Appendix 8. Laboratory Comparison between StablCal and multiple lots of Polymer Turbidity Standard using white clay at the Kansas Water Science Center Laboratory, Lawrence, Kansas

Comparison Description

Station name: Kansas Water Science Center laboratory, Lawrence, Kansas.

Equipment: Two Yellow Springs Instrument (YSI) EXO water-quality monitors, one equipped with two YSI EXO turbidity sensors calibrated in polymer standard and one equipped with two YSI EXO turbidity sensors, one calibrated in StablCal standard and one calibrated in polymer standard were deployed in a laboratory turbidity testing apparatus for comparison between the standards. (See "Performance Evaluation Tests," "Laboratory Tests," p. 7 of main report, for a full description of laboratory methods.) The Hach model 2100AN laboratory turbidimeter with a flow through cell was used as a reference to measure the turbidity in the apparatus bucket every 15 minutes before adding more sediment. No datum corrections were applied to either dataset.

Testing material and water: White clay and deionized water.

Calibration standard used: One sensor was calibrated with Hach StablCal turbidity standard and three sensors calibrated with YSI polymer standard.

Laboratory comparison date: September 13, 2017.

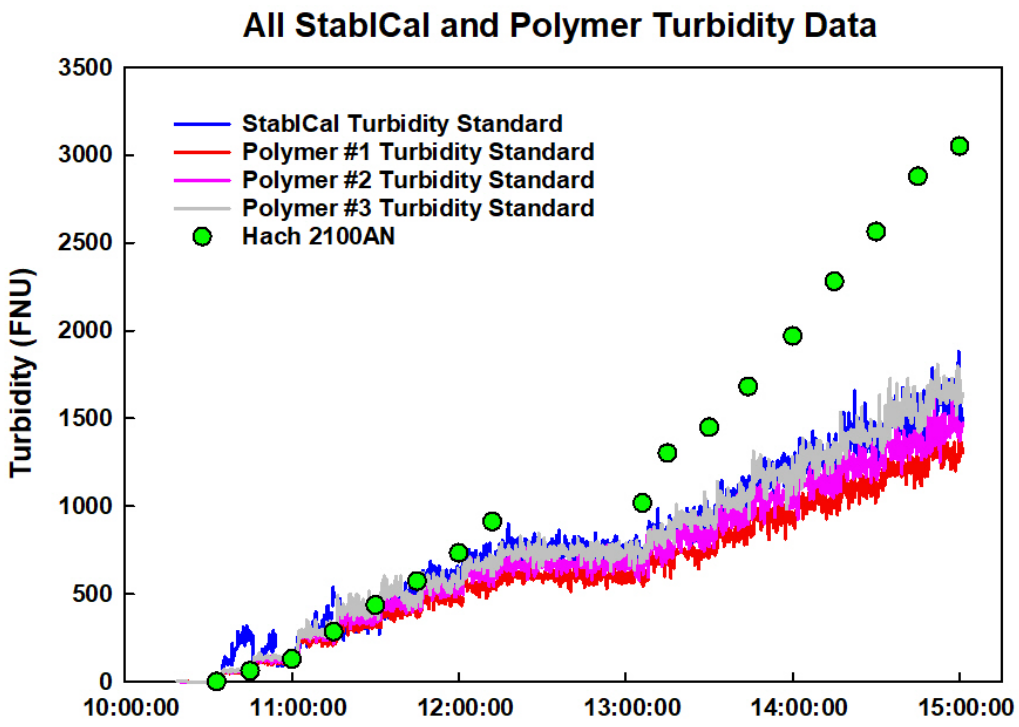
Datasets

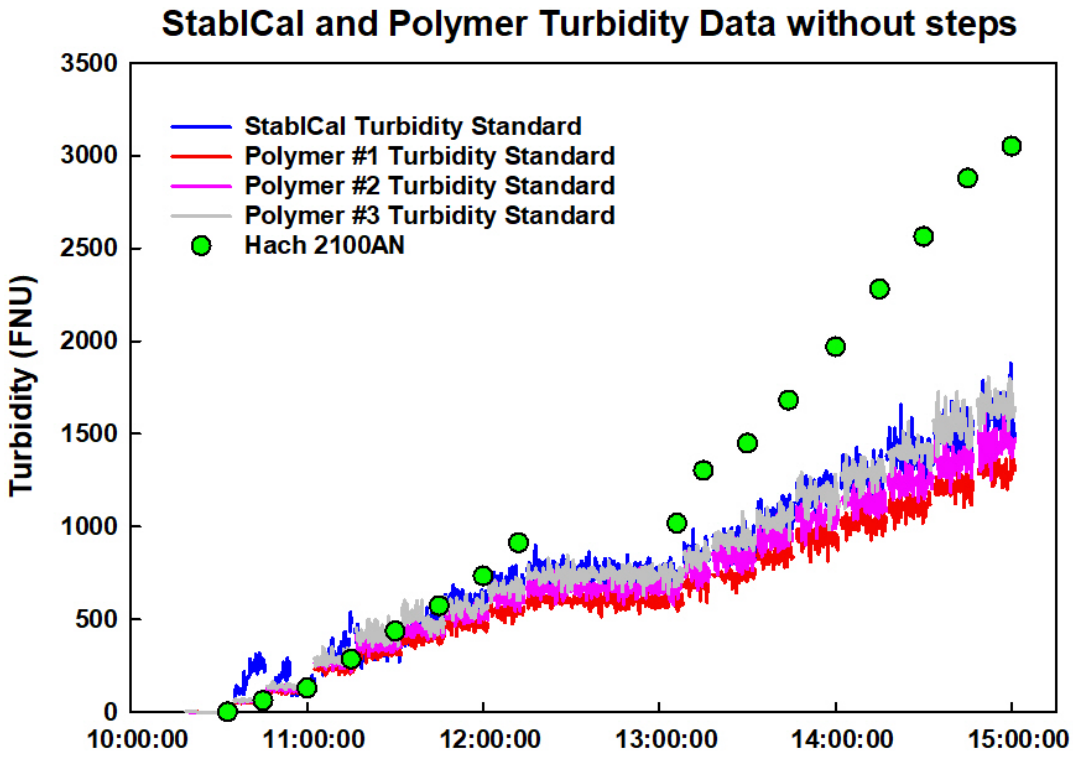
All data were collected using U.S. Geological Survey [USGS] protocols (U.S. Geological Survey, variously dated) and are published in King (2021). Data were edited to remove periods where material was added to the testing apparatus, leaving the steady-state data for analysis.

Polymer Standard Identification

	124 FNU Lot Number	1,010 FNU Lot Number
Polymer #1	17H798860	17H797418
Polymer #2	17E796816	17E794976
Polymer #3	17H799343	17H799341

Time Series


All StablCal and Polymer Turbidity Data
StablCal Turbidity Standard
Polymer #1 Turbidity Standard
Polymer #2 Turbidity Standard
Polymer #3 Turbidity Standard
Hach 2100AN
Turbidity (FNU)
3500
3000
2500
2000
1500
1000
500
0
10:00:00
11:00:00
12:00:00
13:00:00
14:00:00
15:00:00


StablCal and Polymer Turbidity Data without steps
StablCal Turbidity Standard
Polymer #1 Turbidity Standard
Polymer #2 Turbidity Standard
Polymer #3 Turbidity Standard
Hach 2100AN
Turbidity (FNU)
3500
3000
2500
2000
1500
1000
500
0
10:00:00
11:00:00
12:00:00
13:00:00
14:00:00
15:00:00

Statistical Analyses - StablCal and Polymer #1 Data

Slope comparison

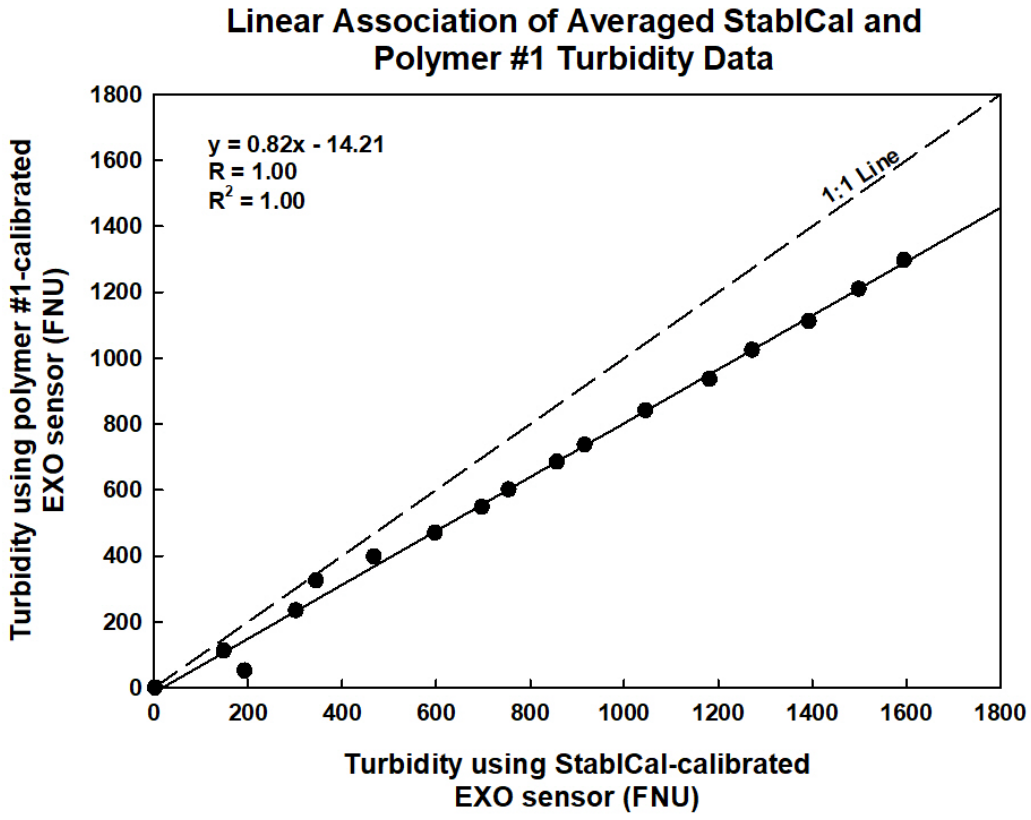
The following is a summary of final regression analysis for sensor-measured turbidity from one YSI EXO turbidity sensor calibrated by using StablCal turbidity standard and one YSI EXO turbidity sensor calibrated by using polymer #1 turbidity standard at the Kansas Water Science Center laboratory, Lawrence, Kansas, on September 13, 2017; the data used in the final regressions were averages of turbidity for each step, each of which had a duration of approximately 15 minutes once the sensor had stabilized:

