

Supplementary Material

Mitigation of Particulate Matter and Airborne Pathogens in Swine Barn Emissions with Filtration and UV-A Photocatalysis

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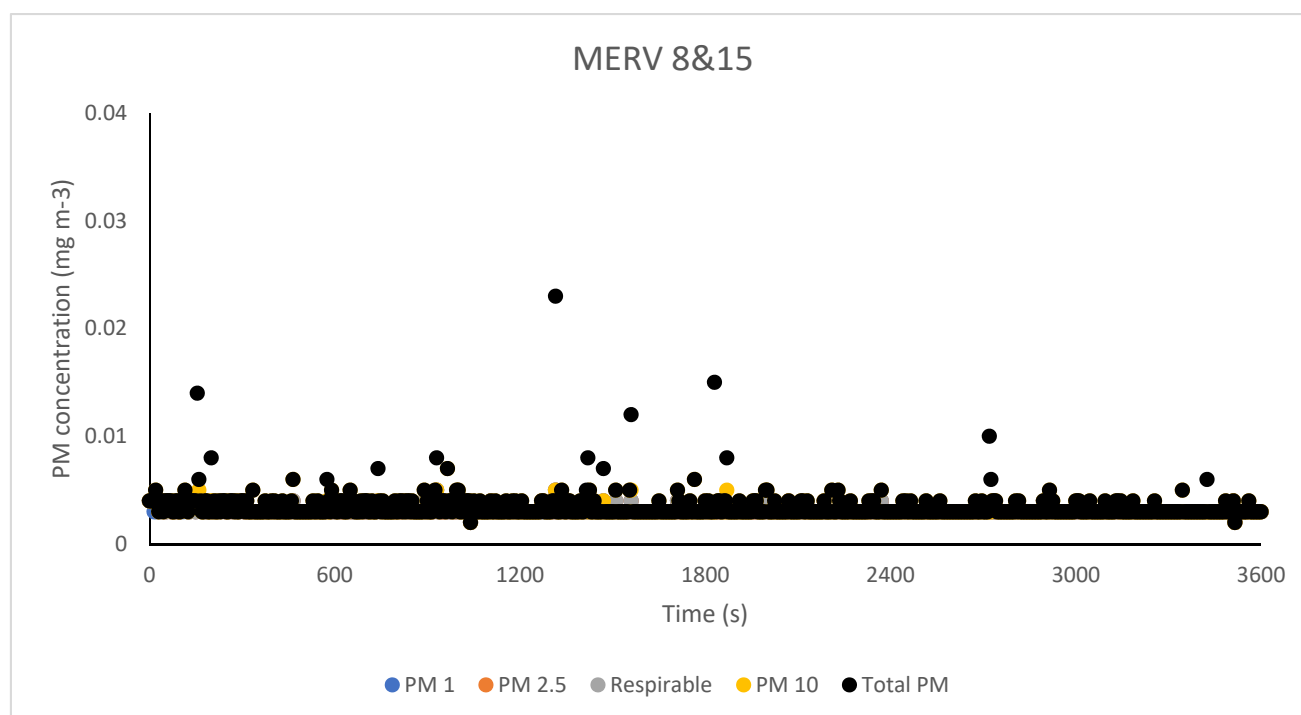
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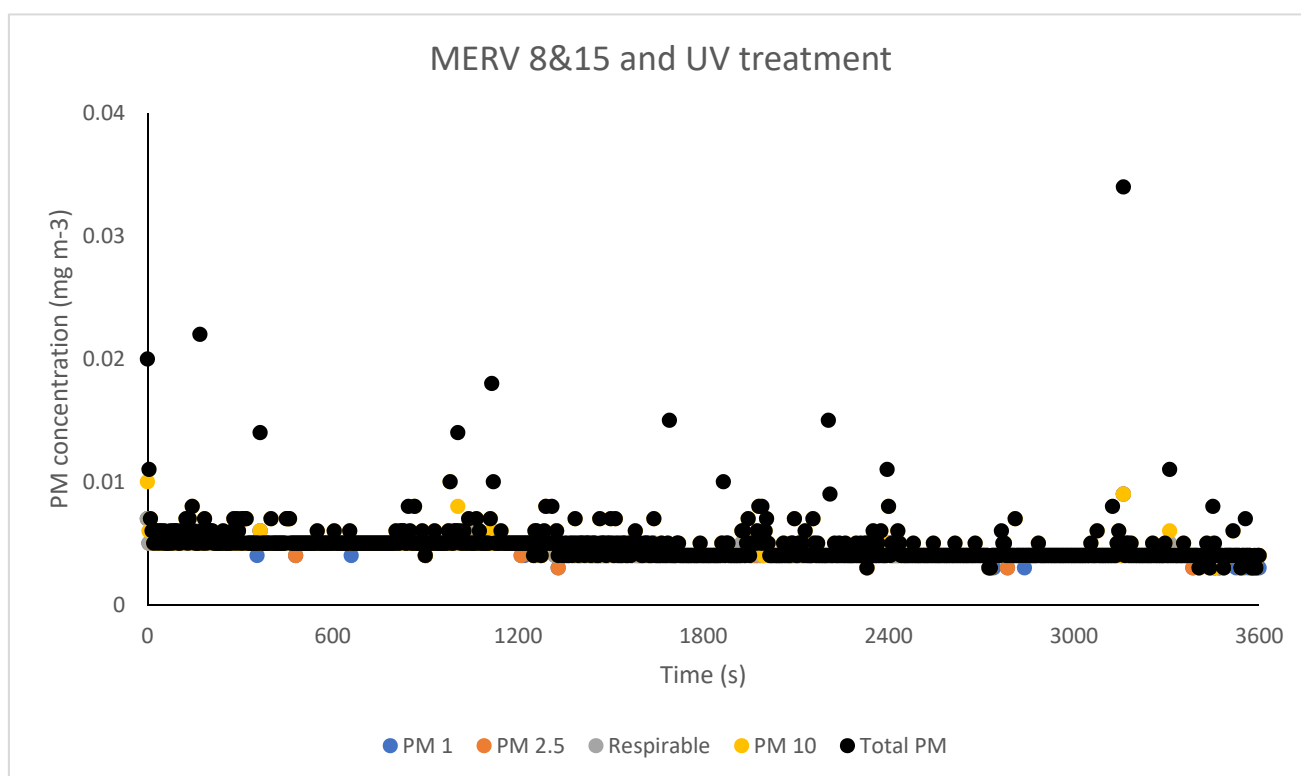
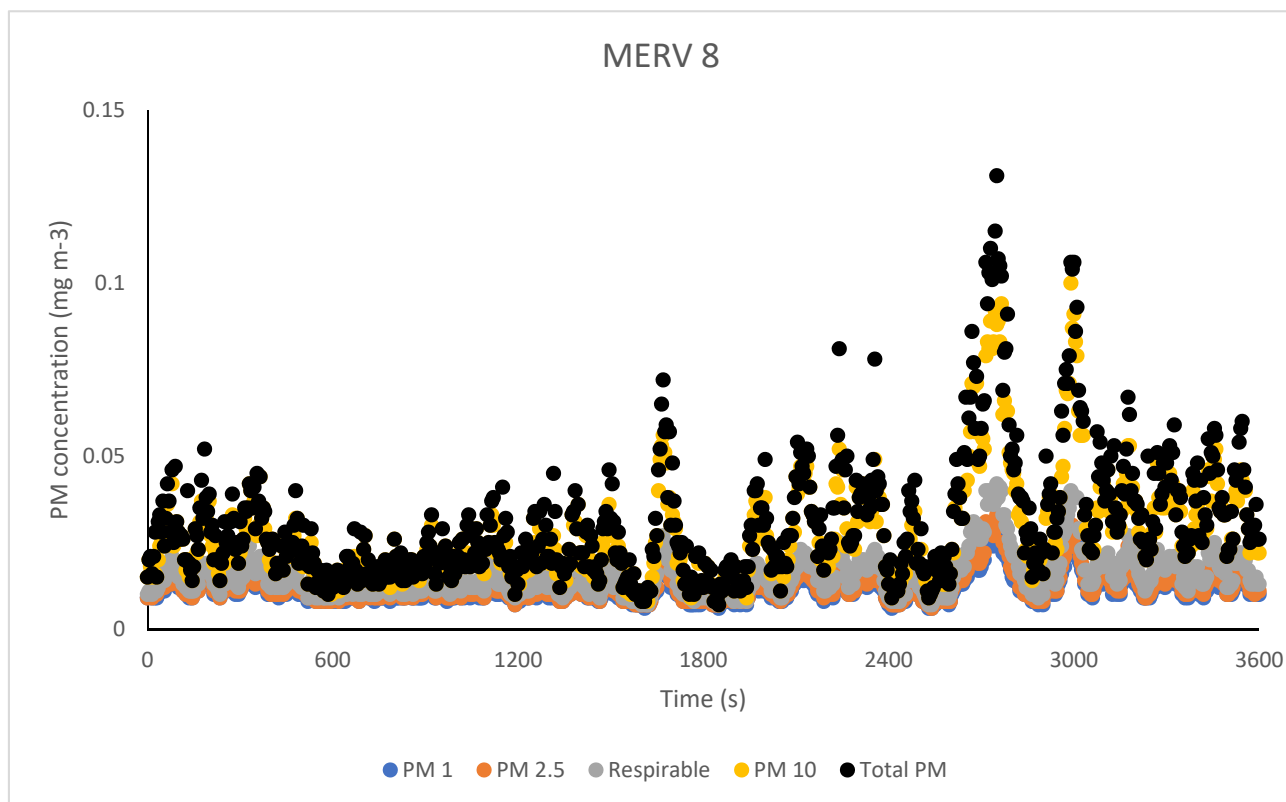


