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Supplementary Material

Mitigation of Odor and Gaseous Emissions from Swine Barn with UV-A and UV-C Photocatalysis

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Results of targeted gases mitigation under UV photocatalysis

Table S1. Mitigation of CH_4 with UV-A photocatalysis treatment. Control temperature = 28.5 ± 2.3 °C, control RH = 69.8 ± 9.5%, treatment temperature: 31.5 ± 1.2 °C, treatment RH = 66.0 ± 4.3%.

UV dose ($mJ{\cdot}cm^{-2}$)	Light intensity ($mW{\cdot}cm^{-2}$)	Treatment time (s)	Control (ppm)	Treatment (ppm)	% reduction (*p*-value)
UV dose control with light intensity & treatment time					
1.9	0.04 & 0.41	15.8 & 3.2	7.3 ± 1.3	7.1 ± 0.5	2.0 (0.83)
2.9	0.04 & 0.41	23.8 & 4.8	7.2 ± 1.0	7.8 ± 1.2	-8.3 (0.08)
2.9	0.04 & 0.14	43.3 & 8.7	19.2 ± 0.4	19.1 ± 0.3	0.5 (0.77)
4.0	0.04 & 0.26	43.3 & 8.7	19.2 ± 0.4	18.7 ± 0.6	2.4 (0.11)
5.3	0.04 & 0.41	43.3 & 8.7	5.0 ± 0.2	4.8 ± 0.5	3.5 (0.69)

Table S2. Mitigation of NH_3 with UV-A photocatalysis treatment. Control temperature = 28.5 ± 2.3 °C, control RH = 69.8 ± 9.5%, treatment temperature: 31.5 ± 1.2 °C, treatment RH = 66.0 ± 4.3%.

UV dose ($mJ{\cdot}cm^{-2}$)	Light intensity ($mW{\cdot}cm^{-2}$)	Treatment time (s)	Control (ppm)	Treatment (ppm)	% reduction (*p*-value)
UV dose control with light intensity & treatment time					
1.9	0.04 & 0.41	15.8 & 3.2	24.9 ± 0.4	24.6 ± 0.3	1.2 (0.14)
2.9	0.04 & 0.41	23.8 & 4.8	20.1 ± 1.1	20.2 ± 1.5	-0.8 (0.14)
2.9	0.04 & 0.14	43.3 & 8.7	26..2 ± 0.5	25.8 ± 0.6	1.4 (0.07)
4.0	0.04 & 0.26	43.3 & 8.7	22.1 ± 1.0	21.9 ± 0.7	1.1 (0.36)
5.3	0.04 & 0.41	43.3 & 8.7	15.2 ± 0.4	15.2 ± 0.3	3.7 (0.08)

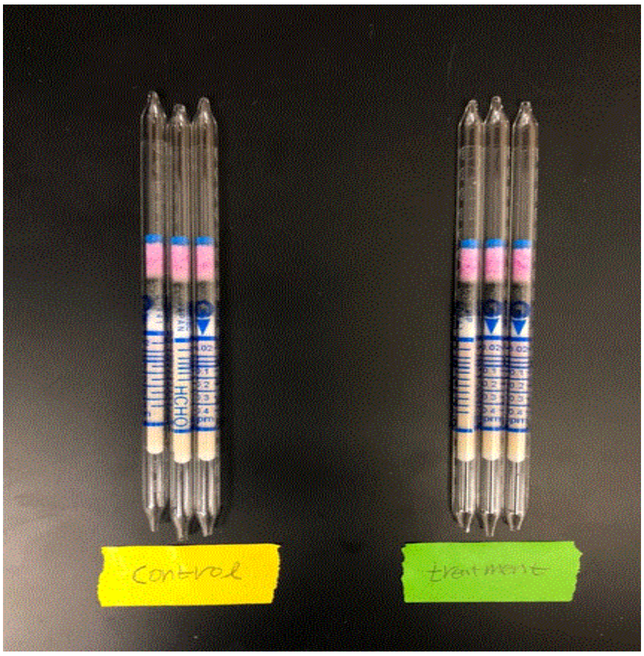

Figure S1. Formaldehyde was not detected by colorimetric tubes.

