Assessing Differences in Water Clarity Measurements Among Transparency Tube Users

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Many citizen monitoring groups across the nation use transparency tubes to assess water clarity in streams. In Wisconsin, about 60 volunteer stream monitoring groups use the tubes as do Department of Natural Resources' staff. These tubes provide an economical means of obtaining water clarity information, but additional information is needed to be able to use the information to its fullest extent. An aspect of concern related to transparency tube measurements is variability among individuals as results are based on subjective assessments.

On three occasions a standard turbidity solution similar to what might be found under natural conditions in Wisconsin streams was prepared using 4000 NTU formazin standard and distilled water. The concentration of the standard solution was not revealed to participants. Volunteers were asked to pour the standard solution into a transparency tube. After removing sunglasses (if any) and shading the tube from the sun, the volunteers were asked to report if they could see contrast between black and white on the Secchi disc in the bottom of the tube. If they could not see the distinction between black and white, an assistant opened the valve on the bottom of the tube and let the standard solution flow out of the tube into a clean bucket. The volunteer aiming to view the Secchi disc told their assistant to close the valve when they could just see the contrast between black and white on the disc. They reported their measurement in centimeters (cm). They repeated this process twice on two occasions and three times on one occasion. An average of all reported scores was calculated for each individual.

Mean transparency (cm), range, standard deviation, and percent error between the mean and standard deviation were calculated for each trial date (Table 1).

Additionally, transparency scores were converted to approximate nephelometric turbidity units (NTU; Table 2) using a conversion chart developed for Wisconsin's volunteer stream monitoring program by Dr. Kevin Fermanich of UW-Green Bay (Figure 1).

Day	Range (cm)	Mean (cm)	Standard deviation (cm)	n	% diff. of s.d. from mean
1	50-73	60	4.46	20	7
2	7-13	12.9	3.03	14	23
3	7-10.5	8.5	1.24	4	15

Table 1. Summary statistics for transparency values (cm) obtained by volunteer monitors on three sampling dates with standard formazin turbidity solutions.

Day	Mean (NTU)	Standard deviation (NTU)	n
1	5.25*	1	20
2	108	45.7	14
3	165	45	4

values.
*Using the conversion chart, we only know that NTU is less than 10. Thus, for calculations, half the detection limit (i.e., 5 NTU) was used.

There was between 7% and 23% error in the standard deviations as compared to the mean transparency readings in the trials. The lowest percent error was found when the transparency value was highest (i.e., when the sample was most clear). When the mean transparency readings were lower (i.e., 8.5 cm and 12.9 cm), the standard deviations represented a higher percent of the mean. Thus, when streams are more turbid, volunteers' results are more likely to be in error. However, in Wisconsin, 74% of 5797 samples collected since 1997 at about 650 stream sites had turbidities of 10 NTU or less (Figure 2). Thus, the data suggest that a fairly low error rate exists for the majority of data collected.

Centimeters	Inches	Transparency Value*
6.4 to 7.0	2.5 to 2.75	240
7.1 to 8.2	2.76 to 3.25	185
8.3 to 9.5	3.26 to 3.75	150
9.6 to 10.8	3.76 to 4.25	120
10.9 to 12.0	4.26 to 4.75	100
12.1 to 14.0	4.76 to 5.5	90
14.1 to 16.5	5.6 to 6.5	65
16.6 to 19.1	6.6 to 7.5	50
19.2 to 21.6	7.6 to 8.5	40
21.7 to 24.1	8.6 to 9.5	35
24.2 to 26.7	9.6 to 10.5	30
26.8 to 29.2	10.6 to 11.5	27
29.3 to 31.8	11.6 to 12.5	24
31.9 to 34.3	12.6 to 13.5	21
34.4 to 36.8	13.6 to 14.5	19
36.9 to 39.4	14.6 to 15.5	17
39.5 to 41.9	15.6 to 16.5	15
42.0 to 44.5	16.6 to 17.5	14
44.6 to 47.0	17.6 to 18.5	13
47.1 to 49.5	18.6 to 19.5	12
49.6 to 52.1	19.6 to 20.5	11
52.2 to 54.6	20.6 to 21.5	10
>54.7	>21.6	<10

Figure 1. Transparency (cm or in.) to turbidity (NTU) conversion chart.

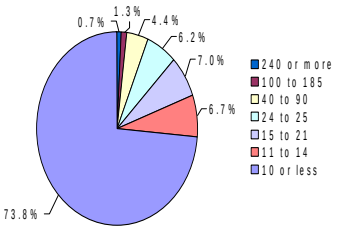

Figure 2. Percent of 5797 turbidity samples in specified NTU ranges in samples collected by Wisconsin volunteer stream monitors between 1997 and 2009.

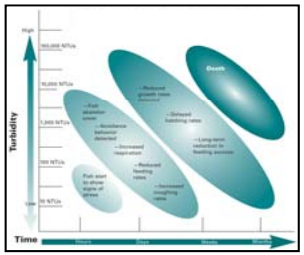

Figure 3. Relational trends of freshwater fish activity to turbidity values and time.

In terms of biological health of a stream ecosystem, measurements of less than 10 NTU represent healthy conditions for fish and other aquatic organisms (Figure 3). Thus, the low error rate found with low turbidity samples helps confirm the majority of streams monitored by volunteers in Wisconsin, at least when sampled, provide healthy water clarity conditions for aquatic life.

When transparency scores were converted to approximate NTU scores, the standard deviation for trials 2 and 3 was nearly equal, at 45 NTU. This suggests the program may want to reconsider the turbidity value categories. Combining categories together to encompass a wider range of NTU values may help minimize error in converted values.

Sources of error in measurement includes eyesight differences among monitors, light conditions, response time of assistant operating the valve, proximity of a person's eye to the tube, and slight differences in methodology between users (e.g., cupping their hand between the top of the tube and their eye vs. not doing so). The program can help minimize these sources of error through careful training, stating explicit directions in written methods, and reinforcing methods through field quality assurance checks and refresher trainings. Purchasing or converting the tubes so they can be operated by the viewer without assistance is another option. Further studies are planned to build the dataset and to assess citizen monitors' results as compared to turbidimeter results.

Photos by Sarah Schmidt and Kristine Stepenuck