Turbidimeter

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Abstract

AguaClara needs a reliable and simple method for candidate communities to monitor the turbidity of their water supply. Portable turbidimeters cost $400 or more and thus are too expensive to provide to a large number of candidate communities. The goals of providing candidate communities with turbidimeters is to determine the source water turbidity range and hence the type of water treatment that will be required. The AguaClara team invented a low cost high range turbidimeter ($5 for materials) that can measure between 15 and 400 NTU during the spring and summer of 2011. The high range turbidimeter needs a few refinements and improved document to facilitate dissemination of the technology. A new challenge is to develop a low range turbidimeter that can measure to 5 or even 1 NTU. The low range turbidimeter could use mirrors to extend the light path, a much longer tube, or it could switch to using a different detector than the human eye.

students	3
skills	some fabrication and experimentation

1 Introduction

The AguaClara high range turbidimeter is an ultra low cost device that can be used to measure turbidity between 15 and 400 NTU. The first version of the high range turbidimeter is currently being evaluated in Honduras. A student from Zamorano University is using the turbidimeter on a regular basis to track the turbidity of their proposed water source for an AguaClara plant. They are also using a conventional turbidimeter and so will be able to compare results.

Create design files and an AutoCAD drawing of the AguaClara turbidimeter. Include a complete parts list, detailed fabrication instructions, a template for the turbidity scale, and guidelines for using the meter.

Write a journal paper for submission to Journal of Environmental Engineering describing the theory and application of the AguaClara turbidimeter. Include feedback from use in Honduras. Connect with the need for a global monitoring program for drinking water quality.

Figure 1: Measuring turbidity with the high range AguaClara turbidimeter at the Zamorano water source in Honduras (August 2, 2011).

The ability to make a low cost turbidimeter that doesn't rely on ambient light or a transparent sample container suggests that it may be worthwhile evaluating the possibility of creating a low range turbidimeter. A low range turbidimeter would be possible to use for monitoring plant performance.

2 Low Range Turbidimeter

The path length required for low turbidity measurements becomes unwieldy for low turbidity measurements. It might be possible to extend the range of the turbidimeter by placing the light source at the top of the water column (facing down) and then using a mirror on a stick. This would double the light path length. It might even be possible to add a mirror at the top surface so that multiple reflections could occur between the two mirrors. In any case, the required path length becomes very long for turbidities

3 Resolution Depth Analysis

The equations for turbidity as a function of depth used in this analysis was obtained from the spring of 2011. The equation developed for the high range turbidimeter by the summer of 2011 had an exponent that was closer to 1.

The equations describing the resolution depth as a function of turbidity are given below.

$$Turbidity\left(Depth\left(m\right)\right) = \frac{b \cdot NTU}{\left(\frac{Depth}{m}\right)^{\frac{7}{4}}} \tag{1}$$

where b is a coefficient from the curve fit equal to 2.14.

Equation 1 can be solved for the depth as a function of turbidity to create a turbidity scale.

$$Depth(Turbidity) = \left(\frac{b * NTU}{Turbidity}\right)^{\frac{4}{7}} m \tag{2}$$

The simplest model for loss of resolution is that the photons originating from the display are blocked by clay. It is possible to estimate the blocking effect of the clay particles. The density of clay is

$$\rho_{Clay} = 2650 \frac{kg}{m^3} \tag{3}$$

The number of clay particles in an optical path is

$$N_{Clay} = \frac{C_{Clay}}{\rho_{Clay}} \frac{A_{Clay}}{V_{Clay}} L_{Path} \tag{4}$$

For a sphere the ratio of volume to area is

$$\frac{V_{Clay}}{A_{Clay}} = \frac{2}{3} d \tag{5}$$

Substituting into equation 4 we obtain

$$N_{Clay} = \frac{3}{2d} \frac{C_{Clay}}{\rho_{Clay}} L_{Path} \tag{6}$$

If we assume that the number of clay particles in the optical path required to obscure the pattern is order 1, then we can obtain an estimate of the path length as a function of clay concentration.

$$L_{Path} = \frac{2}{3} d \frac{\rho_{Clay}}{C_{Clay}} \tag{7}$$

A plot of equation 7 is provided in Figure 2. The results suggest that it could require a 10 m path length to obscure a display if the turbidity is 1 NTU. It is also apparent that low turbidity displays will need to be much larger so they can be detected by the eye. Perhaps a simple Secchi disk pattern could be used for the low turbidity range. Would it be possible to create a sample cell that traveled 1 m a total of 10 times between mirrors before reaching the eye?

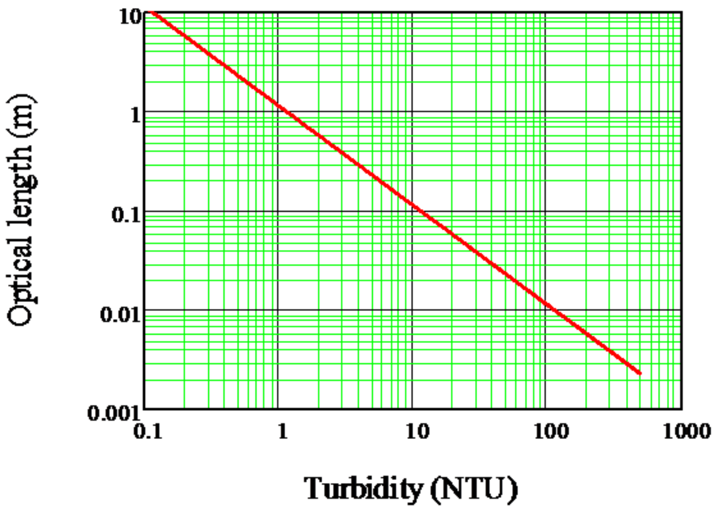

Figure 2: Optical depth vs turbidity based on the assumptions that the clay is 1 μm in diameter and that the display is obscured when an average of one clay particle blocks the light path.