Figure S1. Real-time measured PM concentration during 1 h air sampling (the 'best-case' scenario, MERV 8 & 15 filtration and UV-A treatment).



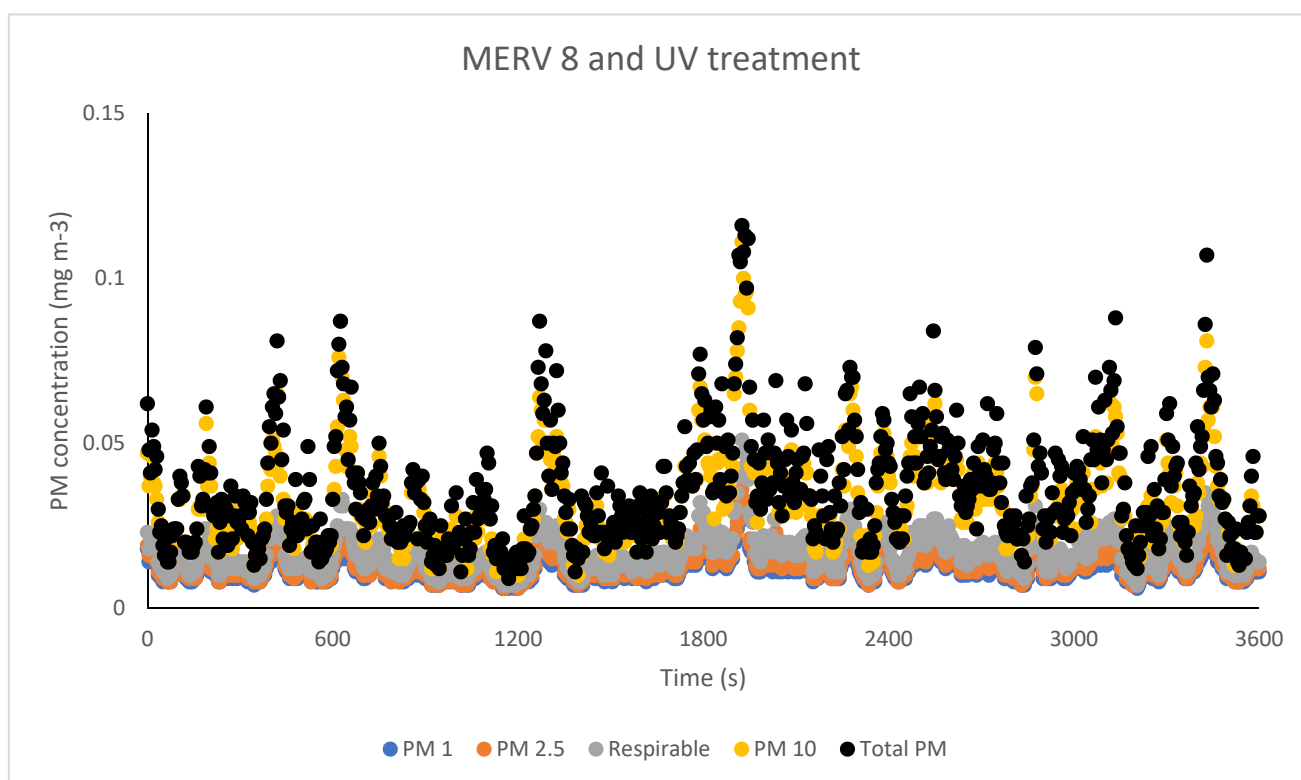
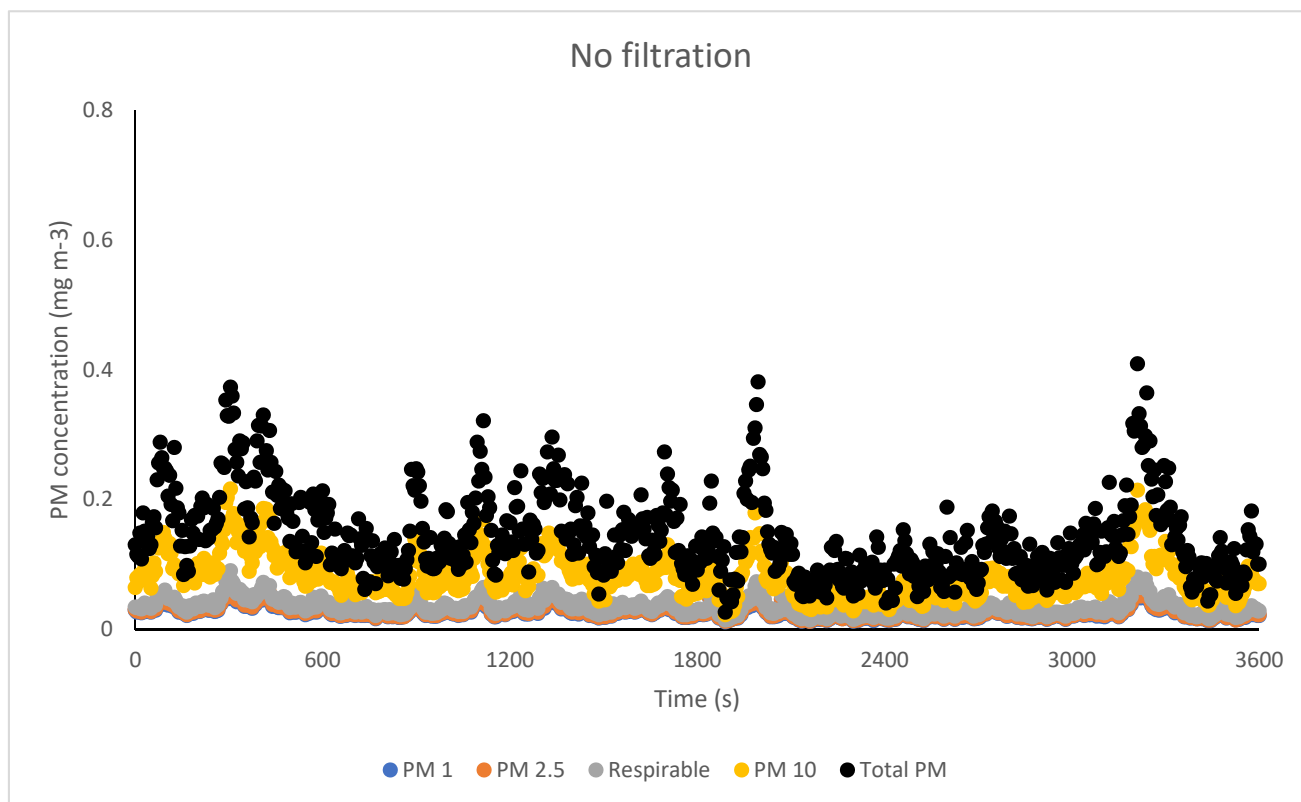


Figure S2. Real-time measured PM concentration during 1 h air sampling (the '*midpoint*' scenario, MERV 8 only, and UV-A treatment).