Table S3. Mitigation of CH_4 with different UV wavelengths irradiating gaseous emissions inside #2 chamber. Air flow = 0.28 m^3·s^{-1}, inlet air temperature (influent of chamber #2) = 28 °C, inlet air RH = 67 %, outlet air temperature (inffluent of chamber #3) = 31 °C, outlet air RH = 61 %.

UV Wavelengths (nm)	UV dose (μJ·cm^{-2})	Light intensity (μW·cm^{-2})	Control (ppm)	Treatment (ppm)	% reduction (*p*-value)
185 + 254	0.03 μJ·cm^{-2}	0.01	9.4 ± 1.5	10.7 ± 1.6	-13.4 (0.13)
222	2.55 μJ·cm^{-2}	0.59	10.0 ± 0.6	9.2 ± 3.6	8.4 (0.75)
254	1.60 μJ·cm^{-2}	0.37	10.2 ± 0.5	11.6 ± 2.7	-14.3 (0.51)
367	1,775 μJ·cm^{-2}	410	10.1 ± 0.2	10.3 ± 1.5	-2.7 (0.80)

Table S4. Mitigation of CO_2 with different UV wavelengths irradiating gaseous emissions inside #2 chamber. Air flow = 0.28 m^3·s^{-1}, inlet air temperature (influent of chamber #2) = 28 °C, inlet air RH = 67 %, outlet air temperature (inffluent of chamber #3) = 31 °C, outlet air RH = 61 %.

UV Wavelengths (nm)	UV dose (μJ·cm^{-2})	Light intensity (μW·cm^{-2})	Control (ppm)	Treatment (ppm)	% reduction (*p*-value)
185 + 254	0.03 μJ·cm^{-2}	0.01	774 ± 107	929 ± 40	-20.1 (0.06)
222	2.55 μJ·cm^{-2}	0.59	823 ± 44	849 ± 39	-3.1 (0.07)
254	1.60 μJ·cm^{-2}	0.37	835 ± 27	845 ± 65	-1.2 (0.70)
367	1,775 μJ·cm^{-2}	410	853 ± 6.8	867 ± 29	-1.7 (0.43)

Table S5. Mitigation of odor with different UV wavelengths irradiating gaseous emissions inside #2 chamber. Air flow = 0.28 m^3·s^{-1}, inlet air temperature (influent of chamber #2) = 28 °C, inlet air RH = 67 %, outlet air temperature (inffluent of chamber #3) = 31 °C, outlet air RH = 61 %.

UV Wavelengths (nm)	UV dose (μJ·cm^{-2})	Light intensity (μW·cm^{-2})	Control (OU$_E$·m^{-3})	Treatment (OU$_E$·m^{-3})	% reduction (*p*-value)
185 + 254	0.03 μJ·cm^{-2}	0.01	369 ± 29	402 ± 54	-8.7 (0.35)

222	2.55 μJ·cm-2	0.59	352 ± 65	455 ± 56	-29.4 (0.19)
254	1.60 μJ·cm-2	0.37	347 ± 29	459 ± 92	-32.1 (0.27)
367	1,775 μJ·cm-2	410	257 ± 87	237 ± 19	7.8 (0.77)

Table S6. Mitigation of odorous VOCs with different UV wavelengths irradiating gaseous emissions inside #2 chamber. Air flow = 0.28 $m^3·s^{-1}$, inlet air temperature (influent of chamber #2) = 28 °C, inlet air RH = 67 %, outlet air temperature (inffluent of chamber #3) = 31 °C, outlet air RH = 61 %.