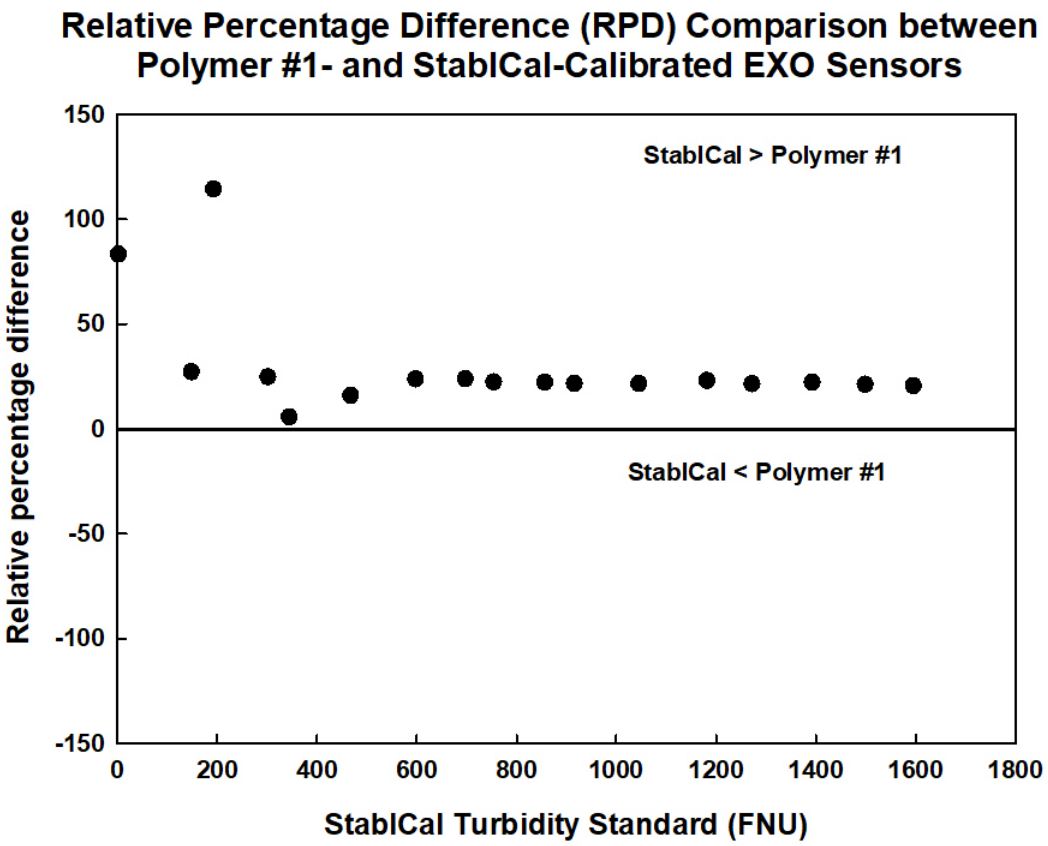
$$y = 0.82x - 14.21$$

where

y = turbidity measured with polymer #1-calibrated EXO sensor (FNU)

x = turbidity measured with StablCal-calibrated EXO sensor (FNU).





Paired t-test for StablCal and Polymer #1 Data

SigmaPlot Statistical Output:

Normality Test (Shapiro-Wilk): Passed (P = 0.433)

Paired t-test:

Treatment Name	N	Missing	Mean	Std Dev	SEM
StablCal	17	0	780.173	497.673	120.704
Polymer #1	17	0	623.007	407.501	98.833
Difference	17	0	157.166	95.619	23.191

t = 6.777 with 16 degrees of freedom.

95 percent two-tailed confidence interval for difference of means: 108.003 to 206.329

Two-tailed P-value = 0.00000444

The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant change (P = <0.001)

One-tailed P-value = 0.00000222

The sample mean of treatment StablCal exceeds the sample mean of treatment Polymer 1 by an amount that is greater than would be expected by chance, rejecting the hypothesis that the population mean of treatment Polymer 1 is greater than or equal to the population mean of treatment StablCal. (P = <0.001)

Power of performed two-tailed test with alpha = 0.050: 1.000

Power of performed one-tailed test with alpha = 0.050: 1.000

Summary of Results

There is a strong linear association between measurements made with the two sensors (R = 1.00). Relative percentage difference ranged from 6 to 114 percent (median: 22 percent; mean: 30 percent). The data passed the Shapiro-Wilk test for normality (P=0.433); therefore, a paired t-test was performed. The difference between mean values for the StablCal- and polymer #1-calibrated EXO sensors was statistically significant (P<0.05).

Statistical Analyses - StablCal and Polymer #2 Data

Slope comparison

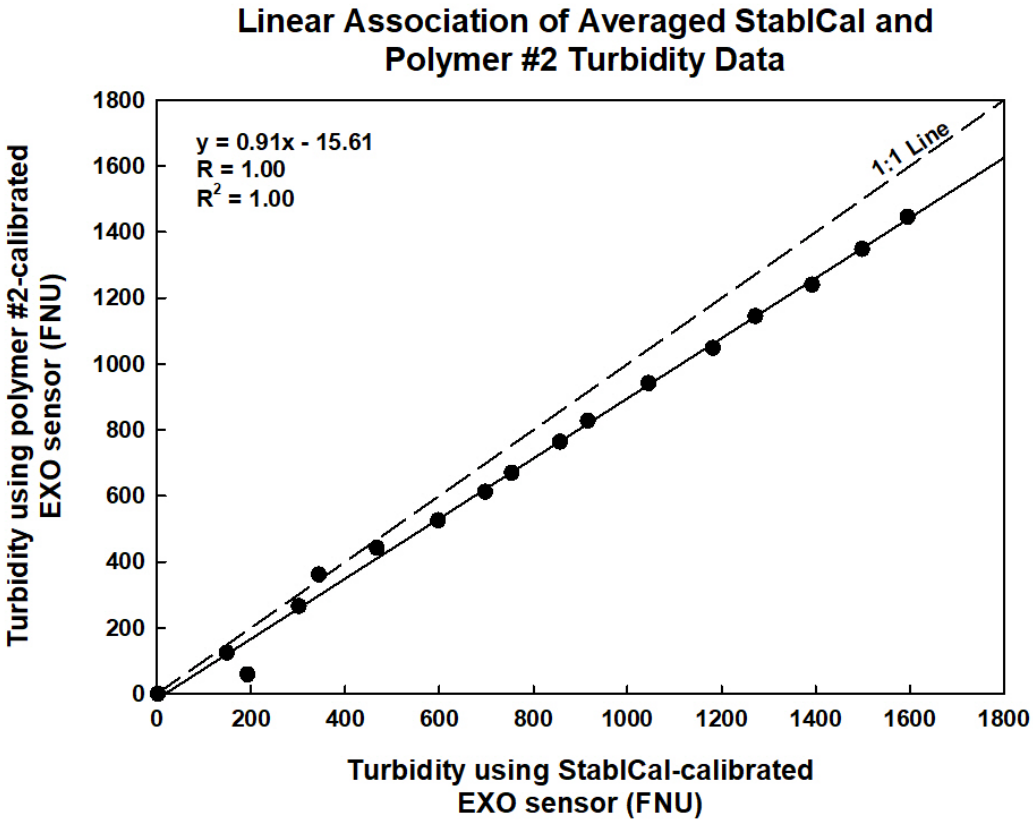
The following is a summary of final regression analysis for sensor-measured turbidity from one YSI EXO turbidity sensor calibrated by using StablCal turbidity standard and one YSI EXO turbidity sensor calibrated by using polymer #2 turbidity standard at the Kansas Water Science Center laboratory, Lawrence, Kansas, on September 13, 2017; the data used in the final regressions were averages of turbidity for each step, each of which had a duration of approximately 15 minutes once the sensor had stabilized:

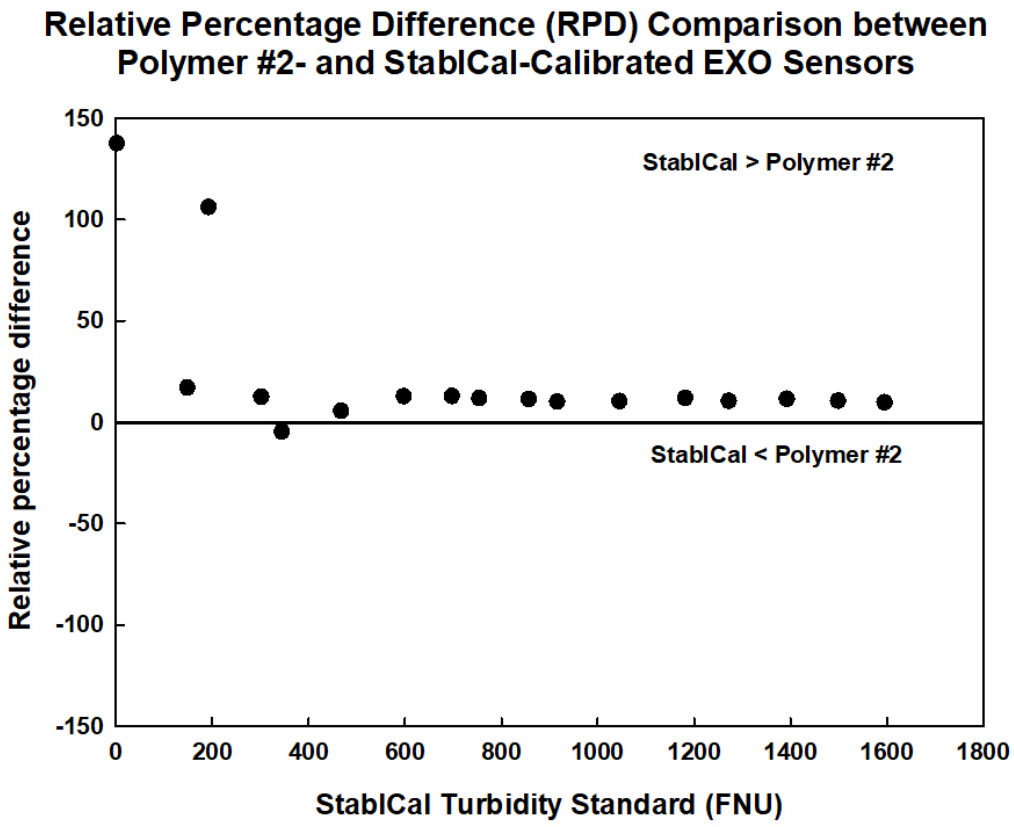
$$y = 0.91x - 15.61$$

where

y = turbidity measured with polymer #2-calibrated EXO sensor (FNU)

x = turbidity measured with StablCal-calibrated EXO sensor (FNU).


Linear Association of Averaged StablCal and Polymer #2 Turbidity Data
y = 0.91x - 15.61
R = 1.00
R2 = 1.00
1:1 Line
Turbidity using polymer #2-calibrated EXO sensor (FNU)
Turbidity using StablCal-calibrated EXO sensor (FNU)
0
200
400
600
800
1000
1200
1400
1600
1800



Paired t-test for StablCal and Polymer #2 Data

SigmaPlot Statistical Output:

Normality Test (Shapiro-Wilk): Passed (P = 0.190)

Paired t-test:

Treatment Name	N	Missing	Mean	Std Dev	SEM
StablCal	17	0	780.173	497.673	120.704
Polymer #2	17	0	695.443	454.677	110.275
Difference	17	0	84.730	54.219	13.150

t = 6.443 with 16 degrees of freedom.

