

1 **Supporting Information**  
2 **Enhanced Disinfection By-Product Formation Due to**  
3 **Nanoparticles in Wastewater Treatment Plant Effluents**

4 Jacob W. Metch, Yanjun Ma, Amy Pruden, Peter J. Vikesland\*

5 \*Corresponding author phone: (540) 231-3568; email: [pvikes@vt.edu](mailto:pvikes@vt.edu). Current address: Via  
6 Department of Civil and Environmental Engineering, 418 Durham Hall, Virginia Tech,  
7 Blacksburg, VA 24061.

8 **1. Supporting Tables**

9 **Table S1: WWTP Effluent Total Organic Carbon (TOC)**

<b>Effluent 1</b>		<b>Effluent 2</b>	
<b>Date</b>	<b>TOC (mg/L)</b>	<b>Date</b>	<b>TOC (mg/L)</b>
9-2-2013	8.33	9-11-2013	8.25
9-17-2013	8.45	9-24-2014	5.67
1-22-2013	12.18	2-10-2014	8.95
4-15-2014	5.2	2-15-2014	8.95
10-10-2014	6.2	4-15-2014	4.21
		10-23-2014	5.73
<b>Average</b>	8.07	<b>Average</b>	7.31
<b>Standard Deviation</b>	2.68	<b>Standard Deviation</b>	2.54

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12 **Table S2: WWTP Effluent pH**

<b>Effluent 1</b>		<b>Effluent 2</b>	
<b>Date</b>	<b>pH</b>	<b>Date</b>	<b>pH</b>
1-22-2014	7.18	2-16-2014	7.15
5-22-2014	7.57	4-14-2014	7.67
4-14-2014	7.64	5-8-2014	7.56
<b>Average</b>	7.46	<b>Average</b>	7.46
<b>Standard Deviation</b>	0.25	<b>Standard Deviation</b>	0.27

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15 **Table S3: Trihalomethane and Chloropicrin formation in Presence of AgNPs (with citrate**  
 16 **controls)**

WWTP Effluent	Disinfection	Condition	DBP formation (ppb)				
			TCM	BDCM	TCNM	DBCM	TBM
1	Cl <sub>2</sub>	BC	95.51	7.82	BD	BD	ND
		B/I	85.58	4.16	BD	BD	ND
		NP	166.44	6.94	BD	BD	ND
		Cit + E	88.08	8.09	BD	BD	ND
		Cit + NW	35.34	BD	BD	BD	ND
		NP + NW	341.20	BD	2.60	BD	ND
	UV then Cl <sub>2</sub>	BC	115.72	8.75	BD	BD	ND
		B/I	98.04	3.97	3.16	BD	ND
		NP	674.70	5.52	BD	BD	ND
		Cit + E	101.24	8.86	BD	BD	ND
		Cit + NW	45.85	BD	BD	BD	ND
		NP + NW	361.25	BD	BD	BD	ND
2	Cl <sub>2</sub>	BC	83.31	41.04	BD	15.28	BD
		B/I	97.19	22.68	BD	8.54	BD
		NP	138.11	40.38	BD	10.62	BD
		Cit + E	82.69	44.75	BD	15.65	2.20
		Cit + NW	35.34	BD	BD	BD	ND
		NP + NW	341.20	BD	2.60	BD	ND
	UV then Cl <sub>2</sub>	BC	81.52	41.10	BD	25.16	BD
		B/I	93.03	32.04	BD	9.23	BD
		NP	495.08	55.35	BD	10.68	BD
		Cit + E	88.29	46.90	BD	25.48	2.07
		Cit + NW	45.85	BD	BD	BD	ND
		NP + NW	361.25	BD	BD	BD	ND
BC: Background Control, B/I: Bulk/Ion Control, NP: Nanoparticle, Cit + E: Citrate and effluent, Cit + NW: Citrate and Nanopure Water, NP + NW: AgNPs and Nanopure Water							
TCM: trichloromethane, BDCM: bromodichloromethane, TCNM: trichloronitromethane (chloropicrin), DBCM: dibromochloromethane, TBM: tribromomethane							

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19 **Table S4: Trihalomethane and Chloropicrin formation in Presence of TiO<sub>2</sub>**

