Accuracy and Precision of Portable Turbidity Meters

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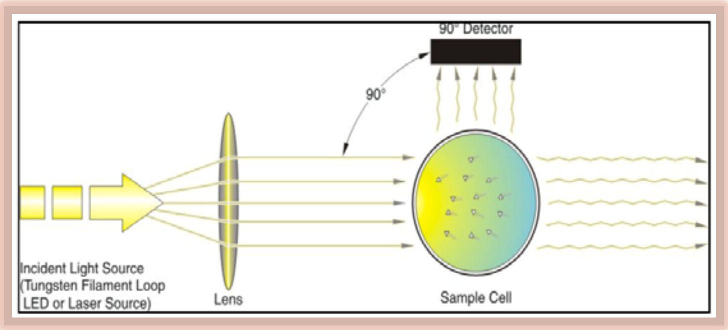
Introduction: Turbidity

- Turbidity measurements as an indicator of water degradation
- Potential sediment loading estimates
- Growing demand for high-quality objective turbidity measurements
- Recent EPA ELGs→ Numeric turbidity limit (280 NTU)

BACKGROUND:
Turbidity

- Water clarity measurement
- Optical property that measures light penetration through water
- SS and dissolved OM reduce light transmission
- Turbid waters= high concentrations of fines
- Typically measured with nephelometers [NTU]
  - Follow EPA 180.1 Method
  - Measure light scatter 90°
  - Tungsten lamp
  - Formazin or AMCO EPA



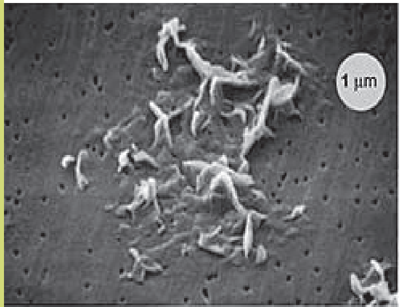
Background: Turbidity Standards

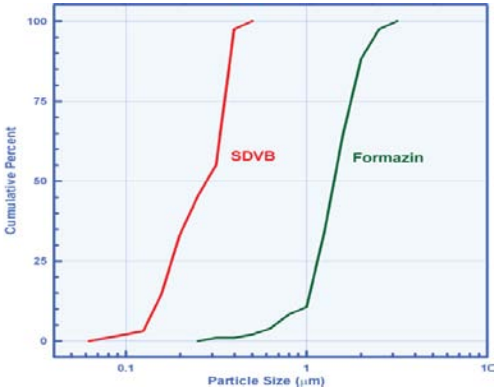
Formazin

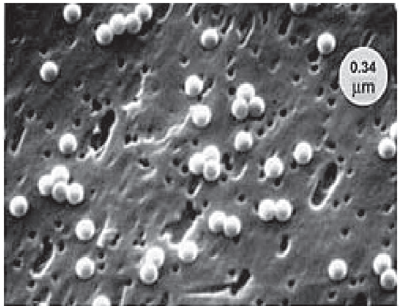
- Primary calibration standard
- Irregular in shape: 0.1 to 10.0 µm
- Primary SSS is difficult to prepare to create PCALs
  - Development of SCALs

AMCO-EPA

- EPA approved in 1984 as SCAL
- SDVB microspheres: uniform size, shape and particle size distribution
- 0.02 to 0.2 µm







RESEARCH OBJECTIVE:

Compare commercially available nephleometers to quantify accuracy and precision of each instrument for use in subsequent soil/water analysis objectives

Procedures:

- 4 nephelometers (EPA 1801.1):
  - Meters A & B= same model
  - Meter C
  - Meter D

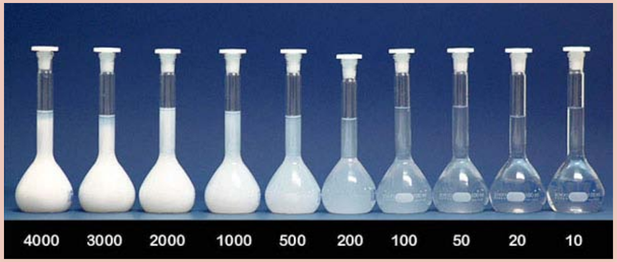
D A&B C

- Initial Tests
  - Meters calibrated to their own SCALs
    - Formazin= StablCal (Meters A & B)
    - SDVB= AMCO EPA (Meters C & D)
  - Good precision