95 percent two-tailed confidence interval for difference of means: 56.853 to 112.607

Two-tailed P-value = 0.00000812

The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant change (P = <0.001)

One-tailed P-value = 0.00000406

The sample mean of treatment StablCal exceeds the sample mean of treatment Polymer 2 by an amount that is greater than would be expected by chance, rejecting the hypothesis that the population mean of treatment Polymer 2 is greater than or equal to the population mean of treatment StablCal. (P = <0.001)

Power of performed two-tailed test with alpha = 0.050: 1.000
Power of performed one-tailed test with alpha = 0.050: 1.000

Summary of Results

There is a strong linear association between measurements made with the two sensors (R = 1.00). Relative percentage difference ranged from 5 to 138 percent (median: 12 percent; mean: 24 percent). The data passed the Shapiro-Wilk test for normality (P=0.190); therefore, a paired t-test was performed. The difference between mean values for the StablCal- and polymer #2-calibrated EXO sensors was statistically significant (P<0.05).

Statistical Analyses - StablCal and Polymer #3 Data

Slope comparison

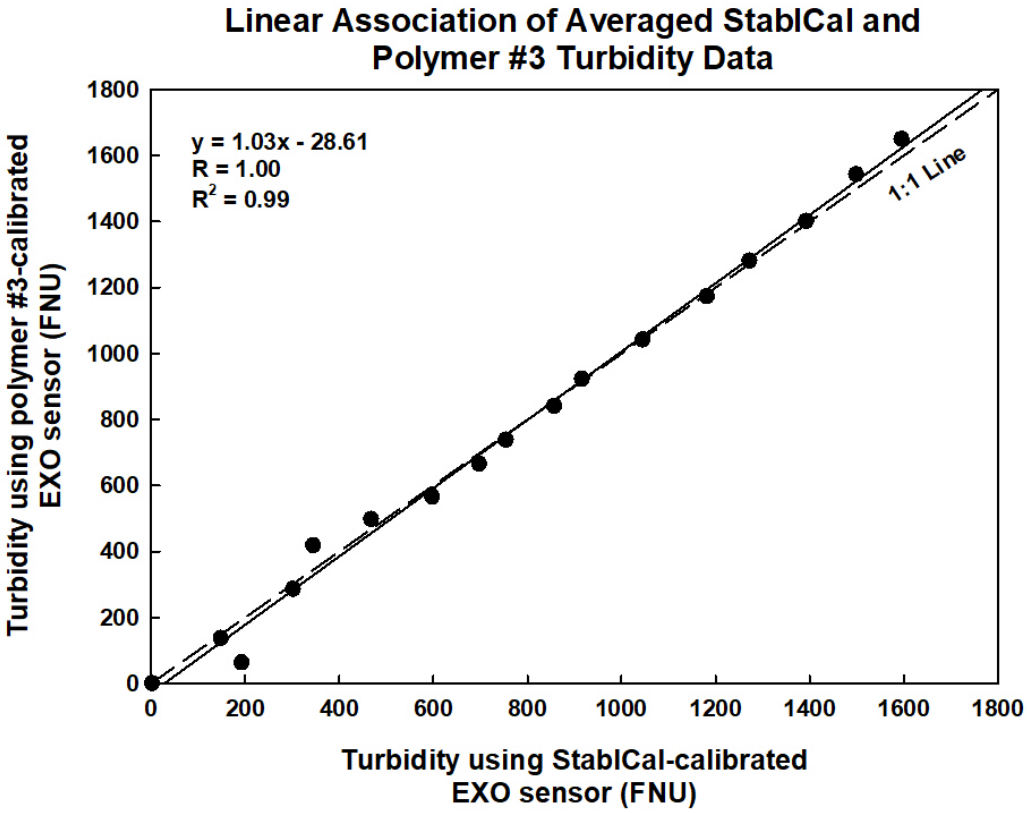
The following is a summary of final regression analysis for sensor-measured turbidity from one YSI EXO turbidity sensor calibrated by using StablCal turbidity standard and one YSI EXO turbidity sensor calibrated by using polymer #3 turbidity standard at the Kansas Water Science Center laboratory, Lawrence, Kansas, on September 13, 2017; the data used in the final regressions were averages of turbidity for each step, each of which had a duration of approximately 15 minutes once the sensor had stabilized:

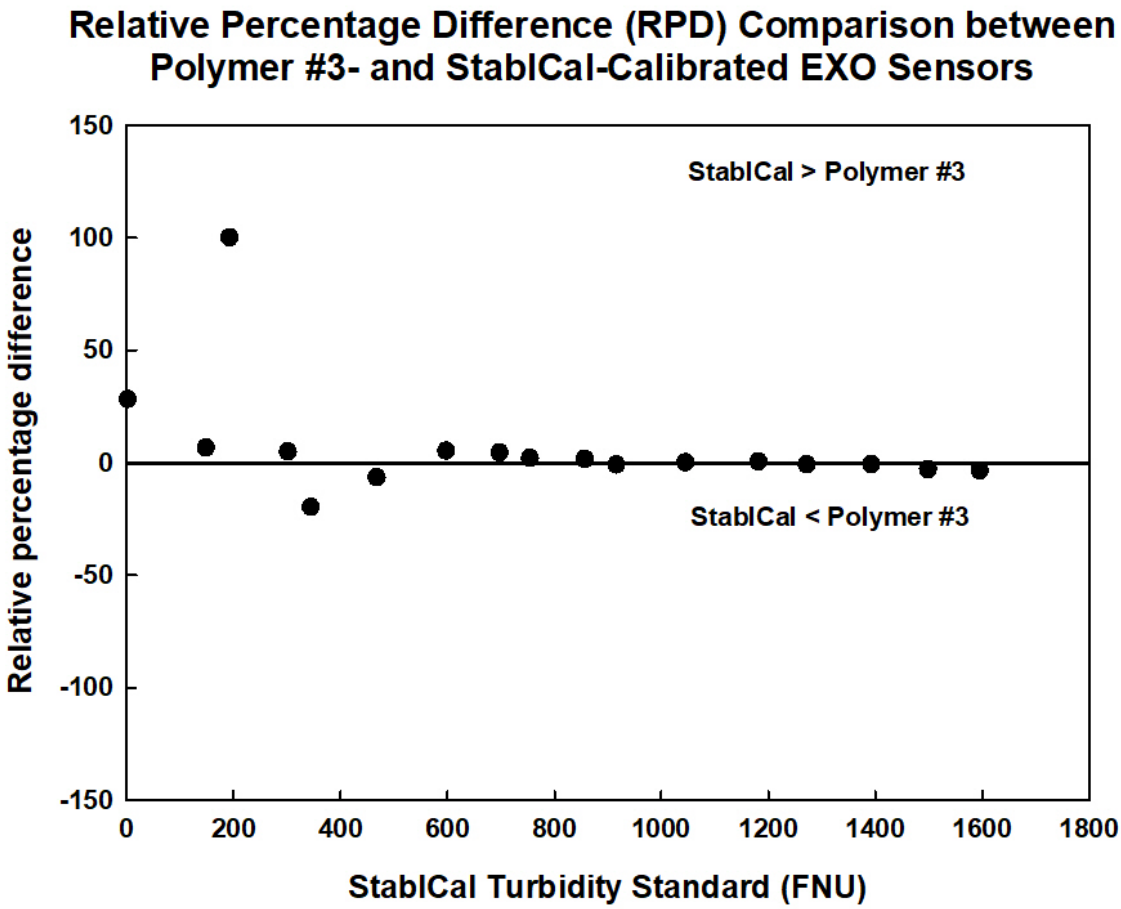
$$y = 1.03x - 28.61$$

where

y = turbidity measured with polymer #3-calibrated EXO sensor (FNU)

x = turbidity measured with StablCal-calibrated EXO sensor (FNU).


Linear Association of Averaged StablCal and Polymer #3 Turbidity Data
y = 1.03x - 28.61
R = 1.00
R2 = 0.99
1:1 Line
Turbidity using polymer #3-calibrated EXO sensor (FNU)
Turbidity using StablCal-calibrated EXO sensor (FNU)
0
200
400
600
800
1000
1200
1400
1600
1800



Wilcoxon Signed-Rank Test for StablCal and Polymer #3 Data

SigmaPlot Statistical Output:

Normality Test (Shapiro-Wilk): Failed (P < 0.050)

Group	N	Missing	Median	25%	75%
StablCal	17	0	753.992	322.932	1226.922
Polymer #3	17	0	738.523	353.172	1227.843

W= -13.000 T+ = 70.000 T-= -83.000

Z-Statistic (based on positive ranks) = -0.308

P(est.) = 0.776 P(exact)= 0.782

The change that occurred with the treatment is not great enough to exclude the possibility that it is due to chance (P = 0.782).

R Statistical Output:

```
Wilcoxon Signed-Rank test with continuity correction

data:  StablCal and Polymer
V = 83, p-value = 0.7819
alternative hypothesis: true location shift is not equal to 0
95 percent confidence interval:
 -20.45046  15.46908
sample estimates:
(pseudo)median
      1.138556
```

Summary of Results

There is a strong linear association between measurements made with the two sensors (R = 1.00). Relative percentage difference ranged from 0 to 100 percent (median: 3 percent; mean: 11 percent). The data did not pass the Shapiro-Wilk test for normality (P<0.05); therefore, a Wilcoxon signed-rank test was performed. The difference between median values for the StablCal- and polymer #3-calibrated EXO sensors was not statistically significant (P>0.05).