WWTP Effluent	Disinfection	Condition	DBP formation (ppb)				
			TCM	BDCM	TCNM	DBCM	TBM
1	Cl <sub>2</sub>	BC	127.62	10.01	BD	BD	ND
		B/I	128.73	9.62	BD	BD	ND
		NP	123.80	9.83	BD	BD	ND
	UV then Cl <sub>2</sub>	BC	121.55	11.44	BD	1.67	ND
		B/I	114.79	11.50	BD	1.61	ND
		NP	119.29	11.51	BD	1.65	ND
2	Cl <sub>2</sub>	BC	126.93	21.09	BD	7.42	BD
		B/I	121.73	20.18	BD	7.28	BD
		NP	129.94	21.01	BD	7.31	BD
	UV then Cl <sub>2</sub>	BC	182.93	29.22	BD	12.33	BD
		B/I	177.82	29.04	BD	12.34	BD
		NP	204.70	28.82	BD	12.31	BD
TCM: trichloromethane, BDCM: bromodichloromethane, TCNM: trichloronitromethane (chloropicrin), DBCM: dibromochloromethane, TBM: tribromomethane							

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21 **Table S5: Trihalomethane and Chloropicrin formation in Presence of NZVI**

WWTP Effluent	Disinfection	Condition	DBP formation (ppb)				
			TCM	BDCM	TCNM	DBCM	TBM
1	Cl <sub>2</sub>	BC	164.58	14.96	BD	BD	ND
		B/I	13.68	1.44	BD	BD	ND
		NP	161.02	14.00	BD	BD	ND
	UV then Cl <sub>2</sub>	BC	175.14	16.51	BD	BD	ND
		B/I	131.93	14.99	BD	BD	ND
		NP	182.18	17.16	BD	BD	ND
2	Cl <sub>2</sub>	BC	452.02	26.51	BD	7.03	BD
		B/I	10.92	7.95	BD	3.07	BD
		NP	470.60	25.52	BD	6.68	BD
	UV then Cl <sub>2</sub>	BC	540.70	14.83	BD	11.06	BD
		B/I	476.50	14.64	1.63	9.02	BD
		NP	544.42	30.03	BD	21.87	BD
TCM: trichloromethane, BDCM: bromodichloromethane, TCNM: trichloronitromethane (chloropicrin), DBCM: dibromochloromethane, TBM: tribromomethane							

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23 **Table S6: Trihalomethane and Chloropicrin formation in Presence of CeO<sub>2</sub>**

WWTP Effluent	Disinfection	Condition	DBP formation (ppb)				
			TCM	BDCM	TCNM	DBCM	TBM
1	Cl <sub>2</sub>	BC	426.67	4.88	BD	BD	ND
		B/I	406.09	6.90	BD	BD	ND
		NP	384.15	7.00	BD	BD	ND
	UV then Cl <sub>2</sub>	BC	486.05	5.69	BD	BD	ND
		B/I	484.11	8.42	BD	BD	ND
		NP	529.57	8.55	BD	BD	ND
2	Cl <sub>2</sub>	BC	449.26	20.37	BD	6.87	BD
		B/I	292.36	17.60	BD	6.56	BD
		NP	386.26	19.59	BD	6.67	BD
	UV then Cl <sub>2</sub>	BC	503.52	20.77	BD	9.03	BD
		B/I	494.69	20.65	BD	8.64	BD
		NP	490.64	39.87	BD	17.45	BD
TCM: trichloromethane, BDCM: bromodichloromethane, TCNM: trichloronitromethane (chloropicrin), DBCM: dibromochloromethane, TBM: tribromomethane							

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25 **Table S7: Trihalomethane and Chloropicrin formation in Presence of 1 mg/L AgNPs**

WWTP Effluent	Disinfection	Condition	DBP formation (ppb)				
			TCM	BDCM	TCNM	DBCM	TBM
1	Cl <sub>2</sub>	BC	286.51	24.53	4.03	BD	ND
		B/I	310.69	24.02	3.92	BD	ND
		NP	496.70	22.64	3.80	BD	ND
	UV then Cl <sub>2</sub>	BC	332.90	34.81	4.14	BD	ND
		B/I	292.62	32.70	4.98	BD	ND
		NP	552.37	40.82	6.01	BD	ND
2	Cl <sub>2</sub>	BC	245.79	65.49	1.36	35.10666	1.94424
		B/I	226.74	62.64	1.32	29.76284	1.438108
		NP	368.44	75.41	1.58	28.81848	1.276649
	UV then Cl <sub>2</sub>	BC	221.52	80.30	1.55	43.13988	2.74107
		B/I	182.65	79.47	1.62	29.82173	1.765468
		NP	405.65	106.08	1.86	31.15115	2.120305
TCM: trichloromethane, BDCM: bromodichloromethane, TCNM: trichloronitromethane (chloropicrin), DBCM: dibromochloromethane, TBM: tribromomethane							

