The Decontamination Effluent Treatment System (DETS): Mass Personnel Decontamination, Road Testing, and Integration

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Engineer Research and Development Center (ERDC)

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Laboratories
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Environmental Engineering Branch

• Integrate science, engineering, and technology to solve environmental problems,
• Research and develop bench, pilot, and full-scale field systems, and
• Promote understanding through technology transfer.
The Problem

- The Army has no capability to treat and/or recycle the effluent from its aqueous based chemical, biological, radiological and nuclear (CBRN) decontamination operations. This effluent is still very hazardous and a major handling, logistical, and potentially a political burden.
The Solution: The Decontamination Effluent Treatment System (DETS)
DETS Treatment Strategy

- Settling Tank
- Sand Filter
- IX Resin
- GAC
- RO Membranes

- Sediment
- Particulates
- Hardness
- Surfactants
- Bleach
- Oils/Greases/Miscellaneous
- Chemical warfare agents
- Radioisotopes (e.g. Cesium-137)
Process control and power supply

- Kubota Diesel 9875 240 V, 40 amp Watt Generator
  - 60 gallon subbase fuel tank and a two-wire auto start control.
  - Sound enclosure keeps noise at 68 dB(A) at 7 m (23 ft), which is helpful for communications.
  - The system is also designed to be suitable for operation of sensitive electronic equipment.
  - Fuel consumption varies from 0.41 to 0.84 gal/hr.
  - The system can also simply be plugged into a 240 V, 60 Hz, single phase, 40 amp source.

- Control architecture: EZAutomation EZ-Touch HMI/PLC
  - Customizable and programmable interface with ladder logic control
  - Data recording
  - Modular I/O
  - Pressure sensitive touch screen – compatible with heavy gloves
Table to the left summarizes costs of elements of the system

The equipment costs were less than $60,000

Keeping costs low allows for a unit to be disposed of in its entirety if it gets highly contaminated during treatment

Enhancement of monitoring equipment is the greatest estimated additional cost

<table>
<thead>
<tr>
<th>Unit</th>
<th>Cost</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse osmosis unit with pump and prefilter</td>
<td>$13,621.44</td>
<td>Price is for all the units described</td>
</tr>
<tr>
<td>Cleaning units for scale and organics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand filter media unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon filter media unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water softener media unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultraviolet sterilization unit (not used in these studies)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kubota Generator</td>
<td>$9,922.45</td>
<td></td>
</tr>
<tr>
<td>Bredel pumps with mounting equipment and hoses</td>
<td>$13,283.09</td>
<td>We purchased 2, but only 1 was used. Cost is for 1 unit.</td>
</tr>
<tr>
<td>Flanges</td>
<td>$1,066.00</td>
<td></td>
</tr>
<tr>
<td>Hose reels</td>
<td>$8,939.92</td>
<td></td>
</tr>
<tr>
<td>Trailer</td>
<td>$5,000.00</td>
<td></td>
</tr>
<tr>
<td>Trailer upgrades</td>
<td>$1,000.00</td>
<td>We determined upgrades were needed after the initial demonstration</td>
</tr>
<tr>
<td>EZ Touch Control units with associated software</td>
<td>$1,800.00</td>
<td></td>
</tr>
<tr>
<td>Pressure gauges</td>
<td>$1,000.00</td>
<td>Estimated</td>
</tr>
<tr>
<td>Wiring</td>
<td>$500.00</td>
<td>Estimated</td>
</tr>
<tr>
<td>Total</td>
<td>$56,632.90</td>
<td></td>
</tr>
</tbody>
</table>
Alpha Version of Mobile Treatment System

Our system treated a simulated effluent with soap, bleach, clay and cesium. The removal was >99 percent of each constituent.

Our pilot reactor capable of treating aqueous effluent from decontamination of 200 people and 10 large vehicles per day for 3 to 5 days.

Flow Rate
- Battalion Sized Event
- Adapted from planning factors of operational DECON (Army G3/5/7 Decontamination Planning factors)
- 10 gpm
ERDC Demonstration: Simulated Decontamination

Details
- 27 June 2017
- 6 hours of total activity
- DETS operation 2 hours
- 10 large military vehicles & 20 cars, trucks, minivans were washed with soapy water & rinsed.
- 1200 gallons collected and spiked with Malathion, cesium, and bleach.
- Observers from JPM-P, Army MSCoE, JPdM A&RS, ECBC, DTRA, & USEPA

Wash Water

Pressure Wash
Sponge Wash
Rinse

Decon Effluent

DETS Pilot System (Trailer Mounted)

Clean Water

Discharge and/or Reuse
All measurements indicate that the DETS is highly effective at treating constituents found in decontamination wash water (98% removal or greater).