Statistical Analyses - Polymer #1 and Polymer #2 Data

Slope comparison

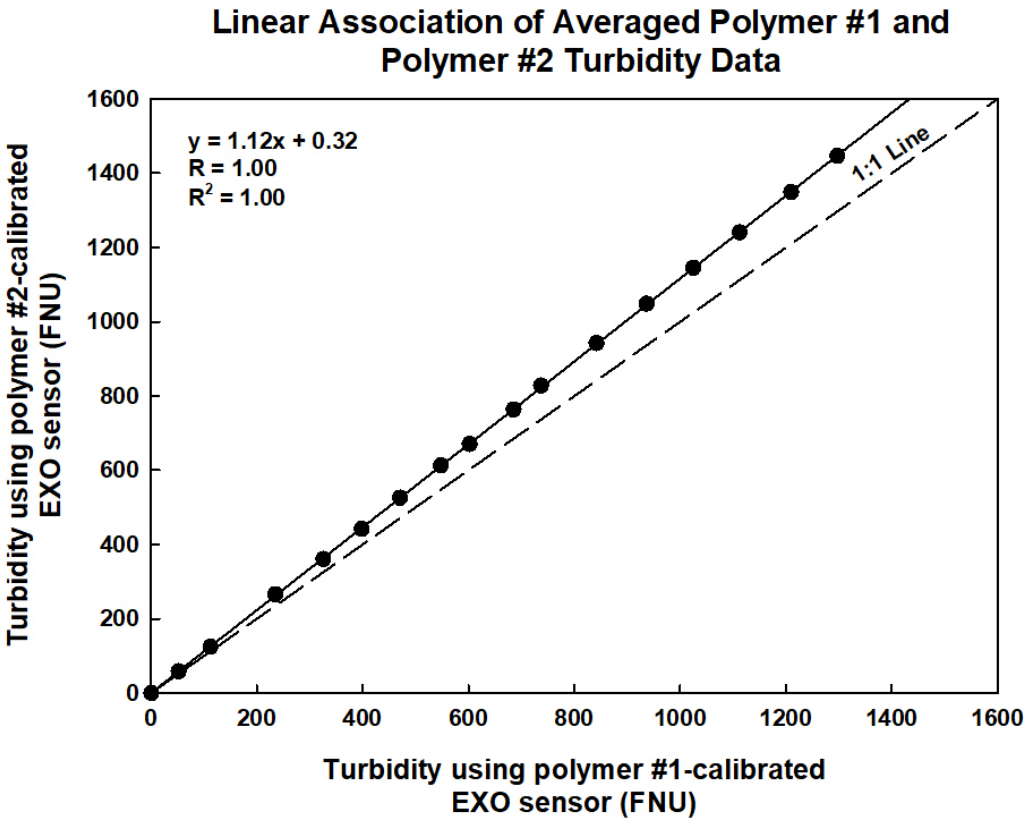
The following is a summary of final regression analysis for sensor-measured turbidity from one YSI EXO turbidity sensor calibrated by using polymer #1 turbidity standard and one YSI EXO turbidity sensor calibrated by using polymer #2 turbidity standard at the Kansas Water Science Center laboratory, Lawrence, Kansas, on September 13, 2017; the data used in the final regressions were averages of turbidity for each step, each of which had a duration of approximately 15 minutes once the sensor had stabilized:

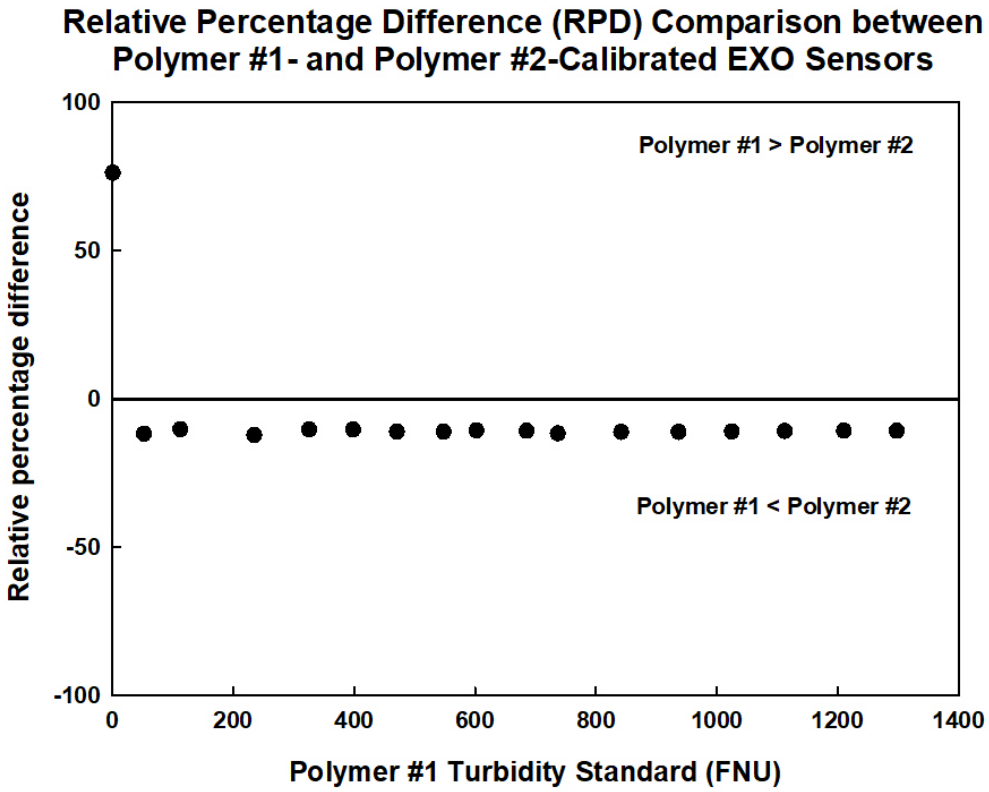
$$y = 1.12x + 0.32$$

where

y = turbidity measured with polymer #2-calibrated EXO sensor (FNU)

x = turbidity measured with polymer #1-calibrated EXO sensor (FNU).


Linear Association of Averaged Polymer #1 and Polymer #2 Turbidity Data
y = 1.12x + 0.32
R = 1.00
R2 = 1.00
1:1 Line
Turbidity using polymer #2-calibrated EXO sensor (FNU)
Turbidity using polymer #1-calibrated EXO sensor (FNU)
0
200
400
600
800
1000
1200
1400
1600



Paired t-test for Polymer #1 and Polymer #2 Data

SigmaPlot Statistical Output:

Normality Test (Shapiro-Wilk): Passed (P = 0.624)

Paired t-test:

Treatment Name	N	Missing	Mean	Std Dev	SEM
Polymer #1	17	0	623.007	407.501	98.833
Polymer #2	17	0	695.443	454.677	110.275
Difference	17	0	-72.436	47.232	11.455

t = -6.323 with 16 degrees of freedom.

95 percent two-tailed confidence interval for difference of means: -96.720 to -48.152

Two-tailed P-value = 0.0000101

The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant change (P = <0.001)

One-tailed P-value = 0.00000506

The sample mean of treatment Polymer 2 exceeds the sample mean of treatment Polymer 1 by an amount that is greater than would be expected by chance, rejecting the hypothesis that the population mean of treatment Polymer 1 is greater than or equal to the population mean of treatment Polymer 2. (P = <0.001)

Power of performed two-tailed test with alpha = 0.050: 1.000

Power of performed one-tailed test with alpha = 0.050: 1.000

Summary of Results

There is a strong linear association between measurements made with the two sensors (R = 1.00). Relative percentage difference ranged from 10 to 76 percent (median: 11 percent; mean: 15 percent). The data passed the Shapiro-Wilk test for normality (P=0.624); therefore, a paired t-test was performed. The difference between mean values for the polymer #1- and polymer #2-calibrated EXO sensors was statistically significant (P<0.05).

Statistical Analyses - Polymer #1 and Polymer #3 Data

Slope comparison

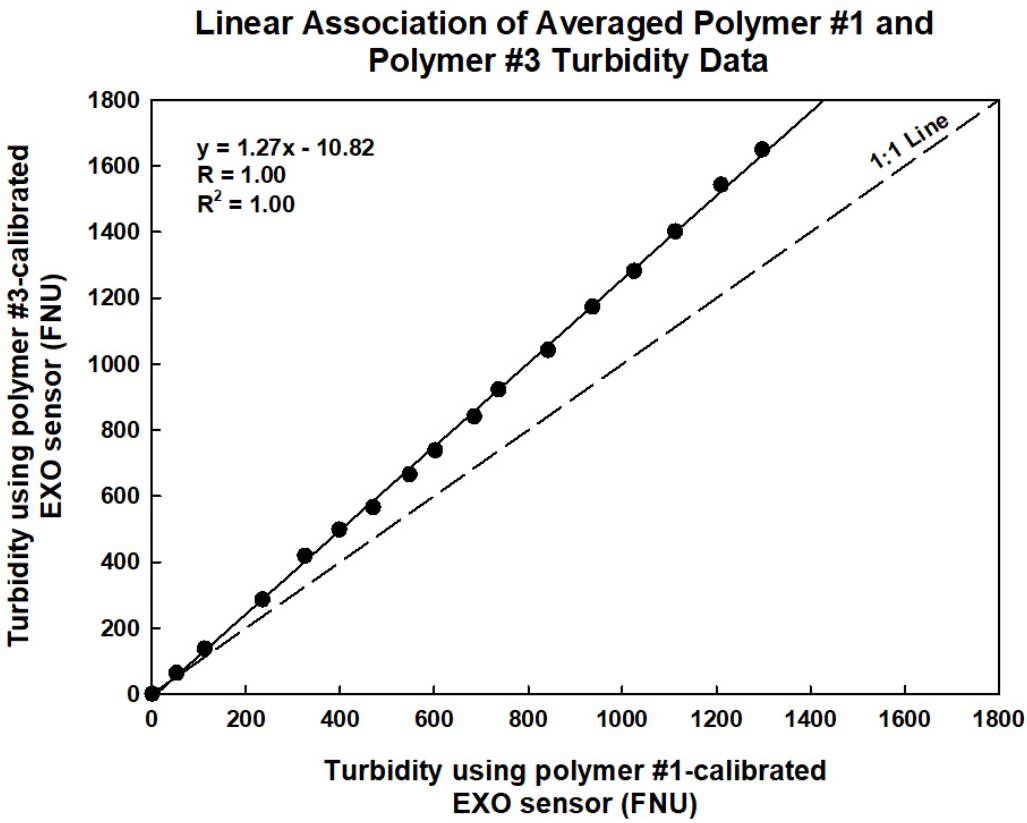
The following is a summary of final regression analysis for sensor-measured turbidity from one YSI EXO turbidity sensor calibrated by using polymer #1 turbidity standard and one YSI EXO turbidity sensor calibrated by using polymer #3 turbidity standard at the Kansas Water Science Center laboratory, Lawrence, Kansas, on September 13, 2017; the data used in the final regressions were averages of turbidity for each step, each of which had a duration of approximately 15 minutes once the sensor had stabilized:

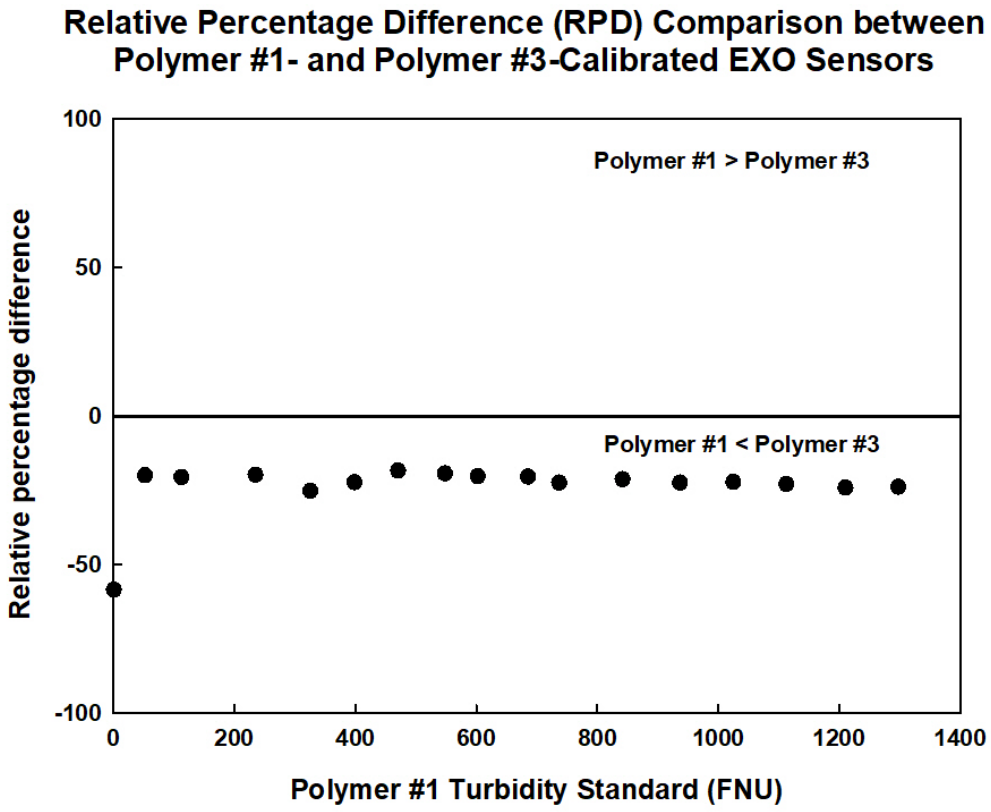
$$y = 1.27x - 10.82$$

where

y = turbidity measured with polymer #3-calibrated EXO sensor (FNU)

x = turbidity measured with polymer #1-calibrated EXO sensor (FNU).