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27 **Table S8: Trihalomethane and Chloropicrin formation in Presence of 10 mg/L AgNPs**

WWTP Effluent	Disinfection	Condition	DBP formation (ppb)				
			TCM	BDCM	TCNM	DBCM	TBM
1	Cl <sub>2</sub>	BC	382.78	28.80	BD	BD	ND
		B/I	365.18	24.49	BD	BD	ND
		NP	720.28	22.21	BD	BD	ND
	UV then Cl <sub>2</sub>	BC	553.70	38.26	BD	BD	ND
		B/I	589.45	27.11	BD	BD	ND
		NP	1257.87	21.83	BD	BD	ND
2	Cl <sub>2</sub>	BC	386.79	70.28	BD	BD	ND
		B/I	387.66	65.44	BD	BD	ND
		NP	556.19	59.00	BD	BD	ND
	UV then Cl <sub>2</sub>	BC	461.00	68.67	BD	11.56	ND
		B/I	523.27	46.94	BD	BD	ND
		NP	798.77	58.20	BD	BD	ND
TCM: trichloromethane, BDCM: bromodichloromethane, TCNM: trichloronitromethane (chloropicrin), DBCM: dibromochloromethane, TBM: tribromomethane							

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29 **Table S9: Trihalomethane and Chloropicrin formation in Presence of 20 mg/L AgNPs**

WWTP Effluent	Disinfection	Condition	DBP formation (ppb)				
			TCM	BDCM	TCNM	DBCM	TBM
1	Cl <sub>2</sub>	BC	343.91	27.96	BD	BD	ND
		B/I	354.12	17.87	BD	BD	ND
		NP	630.80	17.58	BD	BD	ND
	UV then Cl <sub>2</sub>	BC	336.54	26.38	BD	BD	ND
		B/I	363.66	14.63	BD	BD	ND
		NP	1081.91	8.38	BD	BD	ND
2	Cl <sub>2</sub>	BC	397.28	39.53	BD	BD	ND
		B/I	384.30	30.21	BD	BD	ND
		NP	759.54	24.77	BD	BD	ND
	UV then Cl <sub>2</sub>	BC	325.22	37.33	BD	BD	ND
		B/I	296.87	17.57	BD	BD	ND
		NP	945.95	22.91	BD	BD	ND
TCM: trichloromethane, BDCM: bromodichloromethane, TCNM: trichloronitromethane (chloropicrin), DBCM: dibromochloromethane, TBM: tribromomethane							

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31 **Table S10: Chloroform Formation in the Presence of Citrate Coated Gold Nanoparticles in**  
 32 **WWTP 1 Effluent**

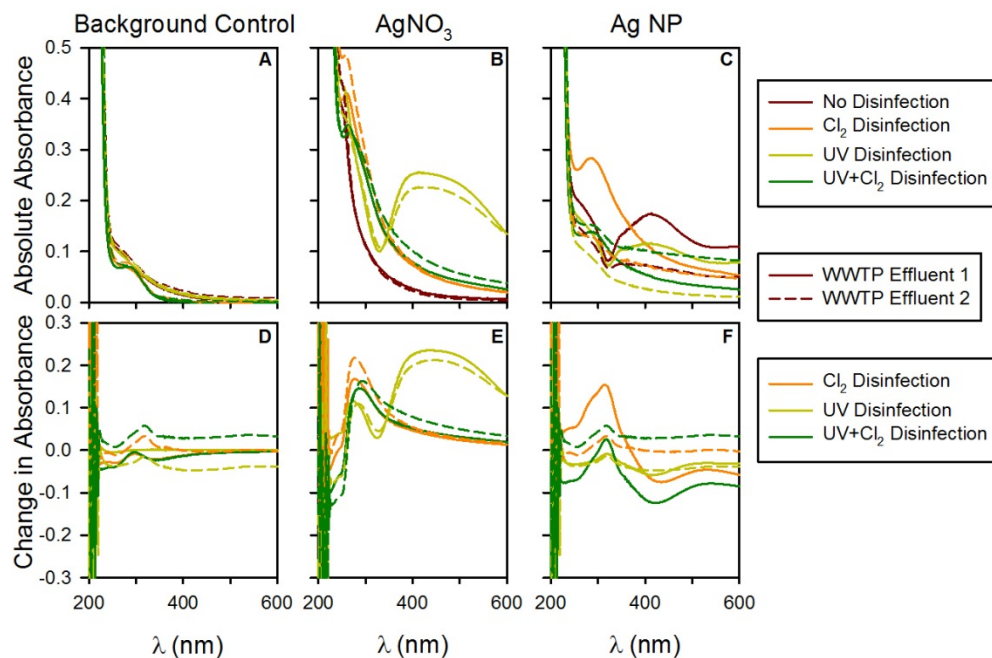
Condition	Chloroform Formation ( $\mu\text{g/L}$ )	
	Cl	UV + Cl
BC	27.76	42.37
B/I	20.30	33.42
NP	63.10	113.31