Type of VOCs	Percent reduction (*p*-value)			
	UV-C dose, μJ·cm-2 (light intensity, μW·cm-2)			UV-A dose, μJ·cm-2 (light intensity, μW·cm-2)
	185 + 254 nm 0.03 (0.01)	222 nm 2.55 (0.59)	254 nm 1.60 (0.37)	367 nm 1,775 (410)
DMDS	-15.7 (0.86)	-16.9 (0.77)	-33.3 (0.71)	7.3 (0.41)
DEDS	Not detected	Not detected	Not detected	Not detected
Acetic acid	-66.1 (0.40)	-7.5 (0.94)	-33.2 (0.72)	-0.6 (0.98)
Propanoic acid	-21.5 (0.78)	-12.0 (0.75)	-49.6 (0.59)	-11.8 (0.32)
Isobutyric acid	33.6 (0.58)	11.8 (0.85)	10.3 (0.32)	-13.1 (0.78)
Butanoic acid	-7.3 (0.93)	1.6 (0.98)	-13.6 (0.83)	14.1 (0.70)
Isovaleric acid	-12.3 (0.74)	-7.4 (0.90)	-30.1 (0.70)	-10.8 (0.88)
Valeric acid	-29.5 (0.74)	-23.3 (0.77)	-33.7 (0.50)	-21.7 (0.70)
Hexanonic acid	-30.4 (0.24)	-55.5 (0.29)	-37.0 (0.50)	15.0 (0.47)
Phenol	-10.0 (0.63)	-4.0 (0.90)	-31.6 (0.40)	0.5 (0.98)
p-Cresol	49.6 (0.27)	-0.7 (0.99)	-58.2 (0.43)	13.5 (0.24)
Indole	-2.3 (0.97)	26.5 (0.49)	-0.6 (0.99)	4.0 (0.88)
Skatole	16.5 (0.73)	-8.8 (0.54)	-31.7 (0.53)	-21.2 (0.43)

DMDS = dimethyl disulfide; DEDS = diethyl disulfide.

Table S7. Mitigation of NH_3 with different UV wavelengths irradiating gaseous emissions inside #2 chamber. Air flow = 0.28 $m^3·s^{-1}$, inlet air temperature (influent of chamber #2) = 28 °C, inlet air RH = 67 %, outlet air temperature (inffluent of chamber #3) = 31 °C, outlet air RH = 61 %.

UV Wavelengths (nm)	UV dose (μJ·cm-2)	Light intensity (μW·cm-2)	Control (ppm)	Treatment (ppm)	% reduction (*p*-value)
185 + 254	0.03 μJ·cm-2	0.01	14.4 ± 1.1	14.4 ± 1.2	-0.4 (0.82)
222	2.55 μJ·cm-2	0.59	16.1 ± 0.8	16.4 ± 0.4	-2.2 (0.09)
254	1.60 μJ·cm-2	0.37	16.9 ± 0.4	17.0 ± 0.3	-0.8 (0.06)
367	1,775 μJ·cm-2	410	16.6 ± 0.3	16.6 ± 0.3	0.3 (0.70)

Table S8. Mitigation of H_2S with different UV wavelengths irradiating gaseous emissions inside #2 chamber. Air flow = 0.28 $m^3·s^{-1}$, inlet air temperature (influent of chamber #2) = 28 °C, inlet air RH = 67 %, outlet air temperature (inffluent of chamber #3) = 31 °C, outlet air RH = 61 %.

UV Wavelengths (nm)	UV dose (μJ·cm^{-2})	Light intensity (μW·cm^{-2})	Control (ppm)	Treatment (ppm)	% reduction (p-value)
185 + 254	0.03 μJ·cm^{-2}	0.01	1.5 ± 0.1	1.6 ± 0.2	-6.9 (0.82)
222	2.55 μJ·cm^{-2}	0.59	1.6 ± 0.2	1.6 ± 0.3	2.1 (0.70)
254	1.60 μJ·cm^{-2}	0.37	1.7 ± 0.1	1.7 ± 0.1	-2.2 (0.27)
367	1,775 μJ·cm^{-2}	410	16.6 ± 0.3	2.3 ± 0.2	1.0 (0.71)

Table S9. Performance of UV-A photocatalysis in mitigating CH_4 concentrations under different PM conditions. UV-A dose: 5.3 mJ·cm^{-2}, airflow = 0.28 m^3·s^{-1}.