Linear Association of Averaged Polymer #1 and Polymer #3 Turbidity Data
y = 1.27x - 10.82
R = 1.00
R2 = 1.00
1:1 Line
Turbidity using polymer #3-calibrated EXO sensor (FNU)
Turbidity using polymer #1-calibrated EXO sensor (FNU)
0
200
400
600
800
1000
1200
1400
1600
1800



Paired t-test for Polymer #1 and Polymer #3 Data

SigmaPlot Statistical Output:

Normality Test (Shapiro-Wilk): Passed (P = 0.531)

Paired t-test:

Treatment Name	N	Missing	Mean	Std Dev	SEM
Polymer #1	17	0	623.007	407.501	98.833
Polymer #3	17	0	778.686	516.563	125.285
Difference	17	0	-155.679	109.651	26.594

t = -5.854 with 16 degrees of freedom.

95 percent two-tailed confidence interval for difference of means: -212.057 to -99.301

Two-tailed P-value = 0.0000245

The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant change (P = <0.001)

One-tailed P-value = 0.0000122

The sample mean of treatment Polymer 3 exceeds the sample mean of treatment Polymer 1 by an amount that is greater than would be expected by chance, rejecting the hypothesis that the population mean of treatment Polymer 1 is greater than or equal to the population mean of treatment Polymer 3. (P = <0.001)

Power of performed two-tailed test with alpha = 0.050: 1.000

Power of performed one-tailed test with alpha = 0.050: 1.000

Summary of Results

There is a strong linear association between measurements made with the two sensors (R = 1.00). Relative percentage difference ranged from 18 to 59 percent (median: 22 percent; mean: 24 percent). The data passed the Shapiro-Wilk test for normality (P=0.531); therefore, a paired t-test was performed. The difference between mean values for the polymer #1- and polymer #3-calibrated EXO sensors was statistically significant (P<0.05).

Statistical Analyses - Polymer #2 and Polymer #3 Data

Slope comparison

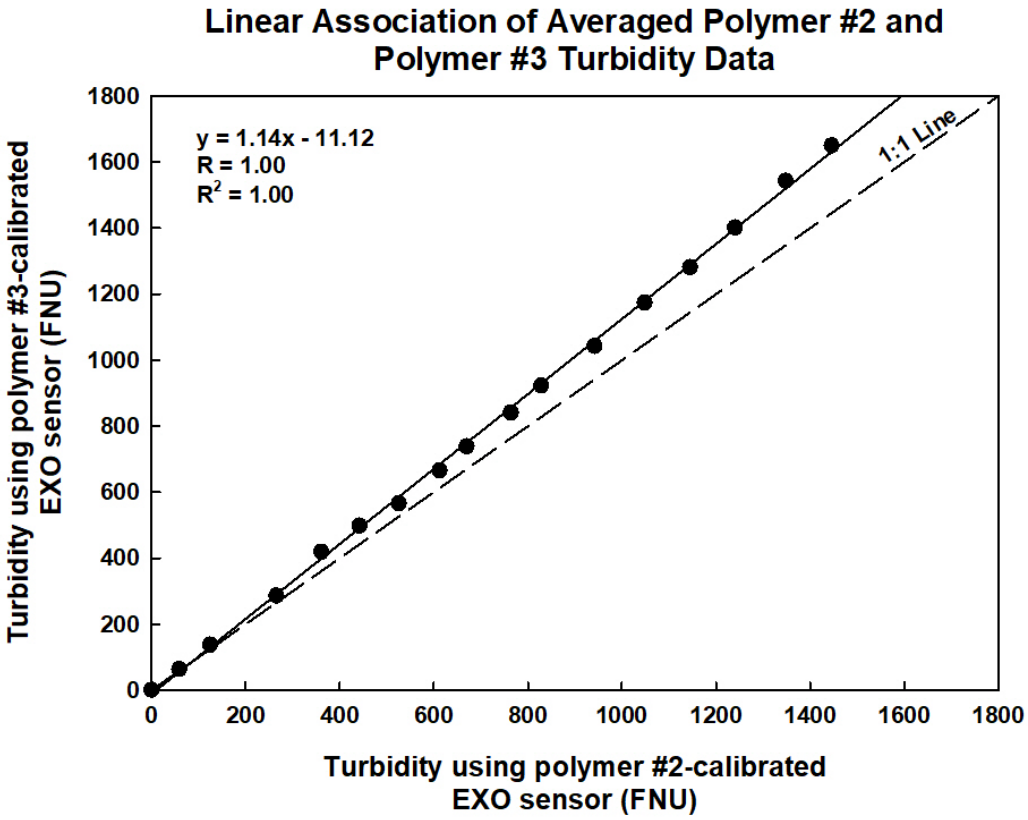
The following is a summary of final regression analysis for sensor-measured turbidity from one YSI EXO turbidity sensor calibrated by using polymer #2 turbidity standard and one YSI EXO turbidity sensor calibrated by using polymer #3 turbidity standard at the Kansas Water Science Center laboratory, Lawrence, Kansas, on September 13, 2017; the data used in the final regressions were averages of turbidity for each step, each of which had a duration of approximately 15 minutes once the sensor had stabilized:

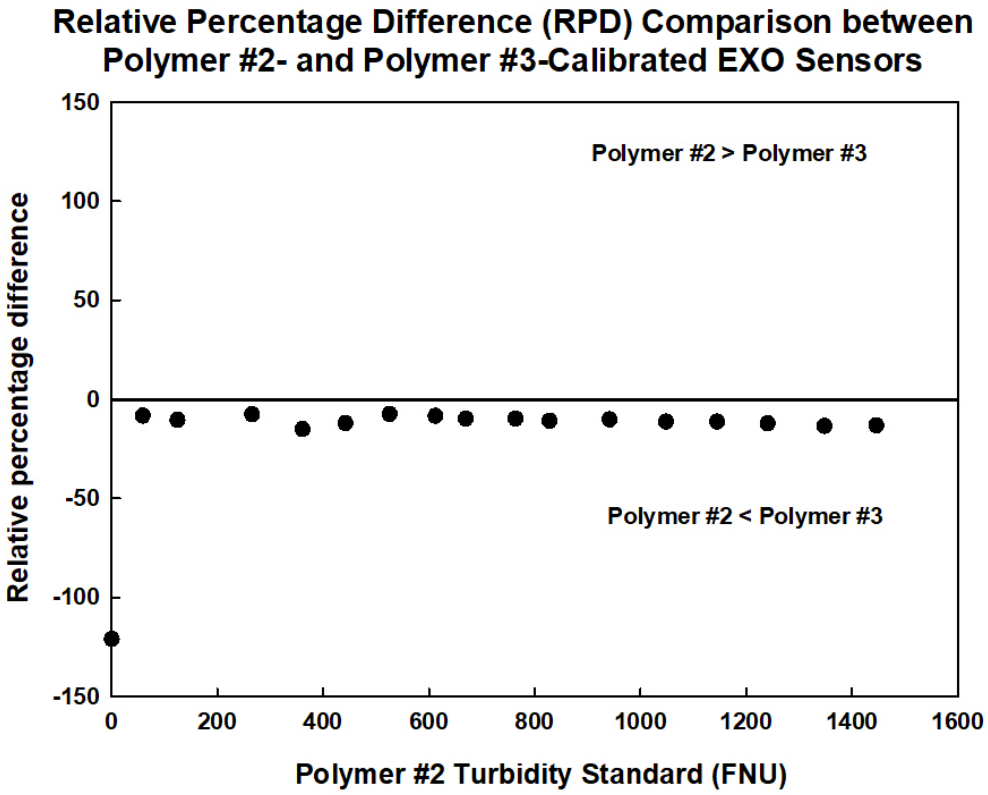
$$y = 1.14x - 11.12$$

where

y = turbidity measured with polymer #3-calibrated EXO sensor (FNU)

x = turbidity measured with polymer #2-calibrated EXO sensor (FNU).


Linear Association of Averaged Polymer #2 and Polymer #3 Turbidity Data
y = 1.14x - 11.12
R = 1.00
R2 = 1.00
1:1 Line
Turbidity using polymer #3-calibrated EXO sensor (FNU)
Turbidity using polymer #2-calibrated EXO sensor (FNU)
0
200
400
600
800
1000
1200
1400
1600
1800



Paired t-test for Polymer #2 and Polymer #3 Data

Sigma Plot Statistical Output:

Normality Test (Shapiro-Wilk): Passed (P = 0.293)

Paired t-test:

Treatment Name	N	Missing	Mean	Std Dev	SEM
Polymer #2	17	0	695.443	454.677	110.275
Polymer #3	17	0	778.686	516.563	125.285
Difference	17	0	-83.243	63.260	15.343

t = -5.426 with 16 degrees of freedom.

95 percent two-tailed confidence interval for difference of means: -115.768 to -50.718

Two-tailed P-value = 0.0000561

The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant change (P = <0.001)

One-tailed P-value = 0.0000280

The sample mean of treatment Polymer 3 exceeds the sample mean of treatment Polymer 2 by an amount that is greater than would be expected by chance, rejecting the hypothesis that the population mean of treatment Polymer 2 is greater than or equal to the population mean of treatment Polymer 3. (P = <0.001)

Power of performed two-tailed test with alpha = 0.050: 0.999

Power of performed one-tailed test with alpha = 0.050: 1.000

Summary of Results

There is a strong linear association between measurements made with the two sensors (R = 1.00). Relative percentage difference ranged from 7 to 121 percent (median: 11 percent; mean: 17 percent). The data passed the Shapiro-Wilk test for normality (P=0.293); therefore, a paired t-test was performed. The difference between mean values for the polymer #2- and polymer #3-calibrated EXO sensors was statistically significant (P<0.05).