Chloroform quantified using EPA Method 551; B/I: Gold Chloride; NP: Gold nanoparticles synthesized by citrate reduction method

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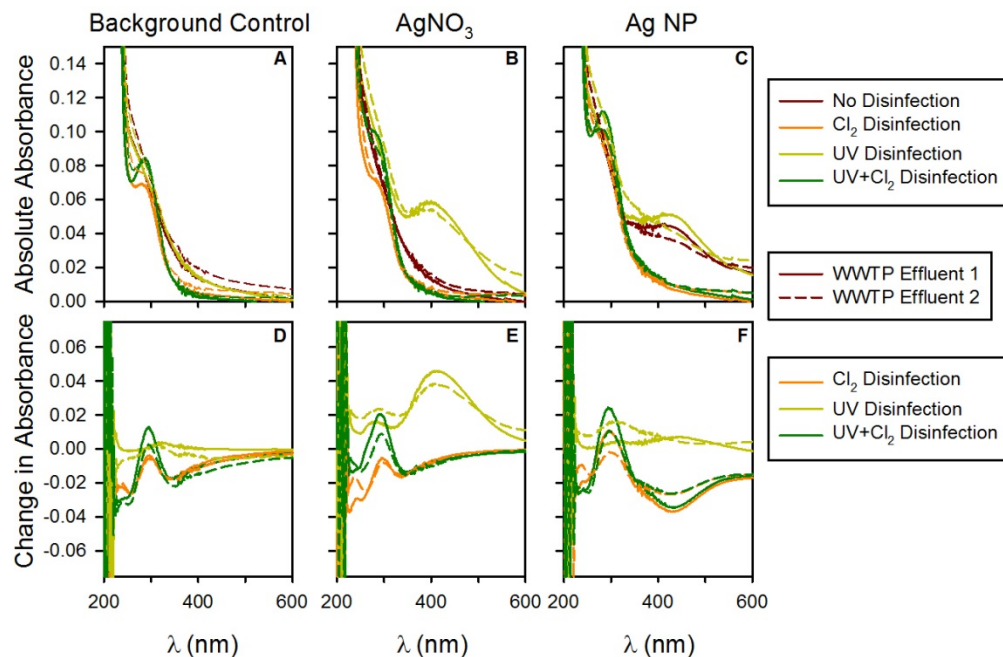
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35 **2. Supporting Figures**



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37 **Figure S1:** A-C: UV-Vis absorbance spectra of effluents at each stage of disinfection (no  
 38 disinfection, free chlorine, UV, and UV + free chlorine) for background and ion control and  
 39 AgNPs, at 10 mg/L. D-F: UV-Vis absorbance differential with respect to that condition with no  
 40 disinfection, for background and ion controls and AgNPs, at 10 mg/L.



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42 **Figure S2:** A-C: UV-Vis absorbance spectra of effluents at each stage of disinfection (no  
 43 disinfection, free chlorine, UV, and UV + free chlorine) for background and ion control and  
 44 AgNPs, at 1 mg/L. D-F: UV-Vis absorbance differential with respect to that condition with no  
 45 disinfection, for background and ion controls and AgNPs, at 1 mg/L.

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