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Analytical Method</th>
<th>Influent Concentration (mg/L)</th>
<th>Effluent Concentration (mg/L)</th>
<th>Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>Summation of Ca\textsuperscript{2+} and Mg\textsuperscript{2+} concentrations as measured by ion chromatography</td>
<td>82.36 ± 40.79</td>
<td>0</td>
<td>100.0%</td>
</tr>
<tr>
<td>Total Chlorine</td>
<td>Standard Method 4500-Cl G</td>
<td>0.26 ± 0.07</td>
<td>0</td>
<td>100.0%</td>
</tr>
<tr>
<td>Surfactants</td>
<td>Spectrophotometric method as given in Kloos (2015)</td>
<td>1.422 ± 0.359</td>
<td>0.019 ± 0.017</td>
<td>98.7%</td>
</tr>
<tr>
<td>Total Organic Carbon</td>
<td>USEPA 5310B</td>
<td>58.23 ± 29.7</td>
<td>1.18 ± 0.84</td>
<td>98.0%</td>
</tr>
<tr>
<td>Malathion</td>
<td>Phosphorus balance</td>
<td>26.71 ± 12.16</td>
<td>0.08 ± 0.05</td>
<td>99.7%</td>
</tr>
<tr>
<td>Malathion</td>
<td>USEPA 8141A</td>
<td>24.7</td>
<td>0.000097</td>
<td>100.0%</td>
</tr>
<tr>
<td>Cesium</td>
<td>USEPA 6020A</td>
<td>2.97 ± 4.21</td>
<td>0</td>
<td>100.0%</td>
</tr>
<tr>
<td>Turbidity</td>
<td>USEPA Method 180.1</td>
<td>&gt;4200 (NTU)</td>
<td>1.825 ± 1.145</td>
<td>100.0%</td>
</tr>
</tbody>
</table>
Mass Personnel Decontamination Field Evaluation

Details
• 24 May 2018
• DETS operation 2.5 hours at 12 gpm
• 1800 gallons collected and spiked with Malathion, cesium, surfactants, and sediment/ash.

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Target Concentration (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malathion</td>
<td>1</td>
</tr>
<tr>
<td>Cesium (CsCl)</td>
<td>5</td>
</tr>
<tr>
<td>Surfactants</td>
<td>20</td>
</tr>
<tr>
<td>Sediment</td>
<td>5</td>
</tr>
<tr>
<td>Ash</td>
<td>6</td>
</tr>
</tbody>
</table>
Mass Personnel Decontamination Field Evaluation: Results

Treatment of target constituents exceeded 99.8%

Pretreatment step (i.e., sand/GAC filtration) removed >97% of contaminants

RO proved to be an effective polishing step for surfactant and cesium removal
LA National Guard Demonstration

- 10 January 2019
- Integrate DETS into National Guard CBRNE Enhanced Response Force Package (CERFP)

![Schematic of water flow in current CERFP shower system](image)

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Future Work: Adapting DETS to PETS for PFAS
Pilot System Construction and Application

- Found in Aqueous Firefighting Foams (AFFF)
- Very challenging to degrade, particularly PFOS
- EPA Drinking Water Health Advisory: 70 ppt
Future Work: Adapting DETS to PETS for PFAS
Pilot System Construction and Application

- PFAS Treatment Systems
  - Media filter treatment train
  - Primary filtration/ GAC/ RO
  - Mobile trailer 10-30 GPM
  - Recovers over 90% of the influent water
  - Treatment of concentrate approaches zero discharge
  - Goal will be to produce effluent with total PFAS measurements of 70 ppt or less

74,000 gallons (2 sites) with C6 AFFF
Future Work: Adapting DETS to PETS for PFAS

Preliminary Results

**RO Only**

*Figure 14. Results of PFAS removal by the DETS using the RO process only.*

**Sand/GAC Filtration & RO**

*Figure 15. Results of PFAS removal by the DETS using the pretreatment steps up to the GAC process and the RO process.*

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Conclusion

• DETS is a low cost treatment system, the first of its kind to treat and recycle decontamination effluent

• An effective means of capturing wash water from vehicle decontamination and MPD was demonstrated
  • The process was effective at 98% removal of all constituents tested

• The system was easily integrated into the National Guards CERFP decontamination practices

• Early studies have demonstrated effectiveness at removing PFAS
Innovative Solutions for a Safer, Better World

We are interested in collaborating to develop the best solutions for clean water!

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