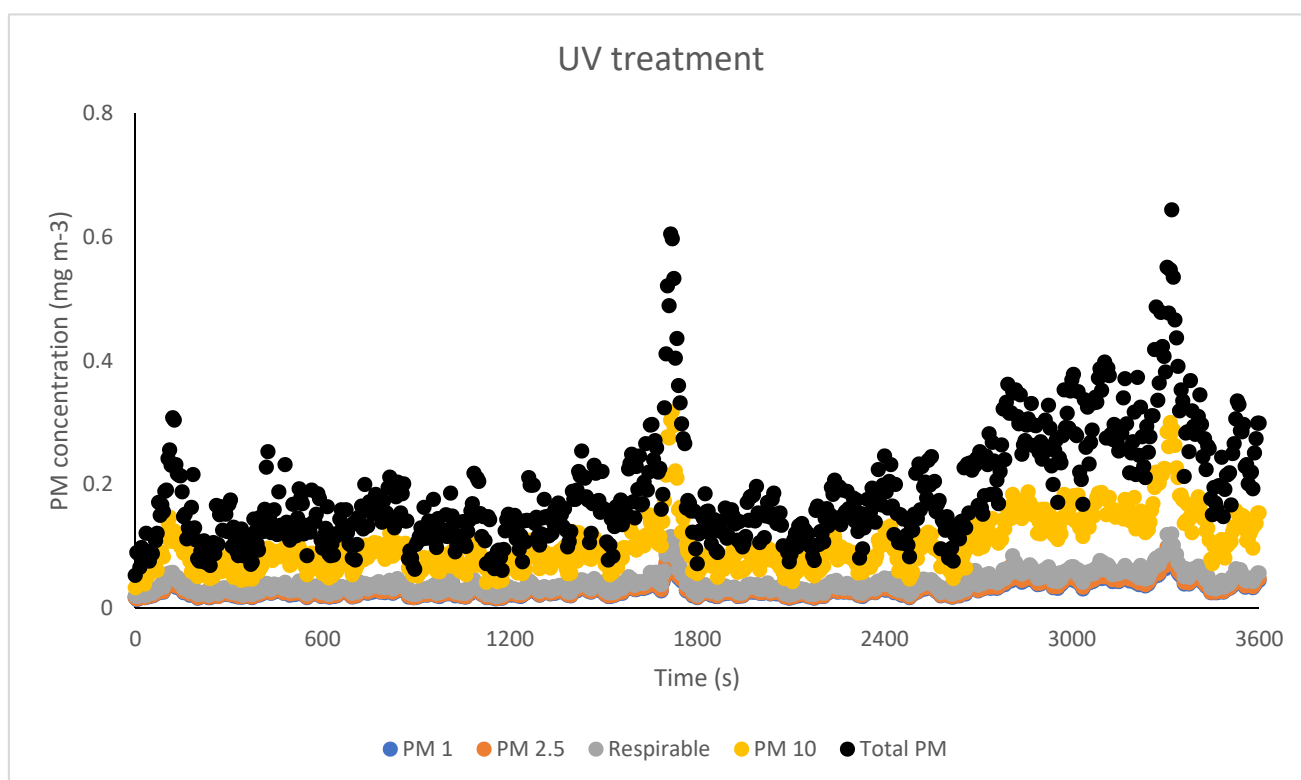


Figure S3. Real-time measured PM concentration during 1 h air sampling (the '*worst-case*' scenario, no filtration and UV-A treatment).

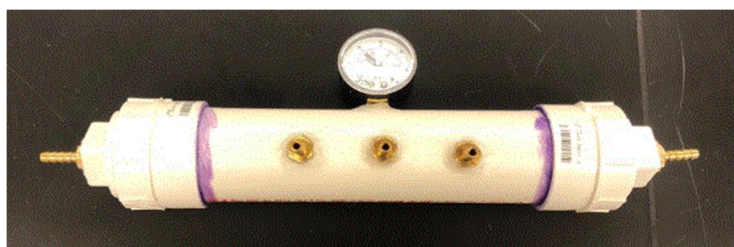


Figure S4. Manifold with a pressure gauge to facilitate the simultaneous collection of three samples of airborne pathogens.