Total PM concentration (mg·m^{-3})	UV dose (mJ·cm^{-2})	Control (ppb)	Treatment (ppb)	% reduction (p-value)
0.22	5.3	22.0 ± 2.6	21.6 ± 0.2	1.9 (0.82)
0.06	5.3	16.5 ± 3.0	15.5 ± 2.0	5.6 (0.78)
0.004	5.3	5.0 ± 0.2	5.2 ± 0.1	-4.2 (0.38)

Table S10. Performance of UV-A photocatalysis in mitigating CO_2 concentrations under different PM conditions. UV-A dose: 5.3 mJ·cm^{-2}, airflow = 0.28 m^3·s^{-1}. Bold signifies statistical significance.

Total PM concentration (mg·m^{-3})	UV dose (mJ·cm^{-2})	Control (ppb)	Treatment (ppb)	% reduction (p-value)
0.22	5.3	967 ± 127	1036 ± 21	-7.2 (0.50)
0.06	5.3	**705 ± 33**	**789 ± 27**	**-11.9 (0.02)**
0.004	5.3	1201 ± 296	1483 ± 91	-26.5 (0.15)

Table S11. Performance of UV-A photocatalysis in mitigating NH_3 concentrations under different PM conditions. UV-A dose: 5.3 mJ·cm^{-2}, airflow = 0.28 m^3·s^{-1}. Bold signifies statistical significance.

Total PM concentration (mg·m^{-3})	UV dose (mJ·cm^{-2})	Control (ppm)	Treatment (ppm)	% reduction (p-value)
0.22	5.3	28.5 ± 0.3	28.4 ± 0.3	0.3 (0.67)
0.06	5.3	18.2 ± 0.6	18.3 ± 0.9	-0.4 (0.75
0.004	5.3	15.0 ± 0.4	14.8 ± 0.3	1.9 (0.12)

Figure S2. Picture of mobile laboratory arrangement outside swine farm.

Figure S3. Picture of connecting the exhaust fan, T duct and filtration unit using the flexible duct. The flexible duct is insulated and plastic-wrapped to protect from punctures and weather.

Figure S4. Picture of connecting filtration unit and the mobile laboratory using the flexible duct.

Figure S5. Picture of the chamber with photocatalysis panels and UV-A LED lamps attached inside the mobile laboratory.

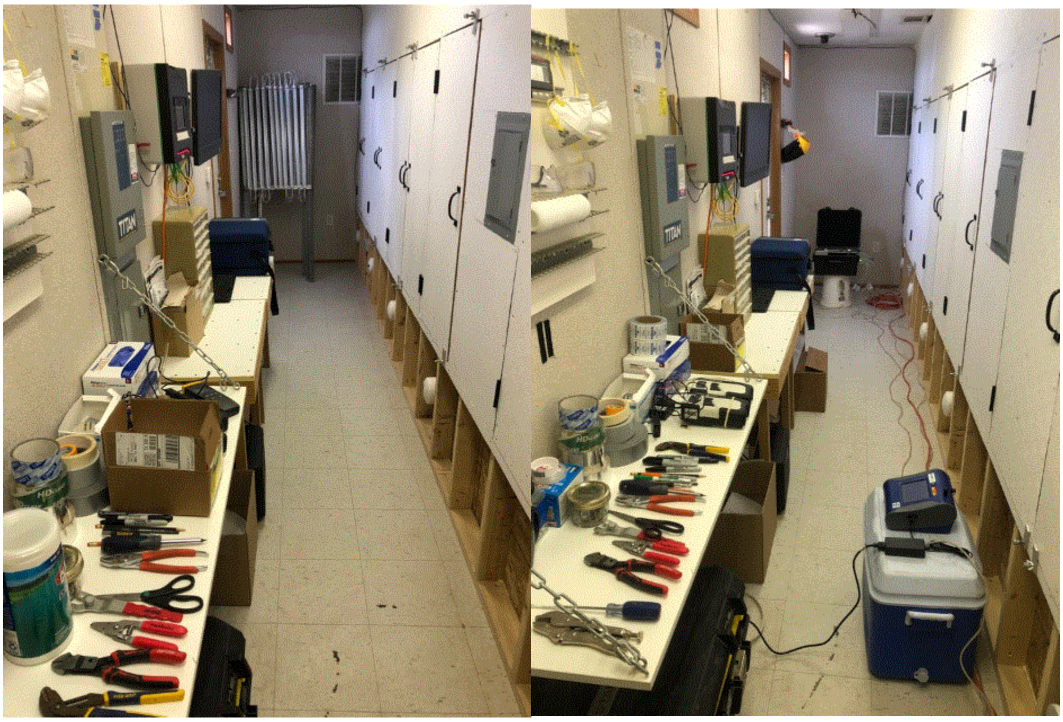

Figure S6. Picture of inside view in the mobile laboratory. (a) Before installing the portable lamp holder (seen in the far back) and (b) during measurements of targeted gases.