- Utilized 4000 NTU primary formazin SSS to create PCALs

Procedures:

- Meter Accuracy and Precision:
  - Calibrated 1)SCALs and then 2)PCALs
  - Test Sample= created PCALs of 1, 10, 50, 100, 280, 500, 750 and 1000 NTU
  - Five readings
  - Accuracy= each reading's percent difference from the true value
  - Precision=each reading's percent difference from the avg. measured value



PROCEDURES:

- Meters Tested with Natural Water Samples
  - Calibrated 1) SCALS and 2)PCALs
  - Test Samples= 4 construction site samples, 1 golf course creek sample, and 1 BG's pond sample
  - Samples diluted if out of instrument's range following EPA's 180.1 example
  - Five readings averaged
  - Results plotted on bar chart

Results:

- **Accuracy:**

	Meter A		Meter B		Meter C		Meter D	
PCAL values[2] [NTU]	Calibrated to provided SCALs	Calibrated to PCALs	Calibrated to provided SCALs	Calibrated to PCALs	Calibrated to provided SCALs	Calibrated to PCALs	Calibrated to provided SCALs	Calibrated to PCALs
1	55.6	44.0	53.0	54.0	61.1	23.6	6.20	31.2
10	6.70	6.20	5.70	5.00	14.9	6.13	3.32	0.50
50	1.58	2.50	1.52	1.00	16.4	5.14	3.70	3.12
100	3.96	0.99	1.63	0.56	10.1	7.24	5.00	2.15
280	4.68	3.18	3.21	2.50	3.14	7.64	3.39	2.11
500	2.20	2.72	2.56	2.46	22.1	6.54	4.48	3.10
750	1.53	2.27	2.15	2.20	78.1	47.9	2.72	1.03
1000	1.12	1.54	1.24	0.62	21.3	24.2	1.11	2.79
AVG	**3.11**	**2.77**	**2.57**	**2.05**	**23.7**	**14.9**	**3.39**	**2.11**

- Meter A, B, D= accurate, but slightly above spec's ±2%
- Meters improved somewhat calibrated to PCALs
  - Meter A, B, C, and D = 0.34%, 0.52%, 8.57%, and 1.28%

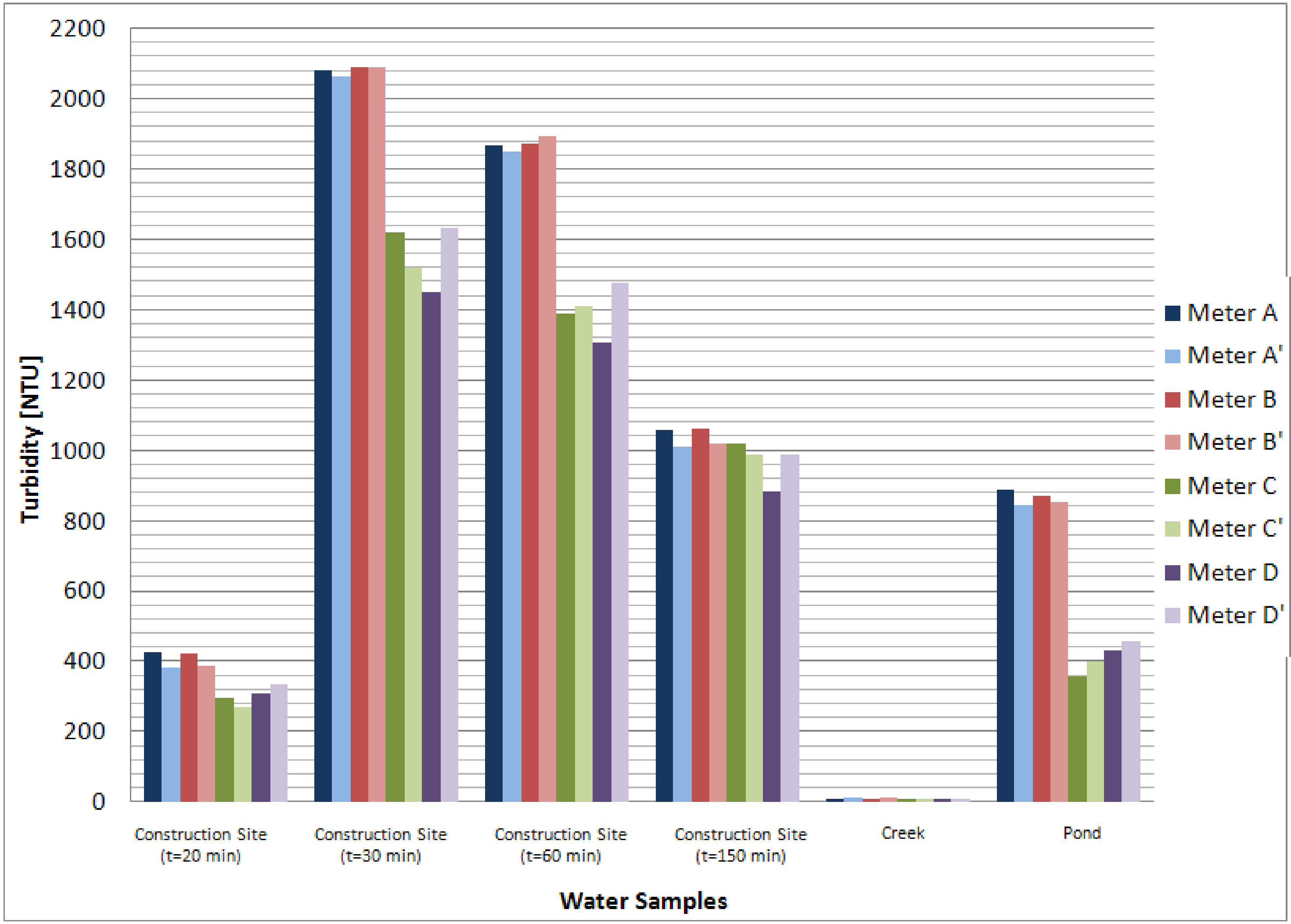
Results:

- **Precision:**

	Meter A		Meter B		Meter C		Meter D	
PCAL values[4] [NTU]	Calibrated to provided SCALs	Calibrated to PCALs	Calibrated to provided SCALs	Calibrated to PCALs	Calibrated to provided SCALs	Calibrated to PCALs	Calibrated to provided SCALs	Calibrated to PCALs
1	6.99	2.24	5.00	2.69	9.93	9.81	7.50	18.92
10	1.69	1.13	0.75	0.57	1.34	4.35	0.50	0.93
50	0.37	0.72	0.61	0.40	0.34	0.40	0.73	0.38
100	0.69	0.54	0.49	0.71	0.47	0.49	0.93	0.60
280	1.05	0.59	0.41	0.22	0.10	0.45	0.67	0.58
500	0.82	1.15	1.29	0.84	2.10	1.03	0.54	0.31
750	1.19	0.70	0.70	0.68	4.83	1.33	0.88	1.22
1000	1.21	0.77	0.65	0.46	1.07	0.42	0.89	0.99
AVG	**1.00**	**0.80**	**0.70**	**0.56**	**1.46**	**1.21**	**0.73**	**0.72**

  - Meters A, B, D= precise and fell within claimed ±1%
  - Meter C= slightly above ±1%

RESULTS:



2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Turbidity [NTU]
Construction Site (t=20 min)
Construction Site (t=30 min)
Construction Site (t=60 min)
Construction Site (t=150 min)
Creek
Pond
Water Samples
Meter A
Meter A'
Meter B
Meter B'
Meter C
Meter C'
Meter D
Meter D'

Results:

- Formazin vs. SDVB (AMCO-EPA) standards:
  - Meters A&B: diluted readings followed proportionality
    - 8.3% and 5.9% error from initial undiluted reading
  - Meters C&D: diluted readings did not follow proportionality
    - 50.7% and 43.2% error from initial undiluted reading
- Did not follow EPA's 180.1 Dilution Protocol of 40 NTU
  - Turbid samples very difficult to dilute and would introduce potential compounded errors
  - Not practical

Conclusions:

1. Meters may be precise, but there is potential for inaccuracy

2. Meters that performed well provided accurate and precise results for both calibration studies.

3. Field sample results suggested that differences from meters are most likely due to differences in formazin standards and SDVB standards.

Conclusions:

4. Formazin standards *may* be a better standard for surface water analysis.
5. Suggest revisions be made to EPA's Method 180.1

QUESTIONS?