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National Solutions Worldwide Impact

A Survey of Telemetry-Enabled Sensors for Onsite Characterization of Air and Flowback Water from Hydraulic Fracturing

Sayan Chakraborti, A. Miller, and S. Shore (MRIGlobal)

M. Boerste and J. Myers. (URS Professional Solutions LLC)

Wyatt, D (URS Corporation, RES/NETL)

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Presentation Outline

- Rationale for sensors and project goals
- Water sensors review
- Air sensors review
- Identified gaps
- What's next?



Rationale for Sensors

- Flowback water needs treatment prior to discharge, and therefore constituents need to be monitored
- The EPA is studying the potential impacts of hydraulic fracturing on drinking water
- In addition to concerns over water pollution, there is increasing concern over air emissions

Project Goals

- Create a list of both water and air potential parameters of interest in shale gas
- Survey commercially available real-time sensors and instruments for monitoring the parameters identified in part 1
- Compile information on sensor capabilities with respect to various analytes and identify gaps in sensor technologies

Environmental Monitoring Opportunities

Sensor Opportunities for Fossil Fuel Extraction

Medium/Raw Material		Transport Pathway		Affected Environmental Media	
Physical State	Material or waste name	Air	Natural Water	Ambient Air	Waterbody or Aquifer
Gas	natural gas, EOR gas (CO ₂ , N ₂)	leak, exhaust, soil vapor	fracture contact zone	air plume, low air	area wells, deep water
Liquid	oil, natural gas liquids, waters (raw, prepped, flowback, produced, treated)	mist, vapor	source level, stormwater (StW) runoff/outfall or seepage, industrial outfall mixing zone, groundwater (GW) plume core	air plume	resource level trend, outfall mixing zone fringe, GW plume fringe
Semi-Solid	coal, drill mud, injection water additives	dust, fumes	StW runoff/outfall or seepage	air plume	StW outfall mixing zone, GW plume

Project scope limited to areas highlighted in yellow

Water Parameters of Interest

- Physical: Temperature, pressure, turbidity, conductance, pH, ORP
- Organic: THC, CH₄, BTEX
- Inorganic: Dissolved oxygen (DO), Cl⁻, As, Other Metals
- Others: Na, K, B, Ba, Sr, Br⁻, SO₄⁻, C₂H₆, C₃H₈, Naphthalene, CH₃OH

Water – Physical Parameters

(a sample of compiled data)

Vendor	Product ID	Water Physical						
		Temp Press/	Depth Turb	Cond*	pH	ORP	Other	
<u>Global Water</u>	various	x	x	x	x	x	x	
<u>HACH</u>	<u>Hydrolab DS5X (or MS5)</u>	x	x	x	x	x	x	chlorophyll, blue green algae, Rhodamine WT, PAR, Tot Diss Gas
<u>Xylem/YSI</u>	<u>EXO2 (or EXO1)</u>	x	x	x	x	x	x	total algae (chlorophyll , blue-green)
<u>INW</u>	Multi-Parameter Sensor	x	x	x	x	x	x	
<u>In-Situ</u>	Aqua Troll 400	x	x		x	x	x	

Water – Organic Analytes

(a sample of compiled data)

Vendor	Product ID	Water Organic							
		TOC	PAH	Individual					
				CH ₄	Benzene	Toluene	Ethyl benzene	Xylene	Other
<u>Xylem/YSi</u>	<u>EXO2 (or EXO1)</u>								fDOM
<u>YSI/Turner</u>	<u>Turner Sensor Adapter, Cyclops-7</u>				x	x	x	x	Offers oil (crude/fine), PTSA, Napthalene, etc.
<u>Petrosense</u>	CMS-1500 Envirologger w/ DHP-485				x	x	x	x	
<u>Franatech</u>	Various, specs listed are for methane			x					
<u>Contros</u>	HydroC CH4 sensor, various others		x	x					
<u>Pro-Oceanus</u>	<u>PSI Mini-Pro CH4</u>			x					

TOC = Total Organic Carbon

PAH = Poly-Aromatic Hydrocarbons

Water – Inorganic Analytes

(a sample of compiled data)

Vendor	Product ID	Water Inorganic					
		Nonmetals				Metals	
		TIC	DO	Cl-	Other	As	Other
<u>Global Water</u>	various		x	x			
<u>HACH</u>	Hydrolab DS5X (or MS5)			x			
<u>Xylem/YSI</u>	EXO2 (or EXO1)		x	x	NH ₄ ⁺ , NO ₃ ⁻		
<u>INW</u>	Multi-Parameter Sensor		x				
<u>In-Situ</u>	Aqua Troll 400		x				
<u>Trace Detect</u>	Arsenic Guard				F-	x	Se, Cu, Fe
<u>Mercury Instruments</u>	Mercury Process Analyzer PA-2						Hg
<u>Franatech</u>	Various, specs listed are for methane	x	x		H ₂ , H ₂ S, CO ₂		
<u>Contros</u>	HydroC CH4 sensor, various others	x			CO ₂		
<u>Pro-Oceanus</u>	PSI Mini-Pro H2S				S ²⁻		
<u>Chemtrac</u>	HydroACT 300/600/1200			x	Free Cl, Total Cl, Cl Dioxide,		