Figure S7. Picture of inside the filtration unit with the MERV filters removed to show more details. Black dots on the floor are flies on the inlet side.

Figure S8. Picture of the sampling of formaldehyde concentration with colorimetric tube and the Gastec pump kit.

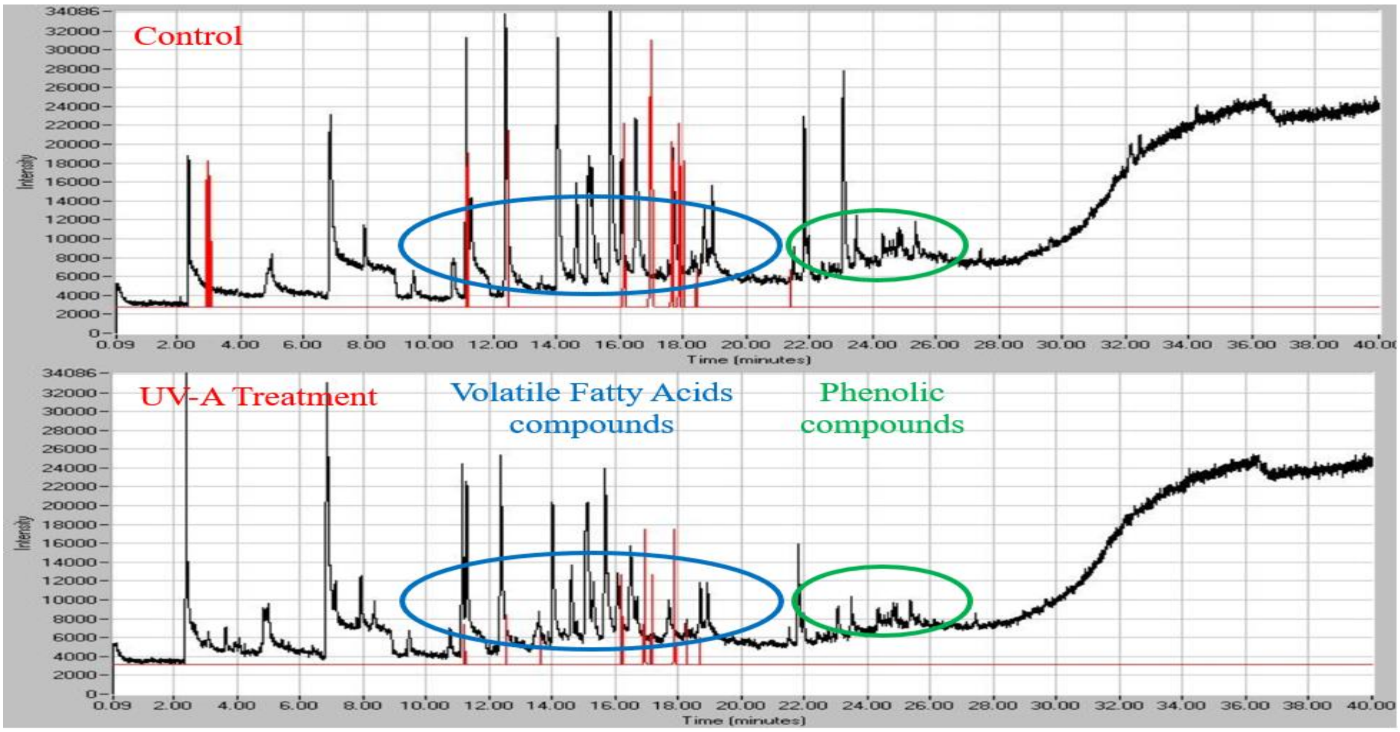

Figure S9. An overlay of the chromatogram (black line) and aromagram (red line) for panelist 2. The height of aromagram peaks represents measured odor intensity (percent relative scale). The TIC signal is collected simultaneously, enabling linking odors to specific chemicals. Several unpleasant (out of 31 total) odors were recorded during analysis with GC-MS-Olfactometry, and few of them were medium-to-strong intensity.