Statistical Analyses - StablCal and Hach 2100AN Data

Slope comparison

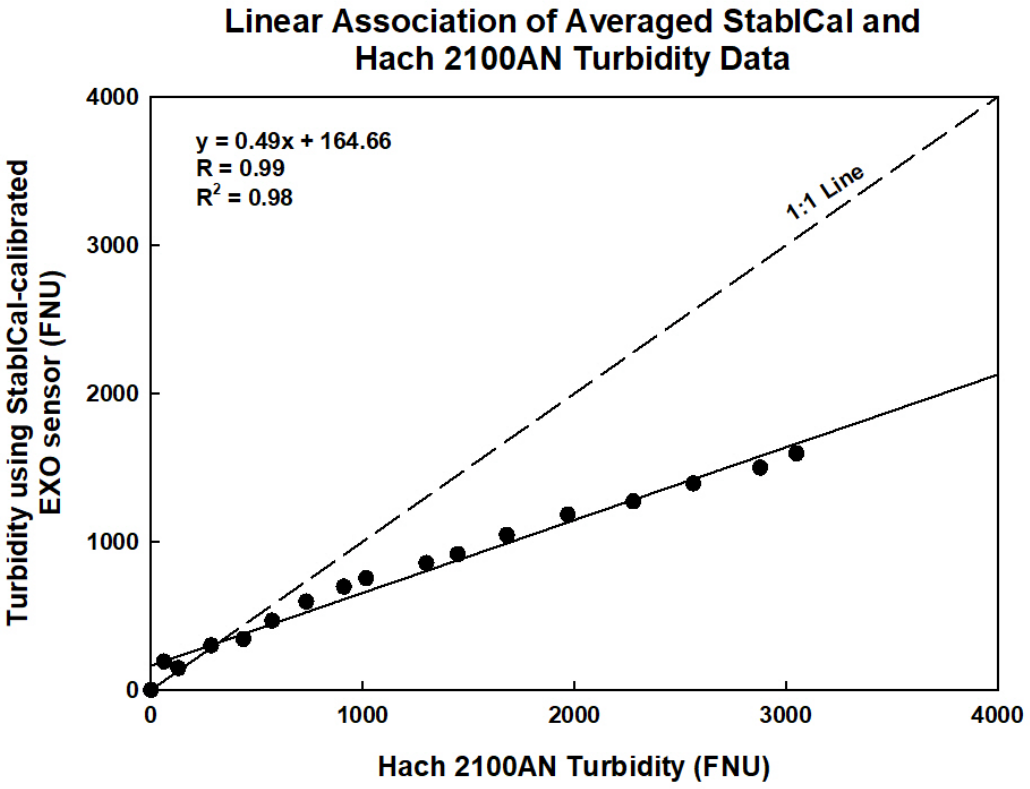
The following is a summary of final regression analysis for sensor-measured turbidity from one YSI EXO turbidity sensor calibrated by using StablCal turbidity standard and the Hach 2100AN laboratory turbidimeter at the Kansas Water Science Center laboratory, Lawrence, Kansas, on September 13, 2017; the data used in the final regressions were averages of turbidity for each step, each of which had a duration of approximately 15 minutes once the sensor had stabilized:

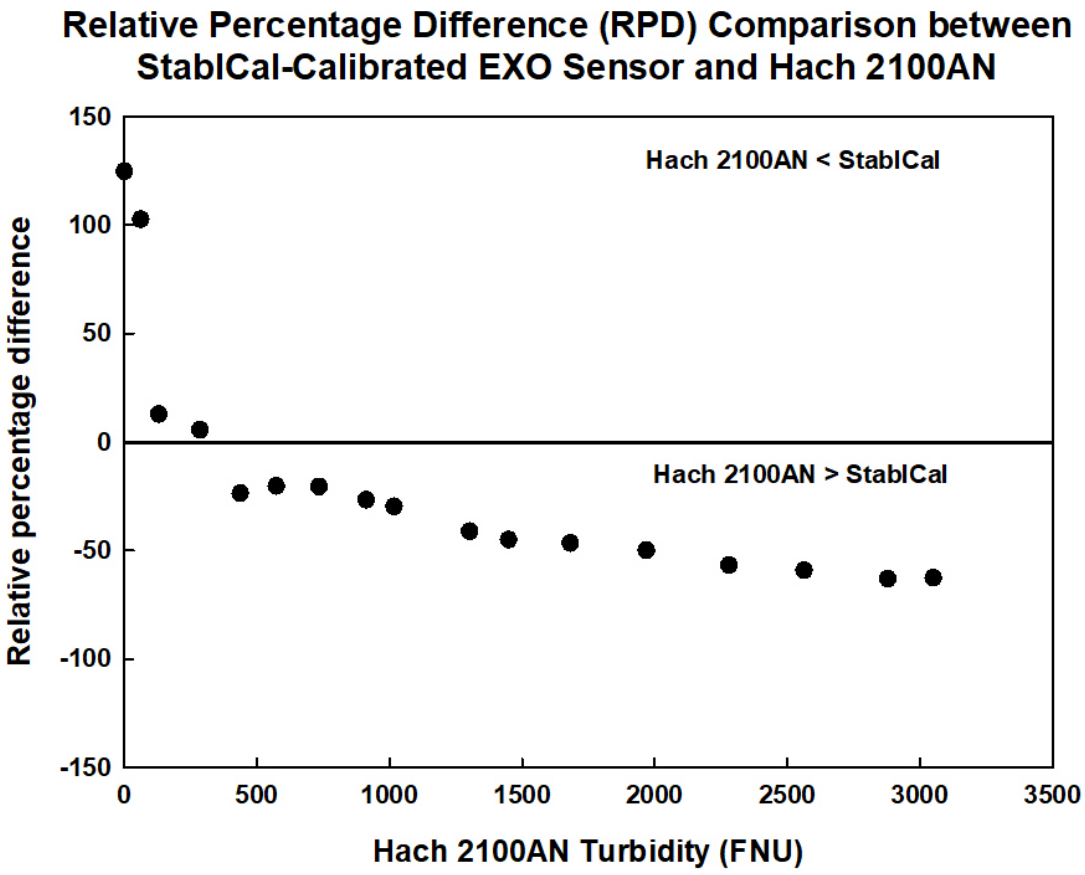
$$y = 0.49x + 164.66$$

where

y = turbidity measured with StablCal-calibrated EXO sensor (FNU)

x = turbidity measured with Hach 2100AN turbidimeter (FNU).


Linear Association of Averaged StablCal and Hach 2100AN Turbidity Data
y = 0.49x + 164.66
R = 0.99
R2 = 0.98
1:1 Line
Turbidity using StablCal-calibrated EXO sensor (FNU)
Hach 2100AN Turbidity (FNU)
0
1000
2000
3000
4000


Relative Percentage Difference (RPD) Comparison between StablCal-Calibrated EXO Sensor and Hach 2100AN
Hach 2100AN < StablCal
Hach 2100AN > StablCal
Relative percentage difference
Hach 2100AN Turbidity (FNU)
150
100
50
0
-50
-100
-150
0
500
1000
1500
2000
2500
3000
3500

Wilcoxon Signed-Rank Test for StablCal and Hach 2100AN Data

SigmaPlot Statistical Output:

Normality Test (Shapiro-Wilk): Failed (P < 0.050)

Group	N	Missing	Median	25%	75%
Hach 2100AN	17	0	1017.000	361.000	2124.500
StablCal	17	0	753.992	322.932	1226.922

W= -129.000 T+ = 12.000 T-= -141.000

Z-Statistic (based on positive ranks) = -3.053

P(est.) = 0.002 P(exact)= 0.001

The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant difference (P = 0.001).

R Statistical Output:

```
Wilcoxon Signed-Rank test with continuity correction

data:  Hach 2100AN and StablCal
V = 141, p-value = 0.001068
alternative hypothesis: true location shift is not equal to 0
95 percent confidence interval:
 130.5485 742.7775
sample estimates:
(pseudo)median
      439.8165
```

Summary of Results

There is a strong linear association between measurements made with the two sensors (R = 0.99). Relative percentage difference ranged from 6 to 125 percent (median: 45 percent; mean: 47 percent). The data did not pass the Shapiro-Wilk test for normality (P<0.05); therefore, a Wilcoxon signed-rank test was performed. The difference between median values for the StablCal-calibrated EXO sensor and Hach 2100AN was statistically significant (P<0.05).

Statistical Analyses - Polymer #1 and Hach 2100AN Data

Slope comparison

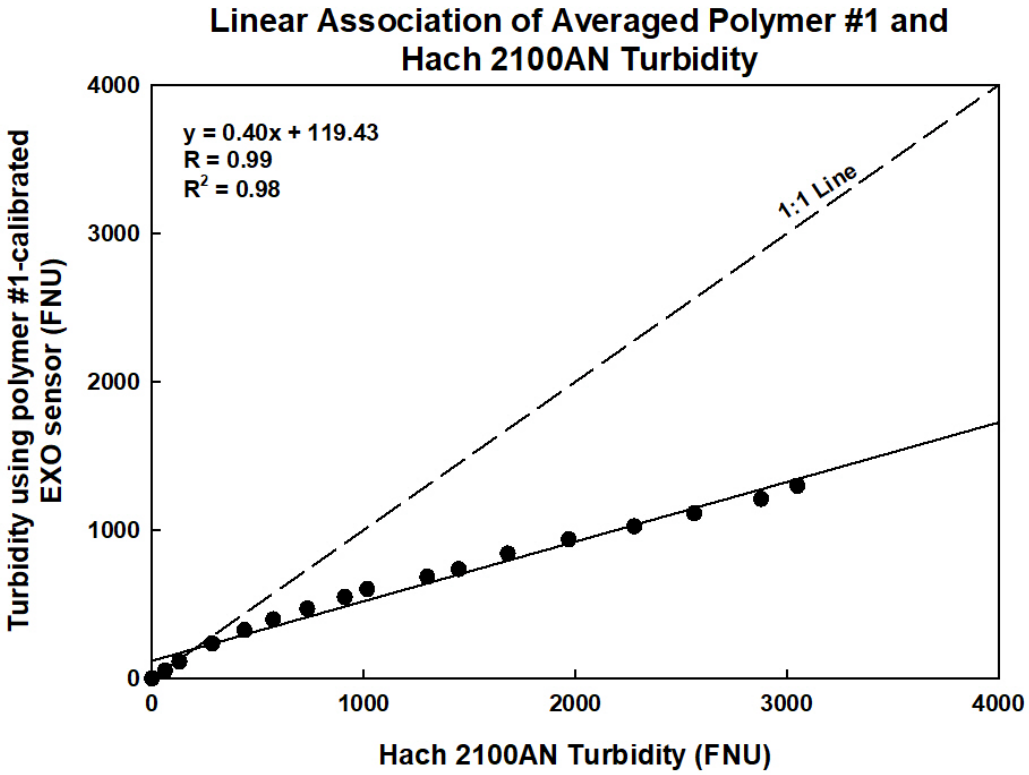
The following is a summary of final regression analysis for sensor-measured turbidity from one YSI EXO turbidity sensor calibrated by using polymer #1 turbidity standard and the Hach 2100AN laboratory turbidimeter at the Kansas Water Science Center laboratory, Lawrence, Kansas, on September 7, 2017; the data used in the final regressions were averages of turbidity for each step, each of which had a duration of approximately 15 minutes once the sensor had stabilized:

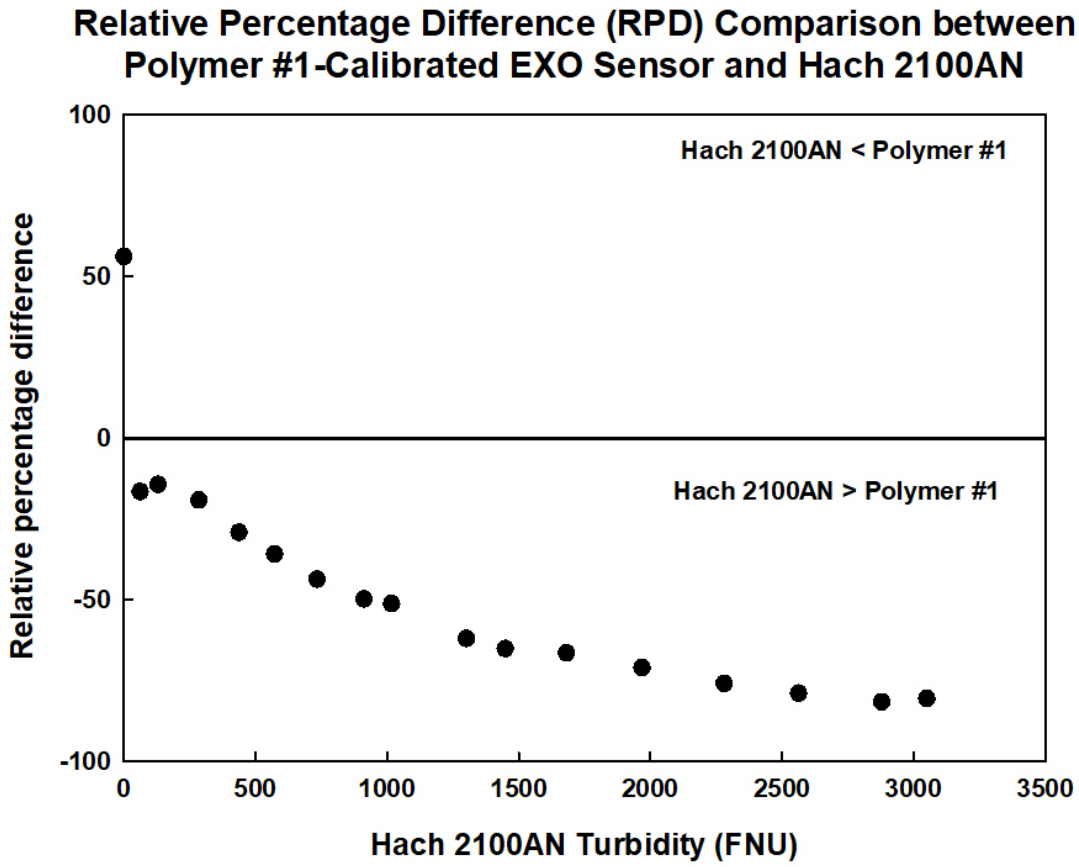
y = 0.40x + 119.43

where

y = turbidity measured with polymer #1-calibrated EXO sensor (FNU)

x = turbidity measured with Hach 2100AN turbidimeter (FNU).





Wilcoxon Signed-Rank Test for Polymer #1 and Hach 2100AN Data

SigmaPlot Statistical Output:

Normality Test (Shapiro-Wilk): Failed (P < 0.050)

Group	N	Missing	Median	25%	75%
Hach 2100AN	17	0	1017.000	361.000	2124.500
Polymer #1	17	0	602.014	280.210	980.887

W= -151.000 T+ = 1.000 T-= -152.000

Z-Statistic (based on positive ranks) = -3.574

P(est.) = <0.001 P(exact)= <0.001

The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant difference (P = <0.001).

R Statistical Output:

```
Wilcoxon Signed-Rank test with continuity correction

data:  Hach 2100AN and Polymer #1
V = 152, p-value = 3.052e-05
alternative hypothesis: true location shift is not equal to 0
95 percent confidence interval:
 232.5368 935.6528
sample estimates:
(pseudo)median
      603.4471
```

Summary of Results

There is a strong linear association between measurements made with the two sensors (R = 0.99). Relative percentage difference ranged from 14 to 87 percent (median: 56 percent; mean: 53 percent). The data did not pass the Shapiro-Wilk test for normality (P<0.05); therefore, a Wilcoxon signed-rank test was performed. The difference between median values for the polymer #1-calibrated EXO sensor and Hach 2100AN was statistically significant (P<0.05).

Statistical Analyses - Polymer #2 and Hach 2100AN Data

Slope comparison

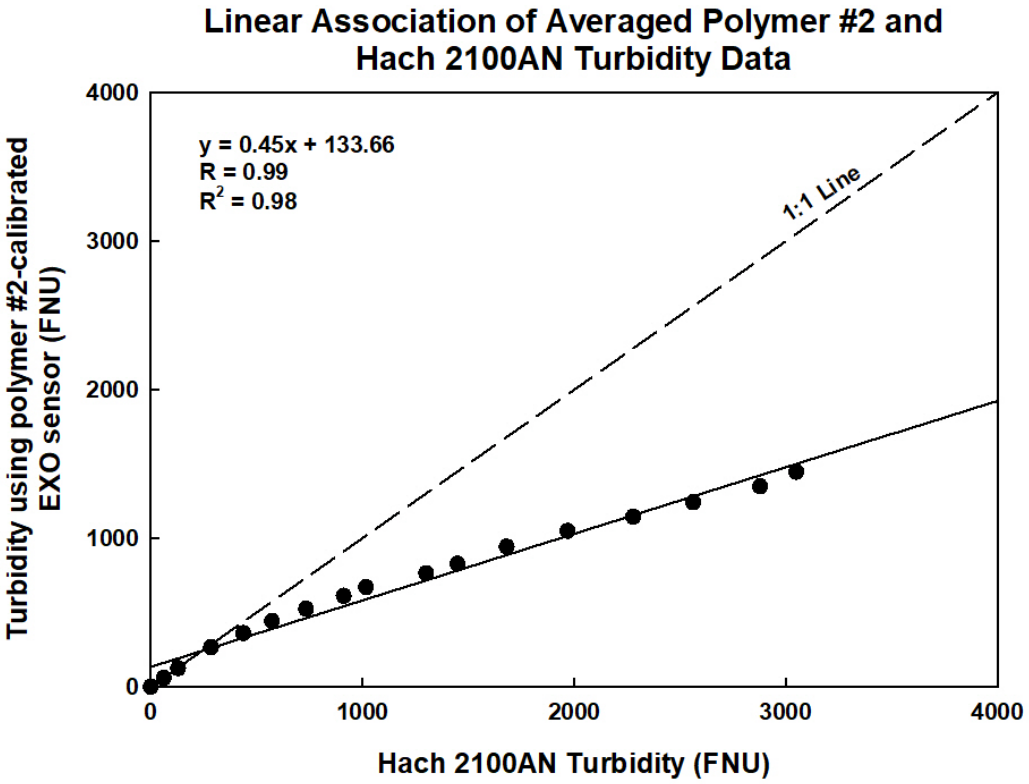
The following is a summary of final regression analysis for sensor-measured turbidity from one YSI EXO turbidity sensor calibrated by using polymer #2 turbidity standard and the Hach 2100AN laboratory turbidimeter at the Kansas Water Science Center laboratory, Lawrence, Kansas, on September 7, 2017; the data used in the final regressions were averages of turbidity for each step, each of which had a duration of approximately 15 minutes once the sensor had stabilized:

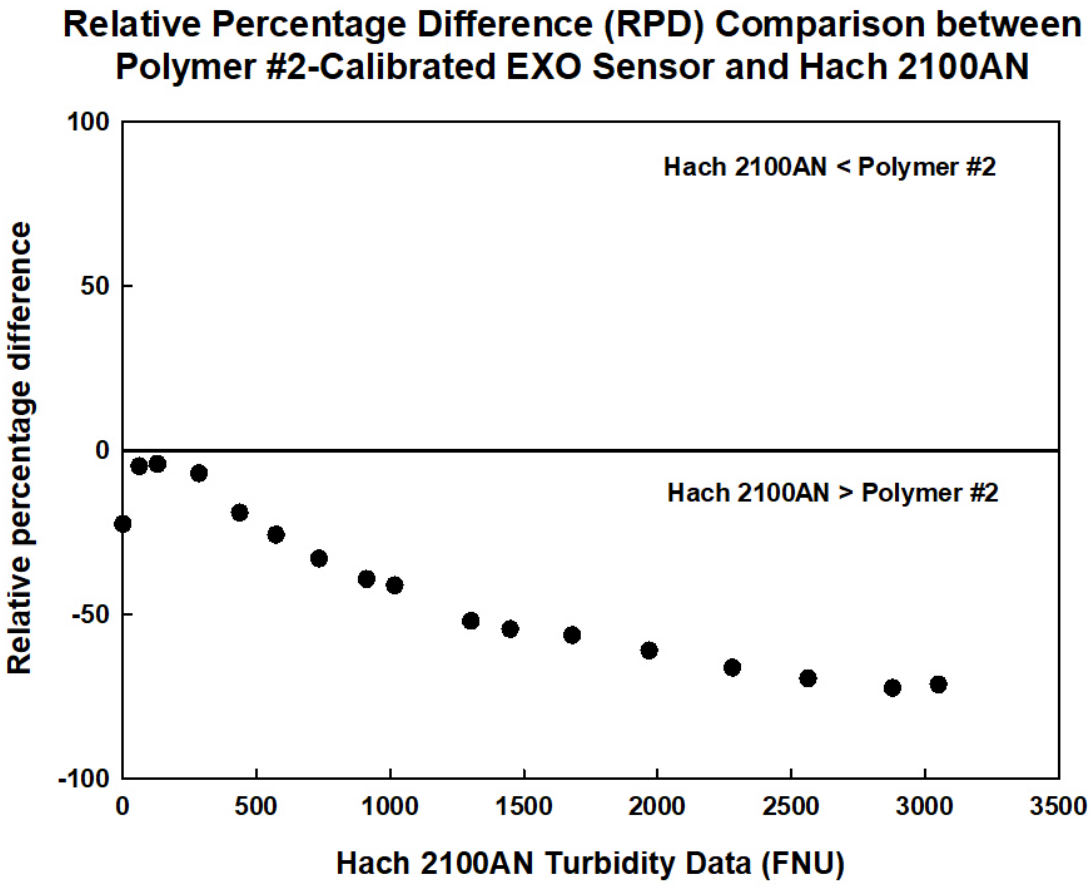
$$y = 0.45x + 133.66$$

where

y = turbidity measured with polymer #2-calibrated EXO sensor (FNU)

x = turbidity measured with Hach 2100AN turbidimeter (FNU).


