Verification Test of Multi-Parameter Water Sensor Technology

Operator Training Committee of Ohio
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Sensicore Multi-parameter Water Sensor

- ✓ Free Chlorine
- ✓ Monochloramine
- ✓ pH
- ✓ Conductivity
- ✓ Total Alkalinity
- ✓ Calcium
- ✓ Ammonia
- ✓ Redox potential

Grab sampling technology, all results in 4 minutes.

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Experimental Plan Stage 1 – Laboratory Testing of DI Water Samples

Parameter Grouping	Water Quality Parameter	Levels	Test Sample Preparation (all samples in DI water)
1	pH	5, 7, 10 (pH units)	Citrate, phosphate, and borate buffers, respectively, prepared at appropriate pHs
2	Alkalinity	22, 130, and 240 mg/L $CaCO_3$	Anhydrous sodium bicarbonate dissolved in DI water
3	Calcium	7, 50, and 90 mg/L	Calcium chloride (pH 8.3)
	Ammonia	0.1, 0.8, 1.5 mg/L	Ammonium chloride (pH 8.3)
4	Conductivity	100, 900, 1700 μS/cm	Sodium chloride (pH 9.0)
	Free Chlorine	0.2, 1.2, 2.2 mg/L	Sodium hypochlorite (pH 9.0)
	Oxidation / Reduction Potential	Use the free chlorine solutions to generate a range of oxidation reduction potentials.	
5	Monochloramine	0.2, 1.2, 2.2 mg/L	Addition of ammonium chloride to Solution #4 with a 15 minute reaction time (pH>9)

- ✓ Each sample analyzed in triplicate
- ✓ Each sample compared with reference method result
- ✓ Two identical Sensicore WaterPoint 870 units tested

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Experimental Plan Stage 2 – Laboratory and Field Testing of Drinking and Surface Water Samples

- ✓ All samples from Columbus, OH (chlorinated system)
- ✓ 10 total samples, 2 tested as field samples
- ✓ All samples analyzed in triplicate with comparison to reference analyses
- ✓ Two Sensicore WaterPoint 870 sensors tested

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Experimental Plan Stage 3 – Pre-Test Field Measurements

- ✓ EPA - along Shaylor's Run off the East Fork of the Little Miami River
- ✓ TCEQ (Christine Kolbe) - lower canyons area of the Rio Grande downstream of Big Bend National Park
- ✓ Qualitative evaluation in a field analysis situation

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Stage 1 Accuracy in DI Water

- ✓ Three levels of WQPs analyzed in triplicate
- ✓ Alkalinity, conductivity, hardness, and ORP: %Ds<10%
- ✓ Ammonia: %Ds from -19.9% to -23.8% (top two conc.) and 47.1% (low conc.)
- ✓ Free chlorine: the %Ds were -41.2% and -29.4% (low), 11.5% and 11.8% (middle), and 23.6% and 26.8% (high) concentration sample.
- ✓ Monochloramine: %Ds ranged from 12.7% to 28.4%
- ✓ pH sensors differed by -0.05 and -0.08 (pH 5.4), 0.13 and 0.21 (pH 7.0) and -0.25 and -0.01 (pH 10)
- ✓ With the exception of the lowest free chlorine concentration, every triplicate set of samples exhibited RSDs that were below 10%, and in most cases less than 5%.

Stage 1 Accuracy Over Sensor Lifespan

Water Quality Parameter	Test Level	Description	%D or D	%RSD
Alkalinity ($mg/L\ CaCO_3$)	130	Pre-DW	-11.7%	9.3%
		Post-DW	8.7%	3.6%
Ammonia ($mg/L\ NH_3$)	0.8	Pre-DW	-20.6%	5.9%
		Post-DW	-19.6%	4.7%
Conductivity (µS/cm)	1100	Pre-DW	-0.3%	0.2%
		Post-DW	2.8%	0.9%
Free chlorine ($mg/L\ Cl_2$)	1.2	Pre-DW	20.9%	4.3%
		Post-DW	19.7%	1.5%
Hardness ($mg/L\ CaCO_3$)	125	Pre-DW	-1.3%	13.3%
		Post-DW	1.6%	0.0%
Monochloramine ($mg/L\ NH_2Cl$)	1.2	Pre-DW	11.1%	1.6%
		Post-DW	19.3%	5.0%
ORP (millivolts)	700	Pre-DW	-11.4%	4.6%
		Post-DW	3.9%	6.8%
pH	7.01	Pre-DW	0.18	n/a
		Post-DW	0.04	n/a

Pre-DW = at start of 30 days
Post-DW= after 30 days and DW analysis

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Stage 2 Accuracy in Drinking Water

- ✓ Conductivity and ORP: %Ds < 5% different from ref.
- ✓ Alkalinity: %Ds from -19.5% to 8.0%
- ✓ Hardness: %Ds from -17.0% to 2.3%
- ✓ pH: 9 out of 12 results < 0.1 pH units from reference which was between pH 7.7 and pH 7.9
- ✓ Monochloramine: 9 out of 12 results < 0.1 mg/L from reference which was between 0.1 and 0.4 mg/L
- ✓ Free chlorine: consistently exhibited a negative %D from -32.2% to -14.3%
- ✓ %RSDs were below 10% (except for monochloramine, which was impacted by the low concentration)

