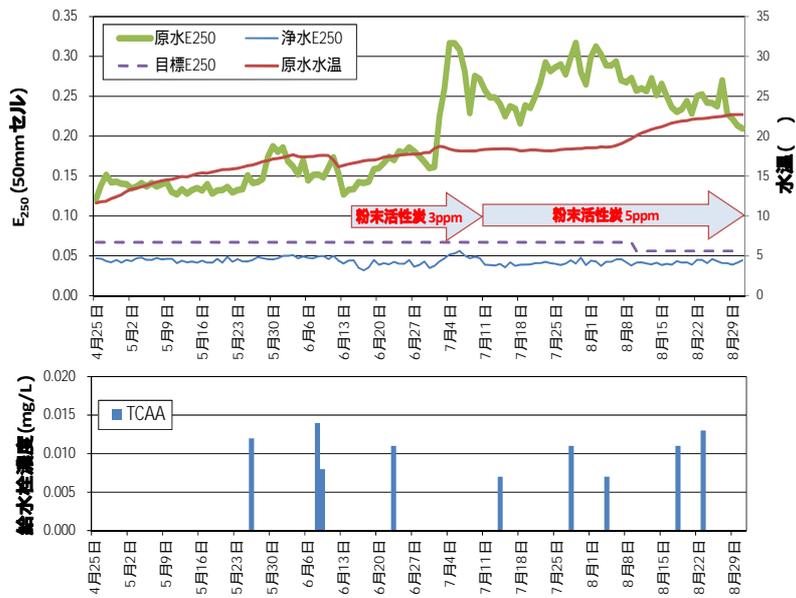
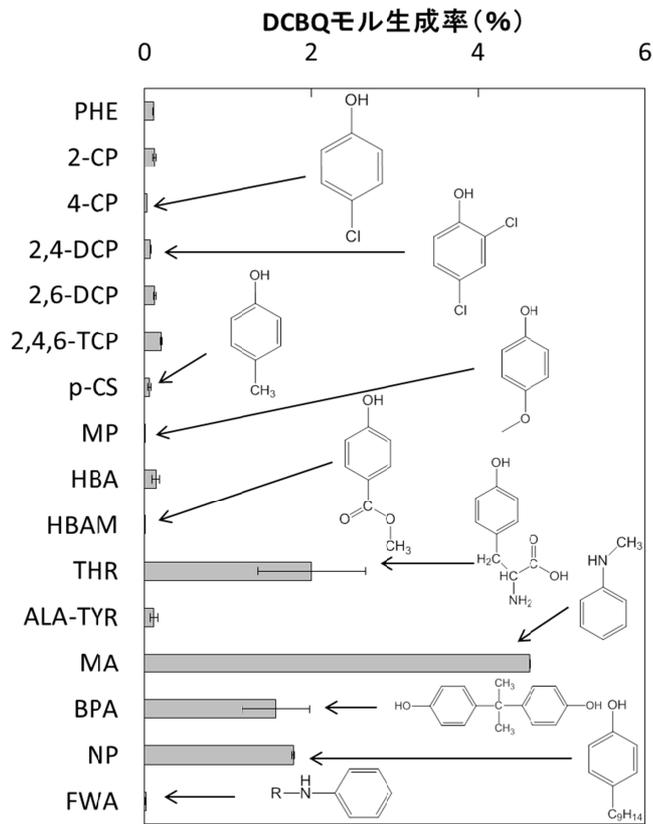


図4 B 浄水場における水質及び給水栓のトリクロロ酢酸の最大値



他の物質からは生成しなかった。
 図5 芳香族化合物からのDCBQモル生成率

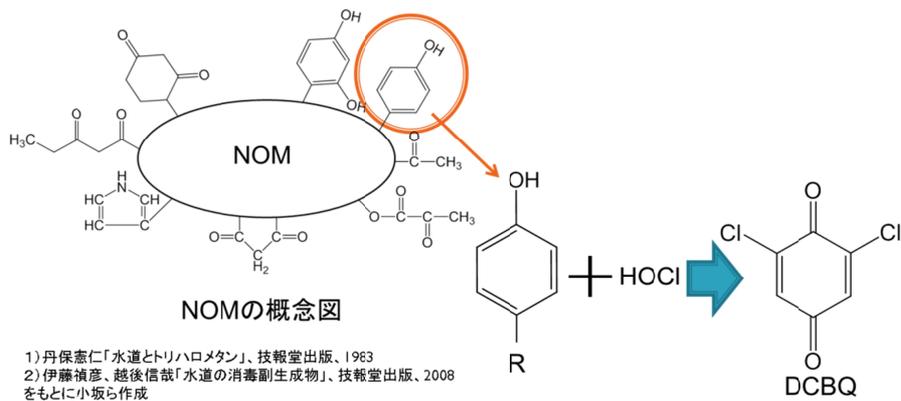


図6 NOMからのHBQsの生成経路(推測)