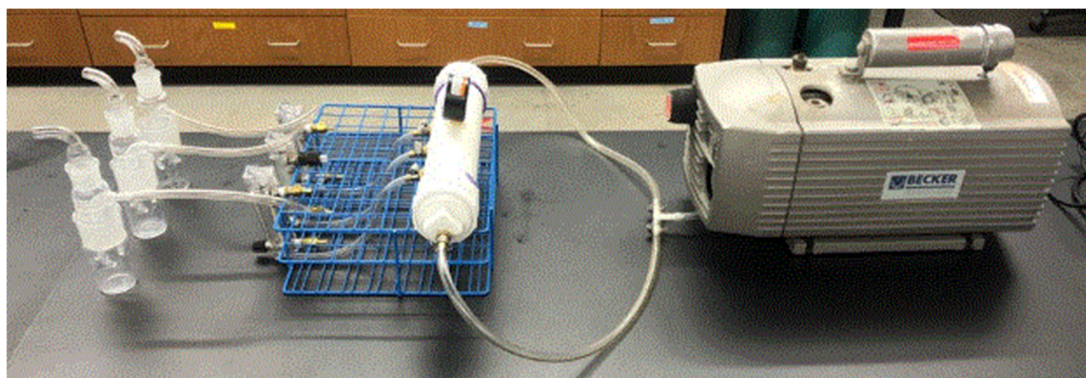


Figure S5. Pathogen sampling system with three impingers, airflow meters, manifold with pressure gauge, and vacuum pump.

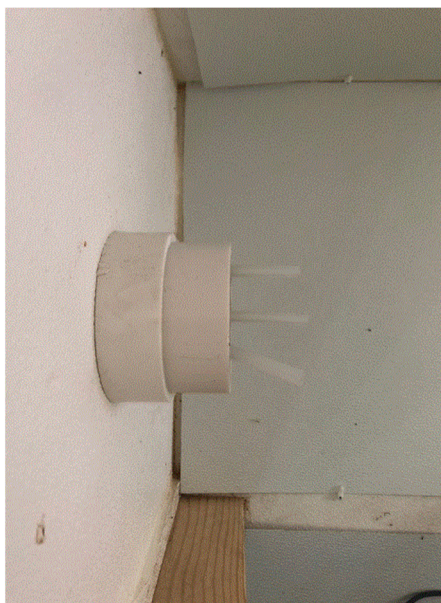


Figure S6. Sampling tube inlets on the UV-A treatment side of sampling ports inside the mobile lab.



Figure S7. Effects of the antifoaming agent addition into impinger solution. Foam formation during sampling (Left); No foam formed when Antifoam A added (Right). Impingers were held in an ice bath during air sampling.

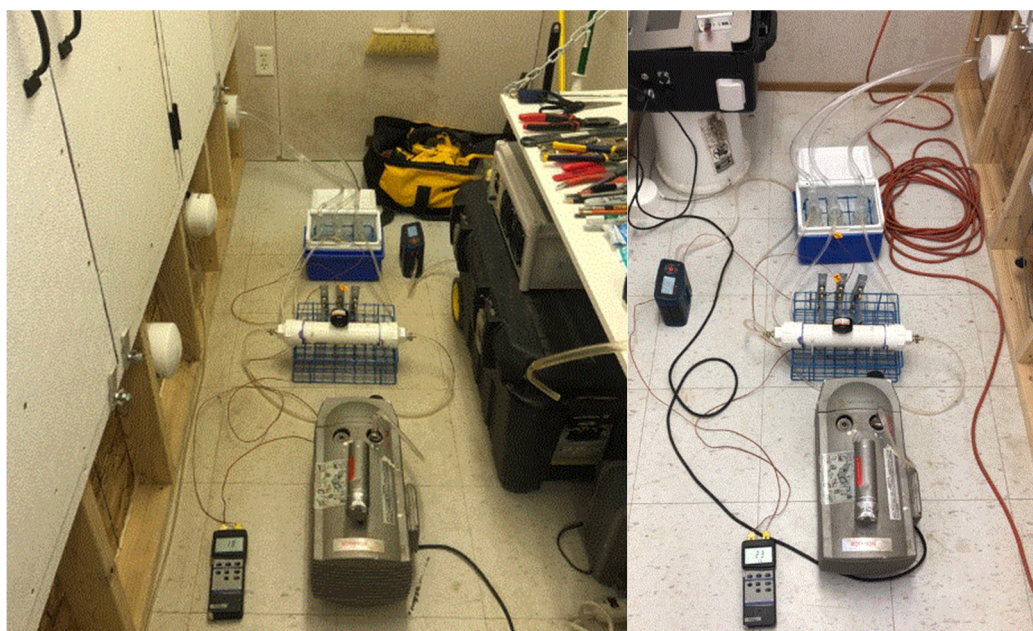


Figure S8. Airborne pathogen sampling system. (Left) Air inlet to the UV mobile lab (downstream from the MERV filtration unit); (Right) air outlet after UV treatment.