Stage 2 - Accuracy in Surface and "In-Process" Water

- ✓ Conductivity: %Ds from 1.2% to 5.5%
- ✓ Alkalinity: %Ds from -26.4% to 3.5%
- ✓ Hardness: %Ds from -17.4% to 3.6%
- ✓ pH: results < 0.25 pH units from reference which was between pH 6.8 and pH 8.9
- ✓ ORP: %Ds from -78.5% to -28.5% (treatment seems to remove a constituent that inhibits the ORP sensor as the drinking water results had much smaller differences)
- ✓ Free chlorine and monochlor. not tested in surface water
- ✓ %RSDs were below 10% in 70 of 80 sample sets

Field Portability and Inter-unit Reproducibility

- ✓ Field Portability: Out of 40 sample sets of surface water and in-process water, the difference between the lab and field measurements exceeded 10% only 4 times, and in those cases the field measurements were closer to the reference than the lab measurements
- ✓ Out of 106 pairs of triplicate results using separate units, only 19 pairs were determined to be significantly different from one another by a paired t-test
  - Extremely small uncertainty in the replicate measurements made small differences significant

Operational Factors

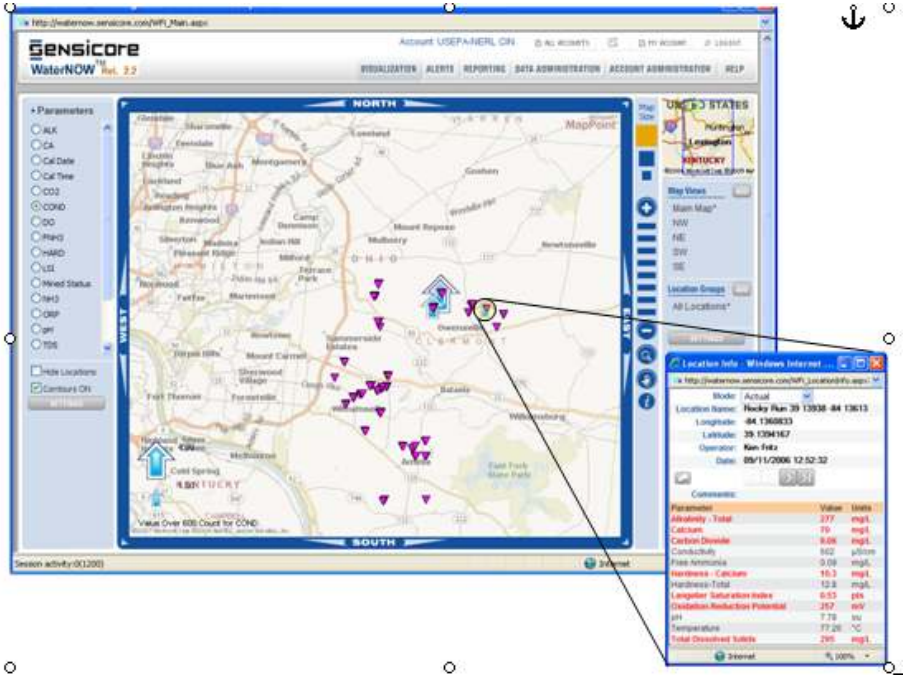
- ✓ Overall, the WP 870 was easy to use both in the laboratory setting and in the various field environments
- ✓ Grab sample sensor – 7-8 mL samples size
- ✓ Results obtained in less than 5 minutes per sample
- ✓ Comma-delimited files transferred with USB cable
- ✓ Full calibrations of the WP870 (15-20 minutes) performed on a weekly basis or whenever a new sensor was installed into the handheld unit
  - Calibration solutions are provided by Sensicore in disposable containers and were clearly labeled
  - Calibration procedure very straight forward
  - Daily quick calibrations also required
- ✓ Sensors were easily installed into the handheld unit by unscrewing the top of the sample tube and inserting the sensor so that the electrical leads matched up with those on the handheld unit
- ✓ Sensors have a lifespan of either 50 samples or 30 days

Operational Factors (cont.)

- ✓ Texas Commission on Environmental Quality and EPA National Exposure Research Laboratory took the WP 870 on field sampling trips and made some observations
  - Battery lasted for 7 days and nine sampling locations
  - Calibrations easily performed in the field
  - Carrying case was adequate in size and was relatively lightweight and easy to carry across difficult terrain
  - Calibration would be more efficiently done in the lab if on a day-long trip
  - WP870 was easily operated on the ground (e.g., on sloped banks along streams or uneven surfaces of streamside boulders and bedrock)
  - One drawback of the WP870 is the limited number of samples that each sensor can measure before disposal

Operational Factors (cont.)

- ✓ EPA NERL imported their data into Sensicore's WaterNOW software, a data evaluation tool
  - Graphical representation of data on maps
  - Cursor over data points reveals more detailed data
  - Controlled by user accounts (service fee required)



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