TIC = Toxic Industrial Chemical
 DO = Dissolve Oxygen

Water Sensors – Summary Findings

- 5 companies were identified which could monitor all of the physical parameters
- Multiple companies offered products for CH₄ detection
- Multiple companies offered DO and Cl-products
- Products were also found to monitor for NH₄⁺, NO₃⁻, H₂S

Air Parameters of Interest

- Gas (organic): Methane, ethane, butane, propane, BTEX
- Gas (inorganic): CO₂, Oxygen, H₂S, N₂
- Metals

Sensors for Gas (Organic)

A sample of compiled data

Vendor	Instrument	Gas Organic							Stbl Iso	
		THC	Individual						CH ₄	
			CH ₄	C ₂ H ₆	C ₃ H ₈	n-butane	iso-butane	Other	C	H
<u>RAE Systems</u>	ppbRAE 3000 (PID)							VOCs		
<u>Svft</u>	Voice 200 (SIFT-MS)							VOCs (BP<200 C and Molar Mass < 300 Da)		
<u>Enmet</u>	EX-5120		x	x	x	x	x	Propylene, Pentane, Ethylene, Isopropanol, Hexane, Methanol, Ethanol, ETO, Acetic Acid, Toluene		
<u>Enmet</u>	GSM60		x	x	x	x	x			
<u>Aeroqual</u>	series 500 and 930		x					VOC and Nonmethane Hydrocarbon		
<u>Aeroqual</u>	AQM60							Non-methane Hydrocarbons, VOCs,		

Sensors for Gas (Organic)

(continued)

Vendor	Instrument	Gas Organic							Stbl Iso	
		THC	Individual						CH ₄	
			CH ₄	C ₂ H ₆	C ₃ H ₈	n-butane	iso-butane	Other	C	H
<u>Owlstone</u>	Lonestar Portable Analyzer							Benzene, Xylene, Toluene, Acetone, Formaldehyde		
<u>California Analytical Instruments</u>	Cal Analytical 600 series FTIR			x	x			Acetylene, Chloroform, Dichloroethylene, Ethanol, Ethyl Benzene, Formaldehyde, Methane Toluene, MEK,		
<u>California Analytical Instruments</u>	Innova 3433							Methanol, Ethanol, Toluene,		
<u>Dynamant</u>	IR Gas Sensors	x	x	x	x	x	x	Ethanol, Ethylene, Ehtylene Oxide, Hexane, Methyl Bromide, Propene, Propylene,		
<u>Figaro</u>	Provides Individual Sensors to Monitor Gases		x					Alcohol, Solvent Vapors,		

Sensors for Gas (Inorganic)

(A sample of compiled data)

Vendor	Instrument	Gas Inorganic					
		Nonmetals				Metals	
		CO ₂	O ₂	H ₂ S	Other	Hg	Other
Tekran	2537B + 1135 cal. (AuCVAFS)					x	
Technical Associates	PTG-7L, incl. ion filter				Tritium		
<u>Enmet</u>	GSM60	x	x	x			
Brooks Rand Labs	Total Hg Systems					x	
Ion Science	GasClam and MVI Portable Mercury Detector	x	x	x	CO	x	
Tiger Optics	Prismatic	x			CO, H ₂		
Picarro	G2401	x			CO		
Aeroqual	series 500	x		x	Ammonia, CO, Hydrogen, Nitrogen Dioxide, Ozone, Sulphur Dioxide,		

Air Sensors – Summary Findings

- Many options are available for monitoring emissions of organic gases emissions
- In addition to the analytes of interest: sensors for ammonia and nitrogen dioxide are widely available

Gaps Identified

- Limited number of sensors was found for the analytes in the table
- Need for increased wireless communication
- Need for integration of all the sensors

Medium	Analyte
Water	Na, K, B, Ba, Sr, Br ⁻ , SO ₄ ⁻ , C ₂ H ₆ , C ₃ H ₈ , Naphthalene, CH ₃ OH
Gas	As, Isotopes, Total Hydrocarbons (THC)

What's Next?

- Select sensors identified in the survey
- Integrate the selected sensors into a real-time monitoring package
- Work with industry partners to determine an appropriate testing site
- Deploy the system for real world testing



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Thank You

Contact Information

Sayan Chakraborti
MRIGlobal, Kansas City
(816) 753 7600 x1505
schakraborti@mriglobal.org