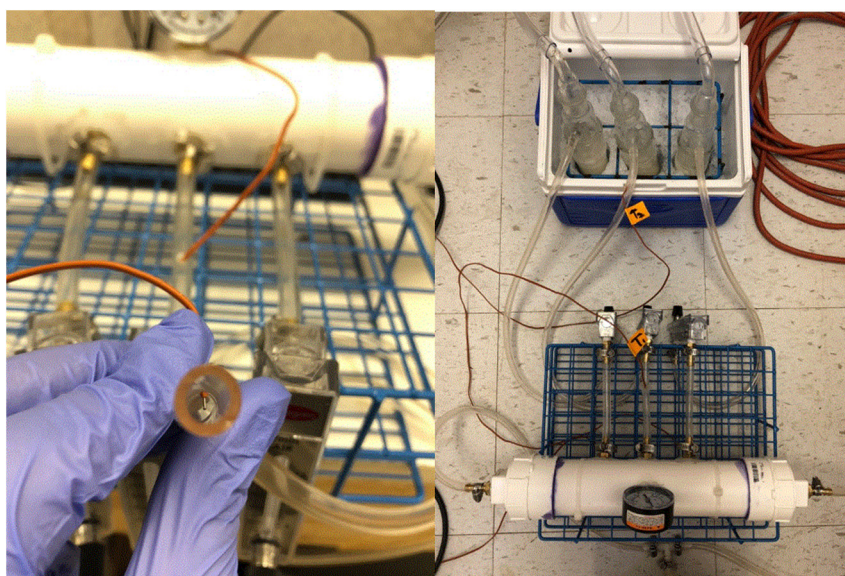


Figure S9. Air sample temperature monitoring. (Left) thermocouple tip and seal; (Right) thermocouples installed immediately downstream from the impinger and after airflow monitor (rotameter).



Figure S10. Mobile laboratory for UV and filtration treatment deployed for testing mitigation of gaseous emissions at a swine farm.



Figure S11. Arrangement of 55 UV-A LED lamps installed in one of the chambers inside the mobile laboratory to treat emissions from the swine barn.



Figure S12. Pathogen sampling system before the MERV filtration unit samples raw exhaust from swine barn fan.

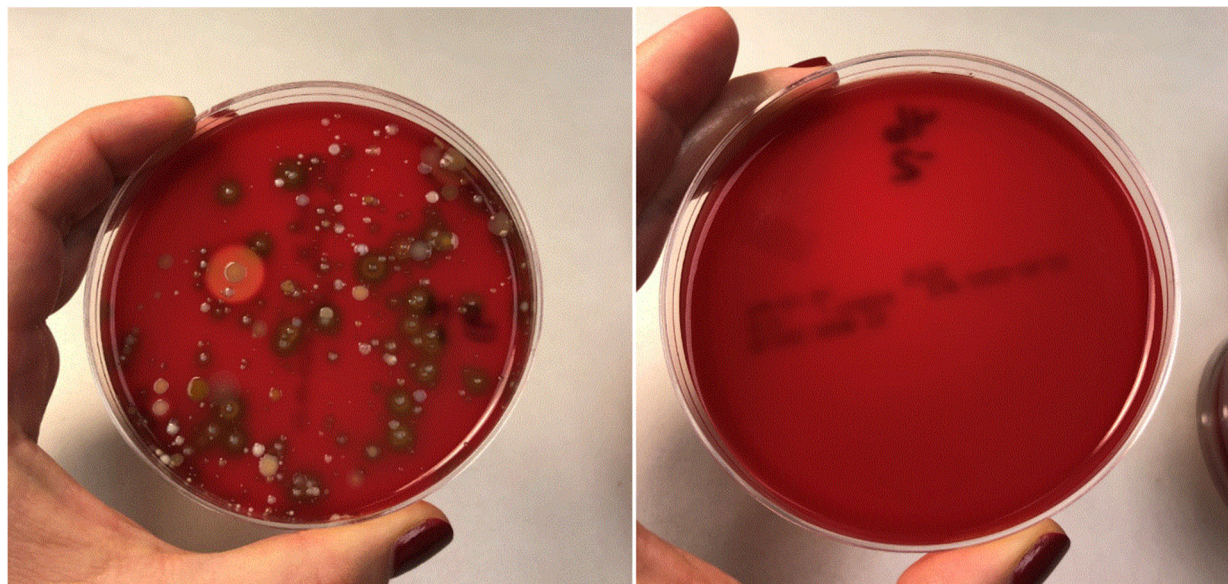


Figure S13. Colony-forming in the culture medium after sampling for 60 min. (Left: before MERV filtration, Right: after MERV 8 and 15 filtration).

