Produced water treatment and reuse in hydraulic fracturing: Using laboratory research to select and implement technology at field-scale

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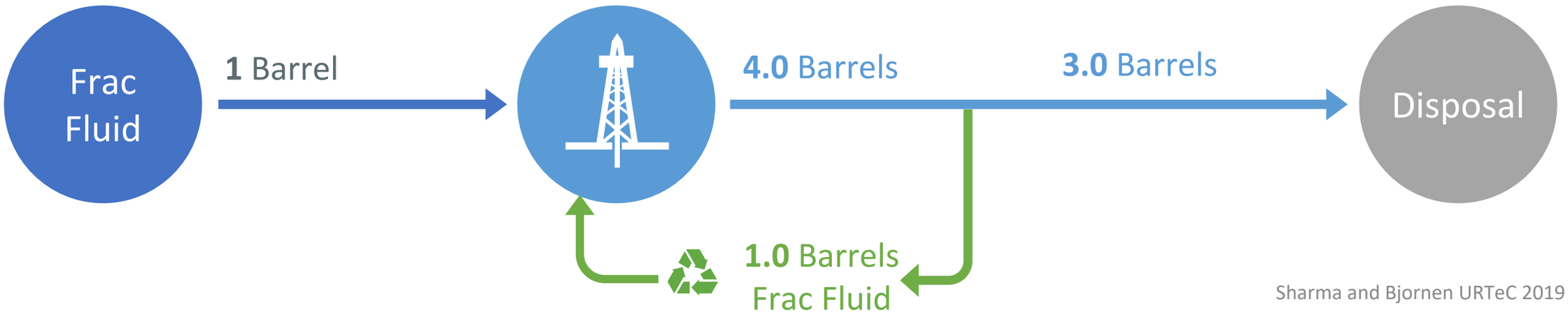
Abstract

Reusing produced water for hydraulic fracturing simultaneously satisfies challenges of fresh water sourcing and the design/operation of an extensive disposal well infrastructure. This presentation provides an overview of a reuse program from concept through implementation including qualification of advanced water recycling technologies. We target the most prolific unconventional reservoir play in the United States – the Permian Basin. Sourcing water for full-field development therein represents a significant problem since it is in short supply in (semi)arid regions of West Texas and Southeastern New Mexico. We report results from a synergistic industry-academia collaboration wherein desalination pretreatment was first evaluated at lab scale to (i) systematically evaluate partial softening (i.e. "floc-and-drop") versus neutral pH oxidation for iron removal (ii) investigate synergistic effects of $FeCl_3$ and polymer addition to destabilize colloids (including particulate iron) and induce high-rate sedimentation and (iii) develop and implement robust techniques using video and image analysis to characterize process performance and floc properties (e.g. morphology, size, and settling velocity). Jar tests and associated measurements were completed in the range 4 - 44 ^{o}C covering the range of temperatures measured in the Permian. $FeCl_3$ in conjunction with an anionic polymer dramatically improved colloid destabilization and floc growth via enmeshment of primary colloids by amorphous iron precipitates and interparticle bridging by the adsorbed polymer. Larger, stronger, and denser flocs thus formed settled extremely rapidly without breakage (i.e. high rate sedimentation). Bench-scale results were integrated in the design and testing a 5,000 BPD pilot scale high-rate clarifier. Pilot scale results show that the neutral pH method of clean-brine generation produced 5-10 times less sludge while achieving 15-20% higher throughput over the alternative floc-and-drop method. Both bench- and pilot-scale findings were incorporated in design and operation of a 50,000 BPD full-scale reuse facility in the Permian Basin. This presentation will share lessons learned from operating a large-scale reuse facility and how academic research can inform and be motivated by industrial practices (and vice versa).

Produced Water Treatment and Reuse in Hydraulic Fracturing: Using Laboratory Research to Select and Implement Technology at Field Scale

Produced water reuse for hydraulic fracturing is key to water management

- Water management during unconventional exploration and production in the Permian Basin is a critical issue impacting both sustainability and economics
- Fresh water sourcing and produced water disposal are important considerations
- Produced water reuse via fit-for-purpose treatment to make “clean brine” assists with both components
  - Robust (resilient), simple to operate, low-footprint, low-cost treatment; i.e. ***high rate***
  - Remove particulate iron and total suspended solids (turbidity)