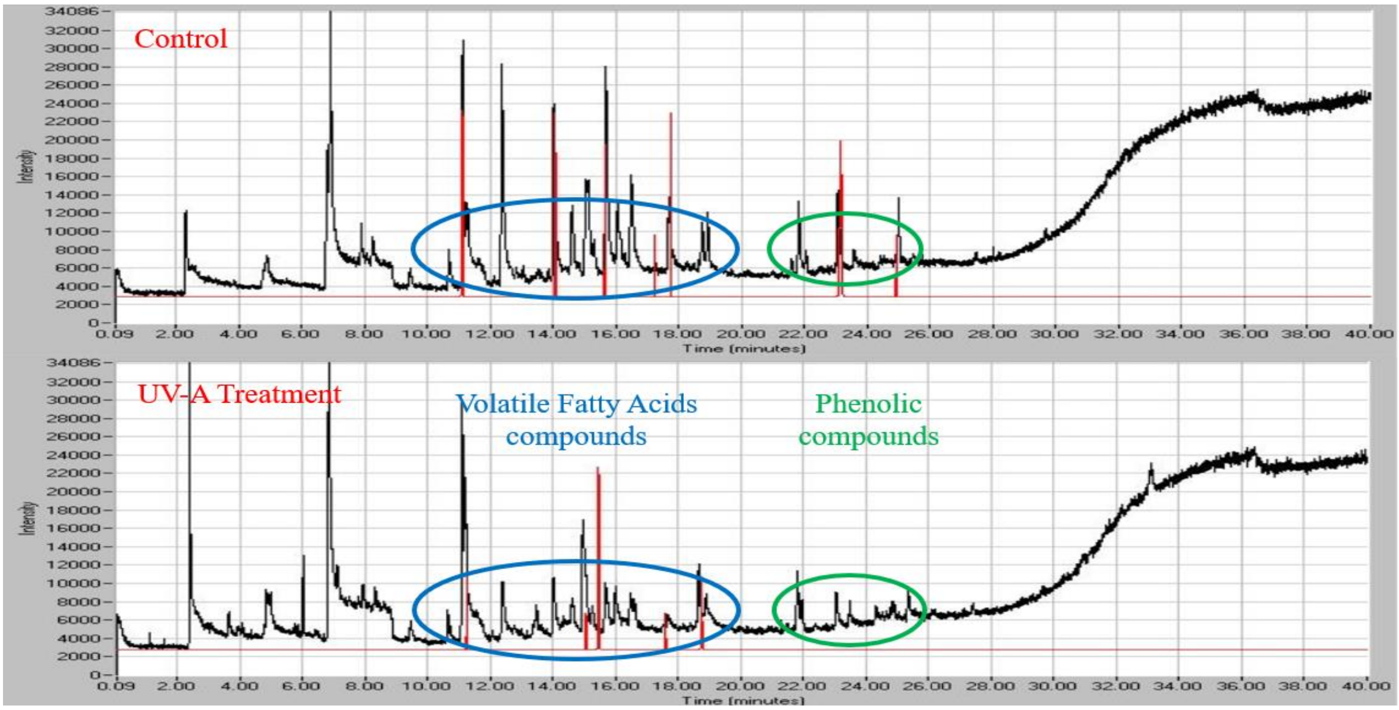

Figure S10. An overlay of the chromatogram (black line) and aromagram (red line) for panelist 3. The height of aromagram peaks represents measured odor intensity (percent relative scale). The TIC signal is collected simultaneously, enabling linking odors to specific chemicals. Several unpleasant (out of 31 total) odors were recorded during analysis with GC-MS-O, and few of them were medium-to-strong intensity.