Linear Association of Averaged Polymer #2 and Hach 2100AN Turbidity Data
y = 0.45x + 133.66
R = 0.99
R2 = 0.98
1:1 Line
Turbidity using polymer #2-calibrated EXO sensor (FNU)
Hach 2100AN Turbidity (FNU)
0
1000
2000
3000
4000



Wilcoxon Signed-Rank Test for Polymer #2 and Hach 2100AN Data

SigmaPlot Statistical Output:

Normality Test (Shapiro-Wilk): Failed (P < 0.050)

Group	N	Missing	Median	25%	75%
Hach 2100AN	17	0	1017.000	361.000	2124.500
Polymer #2	17	0	669.751	313.337	1096.771

W= -153.000 T+ = 0.000 T-= -153.000

Z-Statistic (based on positive ranks) = -3.621

P(est.) = <0.001 P(exact)= <0.001

The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant difference (P = <0.001).

R Statistical Output:

```
Wilcoxon Signed-Rank test with continuity correction

data:  Hach 2100AN and Polymer #2
V = 152, p-value = 3.052e-05
alternative hypothesis: true location shift is not equal to 0
95 percent confidence interval:
 183.3037 836.5805
sample estimates:
(pseudo)median
      525.7767
```

Summary of Results

There is a strong linear association between measurements made with the two sensors (R = 0.99). Relative percentage difference ranged from 4 to 72 percent (median: 41 percent; mean: 41 percent). The data did not pass the Shapiro-Wilk test for normality (P<0.05); therefore, a Wilcoxon signed-rank test was performed. The difference between median values for the polymer #2-calibrated EXO sensor and Hach 2100AN was statistically significant (P<0.05).

Statistical Analyses - Polymer #3 and Hach 2100AN Data

Slope comparison

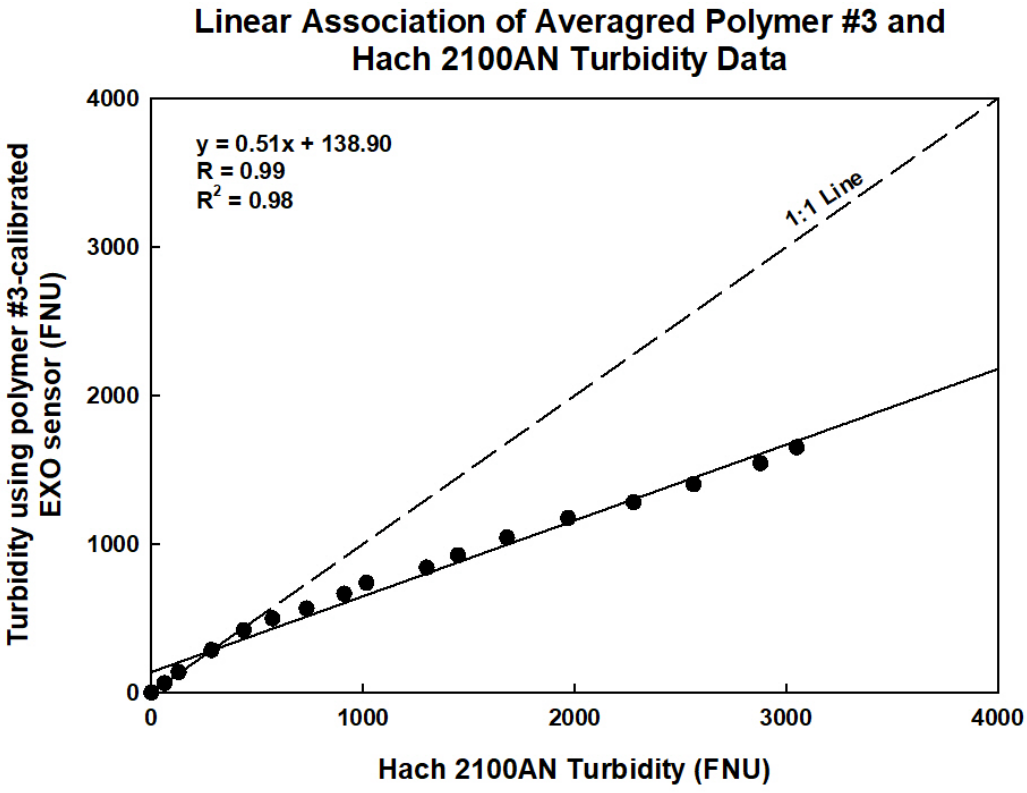
The following is a summary of final regression analysis for sensor-measured turbidity from one YSI EXO turbidity sensor calibrated by using polymer #3 turbidity standard and the Hach 2100AN laboratory turbidimeter at the Kansas Water Science Center laboratory, Lawrence, Kansas, on September 7, 2017; the data used in the final regressions were averages of turbidity for each step, each of which had a duration of approximately 15 minutes once the sensor had stabilized:

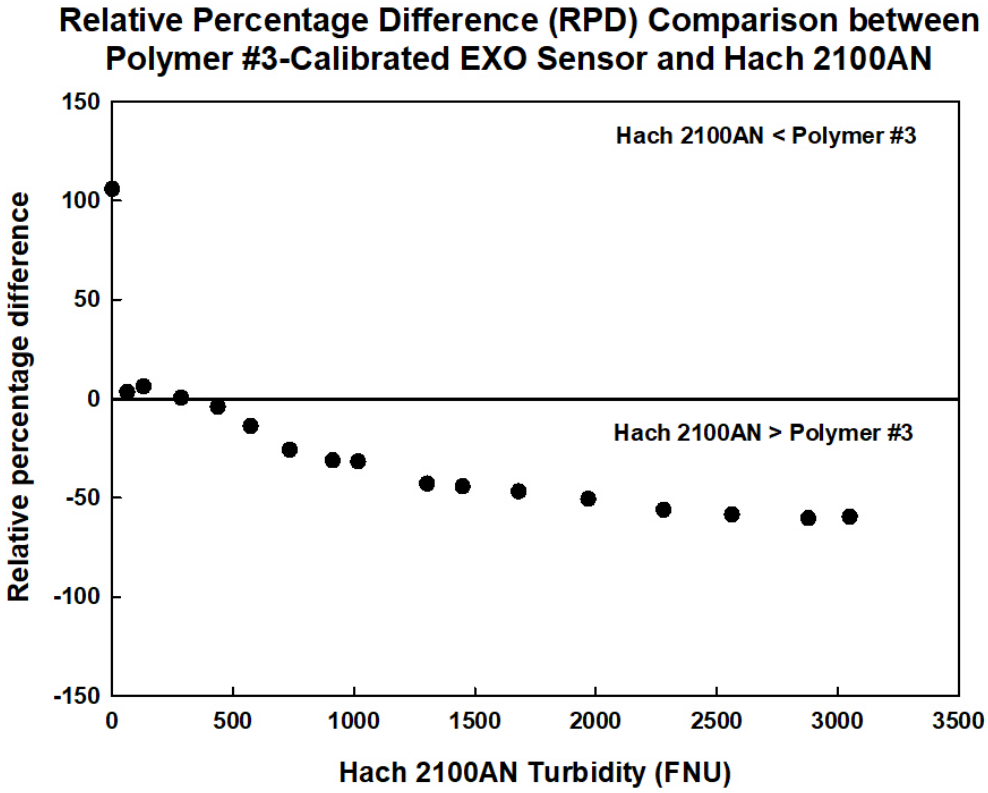
$$y = 0.51x + 138.90$$

where

y = turbidity measured with polymer #3-calibrated EXO sensor (FNU)

x = turbidity measured with Hach 2100AN turbidimeter (FNU).


Linear Association of Averagred Polymer #3 and Hach 2100AN Turbidity Data
y = 0.51x + 138.90
R = 0.99
R2 = 0.98
1:1 Line
Turbidity using polymer #3-calibrated EXO sensor (FNU)
Hach 2100AN Turbidity (FNU)
0
1000
2000
3000
4000


Relative Percentage Difference (RPD) Comparison between Polymer #3-Calibrated EXO Sensor and Hach 2100AN
Hach 2100AN < Polymer #3
Hach 2100AN > Polymer #3
Relative percentage difference
Hach 2100AN Turbidity (FNU)
150
100
50
0
-50
-100
-150
0
500
1000
1500
2000
2500
3000
3500

Wilcoxon Signed-Rank Test for Polymer #3 and Hach 2100AN Data

SigmaPlot Statistical Output:

Normality Test (Shapiro-Wilk): Failed (P < 0.050)

Group	N	Missing	Median	25%	75%
Hach 2100AN	17	0	1017.000	361.000	2124.500
Polymer 3	17	0	738.523	353.172	1227.843

W= -133.000 T+ = 10.000 T-= -143.000

Z-Statistic (based on positive ranks) = -3.148

P(est.) = 0.002 P(exact)= <0.001

The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant difference (P = <0.001).

R Statistical Output:

```
Wilcoxon Signed-Rank test with continuity correction

data:  Hach 2100AN and Polymer #3
V = 143, p-value = 0.0006561
alternative hypothesis: true location shift is not equal to 0
95 percent confidence interval:
 138.3861 719.8264
sample estimates:
(pseudo)median
      441.9948
```

Summary of Results

There is a strong linear association between measurements made with the two sensors (R = 0.99). Relative percentage difference ranged from 1 to 106 percent (median: 43 percent; mean: 38 percent). The data did not pass the Shapiro-Wilk test for normality (P<0.05); therefore, a Wilcoxon signed-rank test was performed. The difference between median values for the polymer #3-calibrated EXO sensor and Hach 2100AN was statistically significant (P<0.05).

Selected References

Cleveland, W.S., 1979, Robust locally weighted regression and smoothing scatterplots: Journal of the American Statistical Association, v. 74, no. 368, p. 829–836.

Helsel, D.R., and Hirsch, R.M., 2002, Statistical methods in water resources—Hydrologic analysis and interpretation: U.S. Geological Survey Techniques of Water-Resources Investigations, book 4, chap. A3, 522 p. [Also available at https://doi.org/10.3133/twri04A3.]

King, L.R., 2021, Laboratory and field data for selected turbidity standard and sensor comparisons, October 2014 to September 2017: U.S. Geological Survey Data Release, https://doi.org/10.5066/P9EVSDHH.

U.S. Geological Survey, variously dated, The national field manual for the collection of water-quality data: U.S. Geological Survey Techniques and Methods, book 9, chaps A1–A10. [Also available at https://water.usgs.gov/owq/FieldManual/.]