Sharma and Bjornen URTeC 2019

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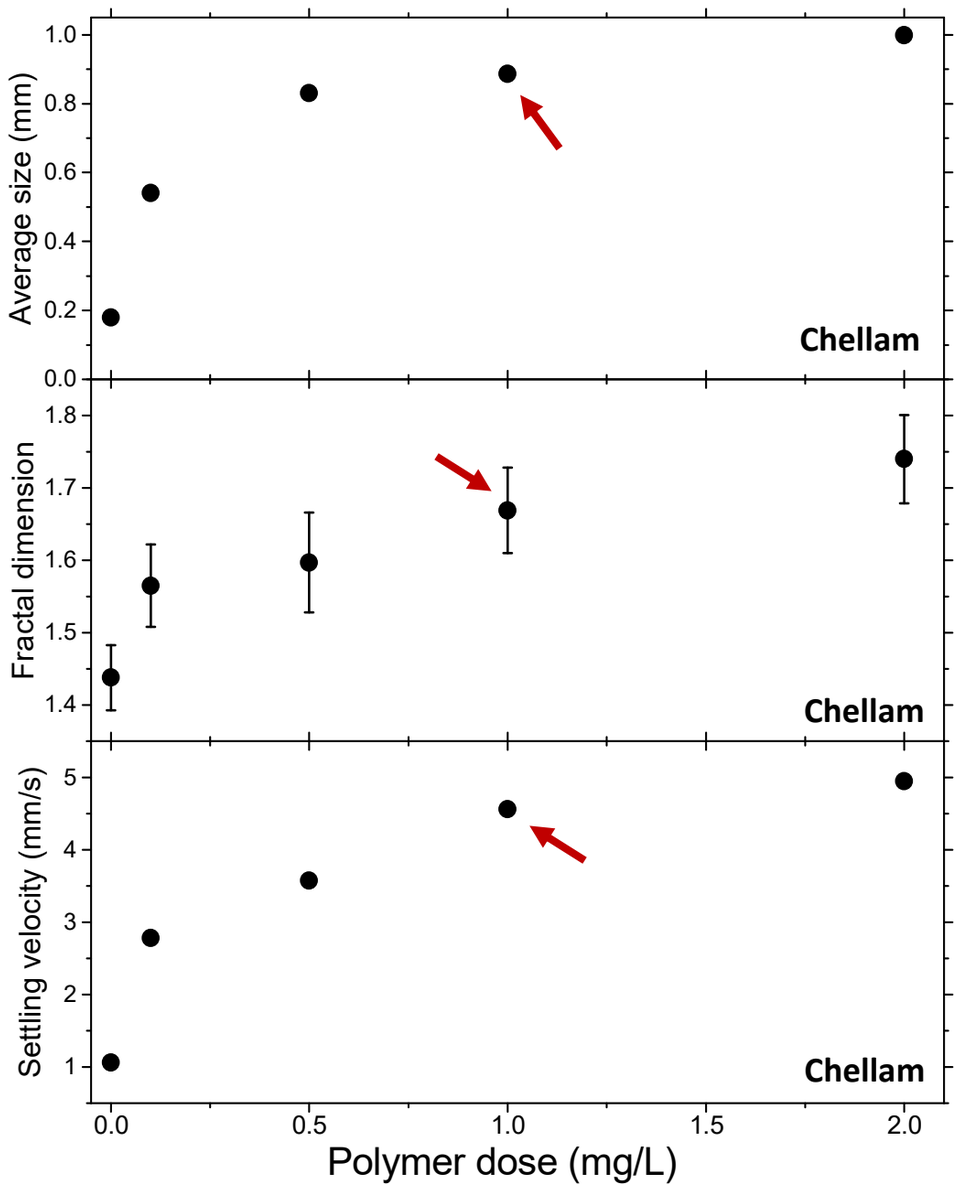
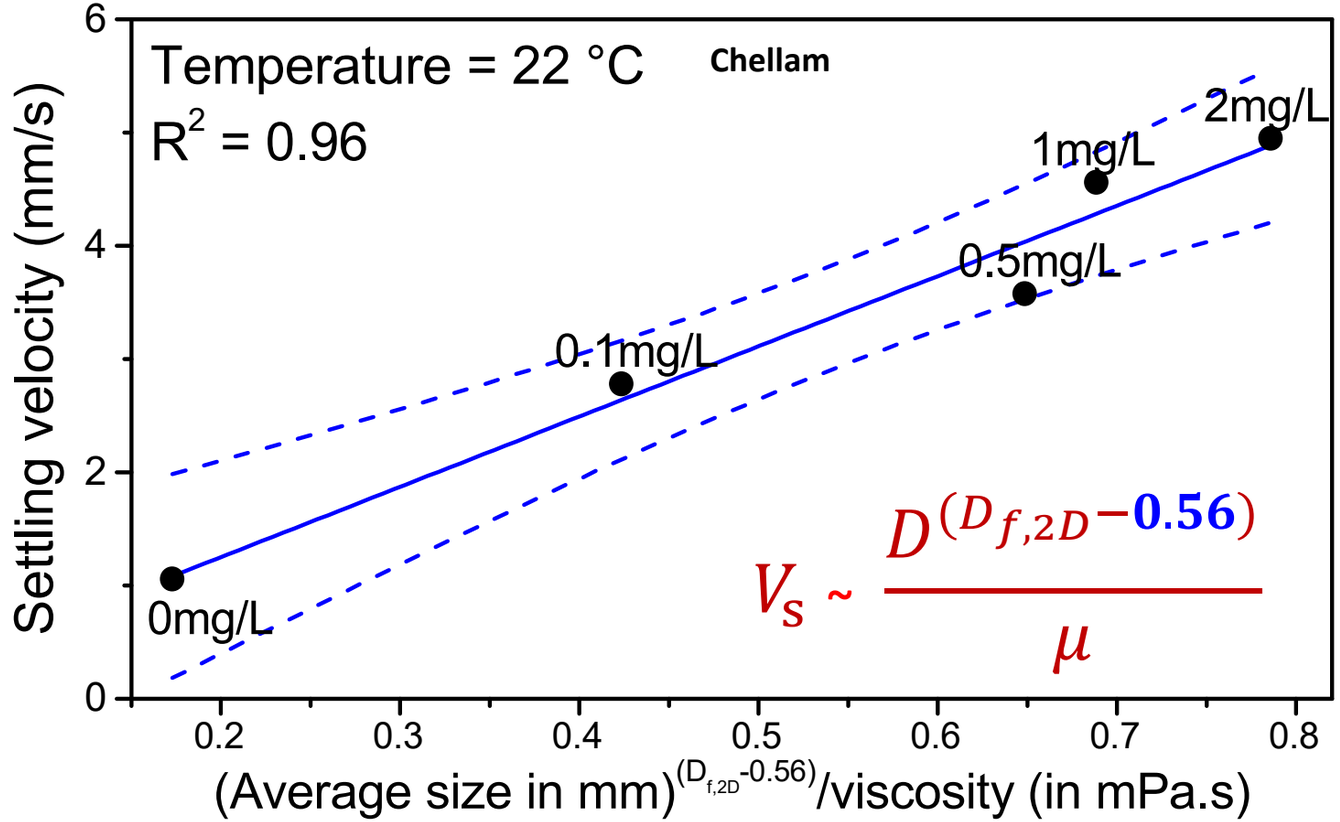
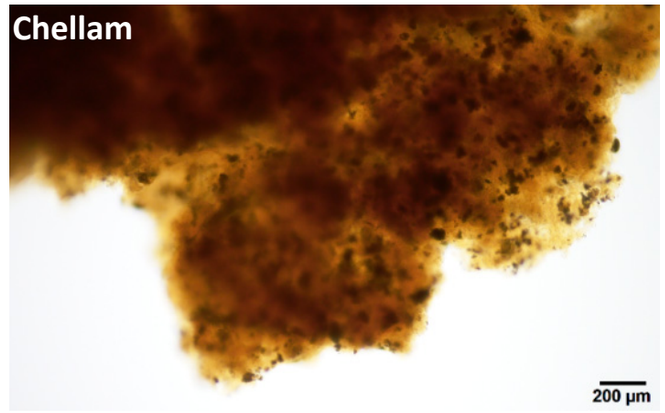
Key results/findings