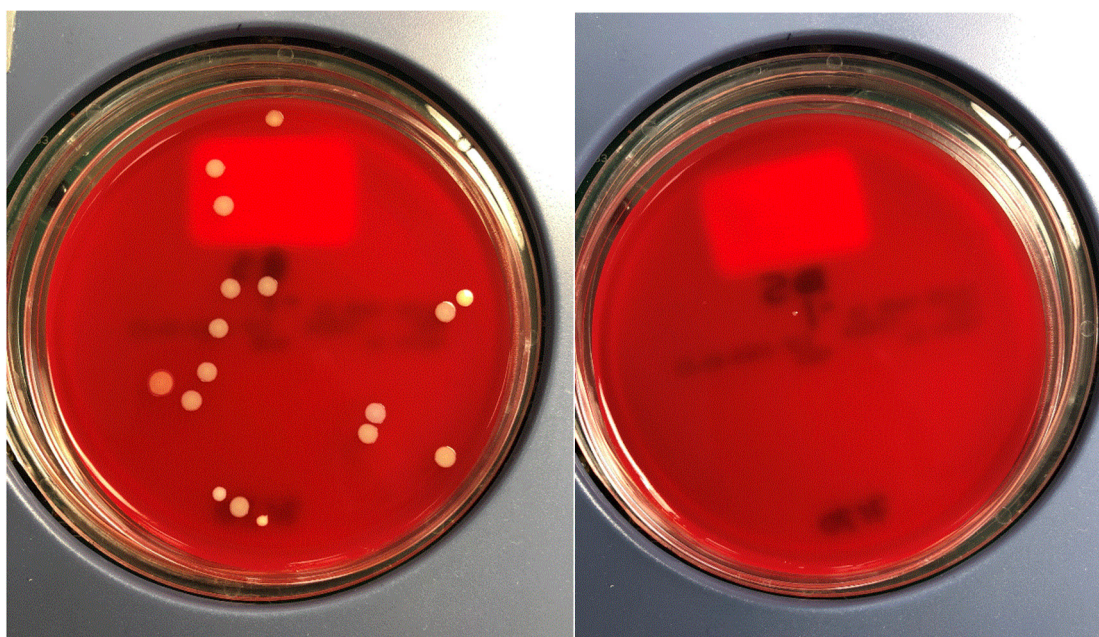


Figure S14. Colony-forming in the culture medium after sampling for 60 min. (Left: after MERV 8 filtration, Right: after UV treatment).



Figure S15. Sterilization of impingers, air sampling tubing, and the impinger-tube connectors prepared for autoclaving.



Figure S16. Dust accumulated inside the inlet port to impinger after sample collection of raw swine barn exhaust and before MERV filtration unit. Dust is the potential carrier of airborne pathogens.

Table S1. Summary of average PM concentration.

| Sampling date (2020) | | Control | | | | | Treatment | | | | |
|-------------------------|---------|--------------------|--------------------|---------------------------------|--------------------|--------------------|--------------------|--------------------|---------------------------------|--------------------|--------------------|
| | | Total PM | PM 10 | Respirable (PM 4 - PM 10) | PM 2.5 | PM 1 | Total PM | PM 10 | Respirable (PM 4 - PM 10) | PM 2.5 | PM 1 |
| MERV 8&15 | Aug. 13 | 0.00339 ±0.0014 | 0.0033 ±0.0008 | 0.00311 ±0.0004 | 0.00309 ±0.0003 | 0.00301 ±0.0003 | 0.00479 ±0.0022 | 0.0047 ±0.0007 | 0.0045 ±0.0006 | 0.0046 ±0.0006 | 0.00431 ±0.0006 |
| | Sep. 8 | 0.00342 ±0.0012 | 0.0033 ±0.0006 | 0.00314 ±0.0004 | 0.00309 ±0.0003 | 0.00307 ±0.0003 | 0.00493 ±0.0019 | 0.00471 ±0.0009 | 0.00446 ±0.0006 | 0.0044 ±0.0006 | 0.00438 ±0.0006 |
| MERV 8 | Sep. 9 | 0.0306 ±0.0182 | 0.02695 ±0.0147 | 0.01502 ±0.0059 | 0.01236 ±0.0043 | 0.01154 ±0.0038 | 0.03596 ±0.0173 | 0.03138 ±0.0144 | 0.01651 ±0.0060 | 0.01303 ±0.0042 | 0.01197 ±0.037 |
| No filtration | Sep. 10 | 0.1442 ±0.0592 | 0.0843 ±0.0411 | 0.03612 ±0.0318 | 0.02711 ±0.0091 | 0.02584 ±0.0247 | 0.191 ±0.0708 | 0.1012 ±0.05354 | 0.0404 ±0.0224 | 0.03488 ±0.0116 | 0.03119 ±0.0209 |
| | Sep. 17 | 0.14227 ±0.0647 | 0.08022 ±0.0328 | 0.03359 ±0.0120 | 0.02832 ±0.0100 | 0.02688 ±0.0095 | 0.18724 ±0.0908 | 0.10061 ±0.0444 | 0.0403 ±0.0161 | 0.03383 ±0.0134 | 0.03209 ±0.0127 |

Table S2. Mitigation of the airborne bacteria under the UV-A photocatalysis with MERV 8 & 15 filtration.

| | Inlet air with filtered out particle matter | | | Outlet air after UV-A treatment | | |
|--|--|-------------------------|------|------------------------------------|------|-------------------------|
| Total CFU·mL ⁻¹ (as measured in the impinger media of 20 mL) | 1.2 ×10 ² | 3.0 ×10 ¹ | 0 | 0 | 0 | 1.0 ×10 ¹ |
| Total CFU | 2.4 ×10 ³ | 6.0 ×10 ² | 0 | 0 | 0 | 2.0 ×10 ² |
| Sampling time (min) | 60 | | | | | |
| Air temperature (°C) | 13.2 | | | 17.3 | | |
| RH (in front of impinger, %) | 68.6 | | | 64.1 | | |
| Pressure (inside the manifold, psi) | 450 | | | 450 | | |
| Airflow rate by rotameter (L·min ⁻¹) | 20 | 20 | 20 | 20 | 20 | 20 |
| Sampling rate of air by each impinger (Q_{st} , L·min ⁻¹ , NTP ^a) | 12.1 | 12.1 | 12.1 | 12.0 | 12.0 | 12.0 |
| Total volume of air sampled (m ³ , NTP ^a) | 0.73 | 0.73 | 0.73 | 0.72 | 0.72 | 0.72 |
| Total CFU·m ⁻³ in air (CFU_D , NTP ^a) | 3,300 | 825 | 0 | 0 | 0 | 279 |
| Average total PM concentration during bioaerosol sampling (mg·m ⁻³) | 0.0034 | | | 0.0049 | | |
| Total CFU _D /average total PM (CFU_{PM} , CFU·µg ⁻¹) | 964 | 241 | 0.0 | 0.0 | 0.0 | 56.6 |
| Average total CFU _D /average PM in exhaust air (CFU·µg ⁻¹ , n=3, mean ± st.dev.) | 402 ± 502 | | | 18.9 ± 32.6 | | |
| % reduction of CFU _{PM} (% R) | 95.3 | | | | | |
| p-Value | 0.33 | | | | | |

Note: ^a Normal temperature and pressure is defined as air at 20 °C and 1 atm.