表8 八口酢酸生成能調査

測定日	ラフト藻 (細胞/ml)	ジクロロ酢酸 生成能 (mg/L)	トリクロロ酢酸 生成能 (mg/L)	
平成24年	6/7	0	0.013	0.017
	7/5	0	0.011	0.013
	8/9	0	0.013	0.011
	9/5	0	0.012	0.013
	10/4	0	0.009	0.010
	11/21	0	0.011	0.009
	12/5	0	0.012	0.014
平成26年	10/27	34	0.019	0.033
	10/28	26	0.016	0.033
	10/30	16	0.014	0.028
	11/4	6	0.014	0.025
	11/6	7	0.013	0.024

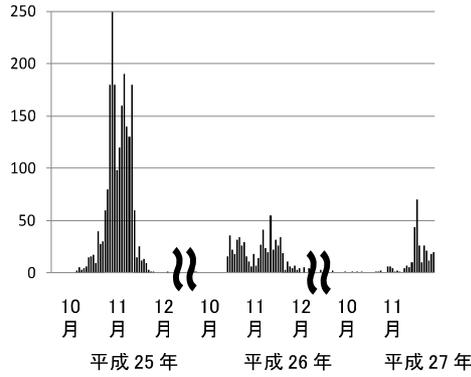


図7 原水中のラフト藻の数

表9 過去10年間の11月における給水中のトリクロロ酢酸濃度

	トリクロロ酢酸 (mg/L)	原水ラフト藻 (細胞/ml)	粉炭 (ppm)	前塩素 ppm
H18	0.003	—	3.0	0.0
H19	0.004	—	0.0	7.0
H20	0.004	—	0.0	4.0
H21	0.004	—	0.0	5.0
H22	<0.002	—	5.0	0.0
H23	0.003	—	5.0	0.0
H24	<0.002	—	3.0	0.0
H25	0.019	98	0.0	10.0
H26	0.003	27	0.0	0.0
H27	0.006 - 0.008	20 - 57	0.0	8.0

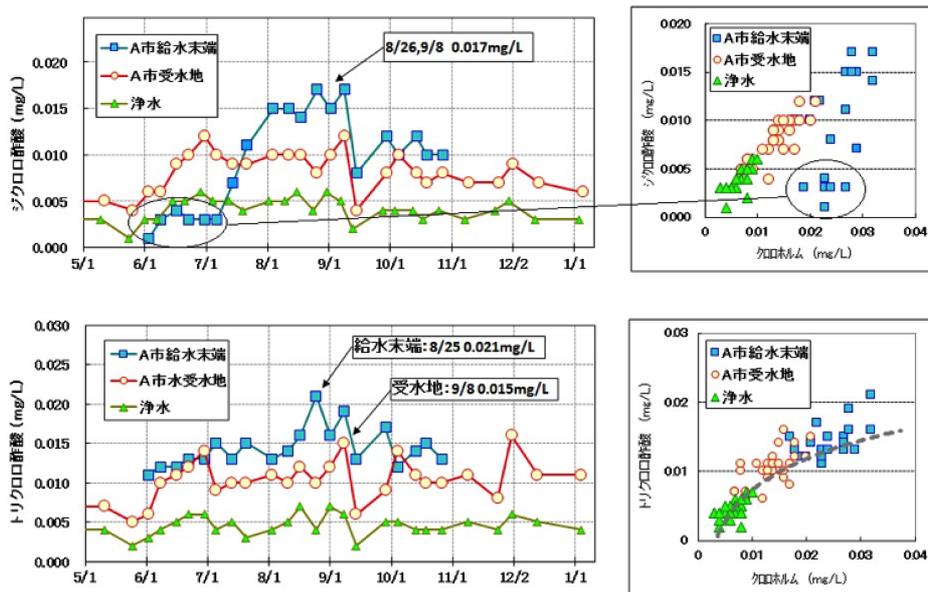


図8 浄水場浄水等のジクロロ酢酸の推移とクロロホルムとの相関(上段)およびトリクロロ酢酸の推移とクロロホルムとの相関(下段)