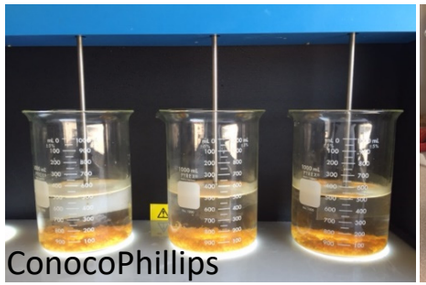


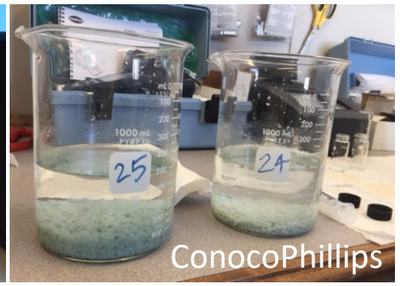


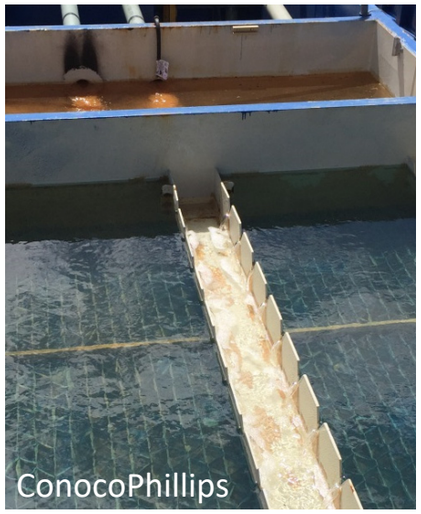
Combining $FeCl_3$ with a high molecular weight anionic polymer generates large, settleable flocs

Nadella, Sharma, and Chellam (2020). *Water Research* **170** 115330

Significance and broader impacts: Lab → pilot → field







- Lab test data replicated within ±2% on actual equipment operation
- Dosing sequence, dosing rates and retention times scaled up very well
- Switching between varying feed sources was easy based on laboratory data generated
- Good quality compact sludge obtained, dry to touch, and no drips
- Least amount of sludge at near neutral pH
- Solids disposed to landfills without need for special permits

- Bench-scale testing useful to screen various products and provide input to pilot- and field-scale testing
- Close coordination of bench- and pilot-scale treatment optimized chemical usage and thereby reduced operating costs by ~50%
- Improved process design for field implementation
  - Bench → Pilot (5,000 BPD) → Full-scale (50,000 BPD)
- Successful example of industry-academic collaboration and student mentoring

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