Table S3. Mitigation of the airborne bacteria under the UV-A photocatalysis with MERV 8 filtration. **Bold** font signifies statistical significance.

| | Inlet air with filtered out particle matter | | | Outlet air after UV-A treatment | | |
|--|--|-------------------------|-------------------------|------------------------------------|-------------------------|-------------------------|
| Total CFU·mL ⁻¹ (as measured in the impinger media of 20 mL) | 3.4 ×10 ² | 3.6 ×10 ² | 4.9 ×10 ² | 2.5 ×10 ² | 2.5 ×10 ² | 2.9 ×10 ² |
| Total CFU | 6.8 ×10 ³ | 7.2 ×10 ³ | 9.8 ×10 ³ | 5.0 ×10 ³ | 5.0 ×10 ³ | 5.8 ×10 ³ |
| Sampling time (min) | 60 | | | | | |
| Air temperature (°C) | 9.8 | | | 13.4 | | |
| RH (in front of impinger, %) | 93.8 | | | 80.2 | | |
| Pressure (inside the manifold, psi) | 450 | | | 450 | | |
| Airflow rate by rotameter (L·min ⁻¹) | 20 | 20 | 20 | 20 | 20 | 20 |
| Sampling rate of air by each impinger (Q_{st} , L·min ⁻¹ , NTP ^a) | 12.3 | 12.3 | 12.3 | 12.1 | 12.1 | 12.1 |
| Total volume of air sampled (m ³ , NTP ^a) | 0.74 | 0.74 | 0.74 | 0.73 | 0.73 | 0.73 |
| Total CFU·m ⁻³ of exhaust air (CFU_D , NTP ^a) | 9,240 | 9,780 | 13,300 | 6,880 | 6,880 | 7,980 |
| Average total PM of exhaust air during bioaerosol sampling (mg·m ⁻³) | 0.0306 | | | 0.0359 | | |
| Total CFU _D /average Total PM (CFU_{PM} , CFU·µg ⁻¹) | 302 | 320 | 435 | 192 | 192 | 222 |
| Mean Total CFU _D /average PM in exhaust air (CFU·µg ⁻¹ , n=3, mean ± st.dev.) | 352±72.3 | | | 202±17.7 | | |
| % reduction of CFU _{PM} (% <i>R</i>) | 42.7 | | | | | |
| <i>p</i> -Value | 0.04 | | | | | |

Note: ^a Normal temperature and pressure is defined as air at 20 °C and 1 atm.

Table S4. Mitigation of the airborne bacteria under the UV-A photocatalysis without MERV filtration.

| | Inlet air with particle matter | | | Outlet air after UV-A treatment | | |
|---|--------------------------------|--------------------------|--------------------------|---------------------------------|--------------------------|--------------------------|
| Total CFU·mL ⁻¹ (as measured in the impinger media of 20 mL) | 3.2 ×10 ³ | 1.38 ×10 ³ | 8.4 ×10 ² | 1.16 ×10 ³ | 1.26 ×10 ³ | 7.8 ×10 ² |
| Total CFU | 6.4 ×10 ⁴ | 2.76 ×10 ⁴ | 1.68 ×10 ⁴ | 2.32 ×10 ⁴ | 2.52 ×10 ⁴ | 1.56 ×10 ⁴ |
| Sampling time (min) | 60 | | | | | |
| Air temperature (°C) | 15.2 | | | 18.9 | | |
| RH (in front of impinger, %) | 51.6 | | | 45.8 | | |
| Pressure (inside the manifold, psi) | 450 | | | 450 | | |
| Airflow rate by rotameter (L·min ⁻¹) | 20 | 20 | 20 | 20 | 20 | 20 |
| Sampling rate of air by each impinger (Q_{st} , L·min ⁻¹ , NTP ^a) | 12.0 | 12.0 | 12.0 | 11.9 | 11.9 | 11.9 |
| Total volume of air sampled (m ³ , NTP ^a) | 0.72 | 0.72 | 0.72 | 0.71 | 0.71 | 0.71 |
| Total CFU·m ⁻³ of exhaust air (CFU_D , NTP ^a) | 88,600 | 38,210 | 23,260 | 32,530 | 35,330 | 21,870 |
| Average total PM of exhaust air during bioaerosol sampling (mg·m ⁻³) | 0.142 | | | 0.187 | | |
| Total CFU _D /average Total PM (CFU_{PM} , CFU·μg ⁻¹) | 623 | 269 | 163 | 174 | 189 | 117 |
| Mean Total CFU _D /average PM in exhaust air (CFU·μg ⁻¹ , n=3, mean ± st.dev.) | 352±241 | | | 160±38 | | |
| % reduction of CFU _{PM} (% R) | | | | 54.6 | | |
| p-Value | | | | 0.28 | | |

Note: ^a Normal temperature and pressure is defined as air at 20 °C and 1 atm.