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Turbidity and Total Solids in Surface Water
--Manuscript Draft--

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PI: Kimberly Frye and Margaret Workman, DePaul University

Environmental Science Education Title:

Turbidity and Total Solids in Surface Water

Overview: Turbidity and total solids are related measurements addressing clarity of surface waters. Turbidity is an indirect measure of water clarity that determines the amount of light that can pass through the water. Total solids is direct measurement of solid particles suspended in water determined by weight.

High levels of turbidity (fig1) and total solids are caused by soil erosion, waste discharge, runoff, or changes in ecological communities including algal growth or abundance of benthic organisms that can disrupt sediments up into the water. Higher levels of turbidity and suspended solids can lower water quality by absorbing heat causing an increase in water temperature and a decrease in oxygen levels (warm water holds less oxygen). These conditions can also cause a decrease in photosynthesis as less sunlight penetrates the water, making the water unable to support some aquatic life. Suspended solids can also clog gills, smother eggs, reduce growth rates, and disrupt microhabitats of many aquatic organisms.

An alternative method of measuring turbidity includes using a Secchi disk. A Secchi disk is a metal disk with alternate black and white quarters (fig2). It is attached to a rope that has one foot markings along it. The disk is dropped into water until it can no longer be seen (fig3). The drawback of this method is that it must be done in the field. By using the turbidity tubes, one can collect water and then perform the turbidity measurements back in the laboratory. In addition, if there is a large distance between the river bank and the water level, it is difficult to use the Secchi disk.

Principles: Turbidity is a relative measurement determined by measuring how much light can pass through the water sample. The higher the turbidity, the less light will pass through the sample and the “cloudier” the water will appear. Higher turbidity levels are caused by solid particles suspended in the water that scatter rather than transmit light. The collected unknown water sample is compared to a deionized (DI) water blank sample that represents a turbidity value of zero. A standard turbidity reagent (<1% kaolin, <0.1% magnesium nitrate, <0.1% magnesium chloride, < 0.1 % 2-Methyl-4-isothiazolin-3-one, < 0.1% 5-Chloro-2-Methyl-4-isothiazolin-3-one) is added to the blank test column in predetermined measurements to increase cloudiness in known increments until the blank and unknown sample match in turbidity based on observation of a fixed point on the bottom of two test columns. The amount of reagent required to achieve matching samples can then be converted with table into Jackson Turbidity Units

(JTUs), named after the original method of holding a long glass "Jackson" tube over a lit candle.

Total Solids is a direct measurement of the suspended solid material in the water sample. The mass of the solids is determined by using an oven to evaporate the water from the sample and isolate and weigh the solids.

Procedure:

1. Measuring Turbidity

- 1.1. Fill the "Sample" Turbidity Column to the 50 ml line with the sample water.
- 1.2. Fill the second "Blank" Turbidity Column with deionized water to the 50 ml line.
- 1.3. Place the two tubes side by side and note the difference in clarity. If the black dot is equally clear in both tubes, the turbidity is zero. If the black dot in the sample tube is less clear, proceed to next step.
- 1.4. Shake the Standard Turbidity Reagent.
- 1.5. Add 0.5 ml of the reagent to the distilled water tube. Use the stirring rod to stir contents.
- 1.6. Check for amount of turbidity by looking down through the solution at the black dot. If the turbidity of the sample water is greater than that of the distilled water, continue to add Standard Turbidity Reagent in 0.5 ml increments to the distilled water tube, recording the amount of reagent used and mixing after each addition until the turbidity equals that of the sample.
- 1.7. Record the total amount of Turbidity Reagent added.

2. Measuring Total Solids

- 2.1. With gloved hands, label three beakers with a grease pencil. Do not use labeling tape because these beakers are going into the oven.
- 2.2. Turn on balance and zero it.
- 2.3. Place the beaker on the balance and record the weight. Make sure to use a balance that records to the thousandths of a gram. Use gloves to avoid

touching the beaker with bare hands and transferring body moisture, thereby changing the weight of the beaker.

- 2.4. Using a graduated cylinder, measure 100 ml of your water sample. If the sample has been sitting, swirl the sample water before you measure out the 100 ml.
- 2.5. Pour this amount into your beaker.
- 2.6. Place the beaker in an oven at 100°C for 48 hours to evaporate the liquid and dry the resulting residue.
- 2.7. After 48 hours, reweigh your beaker with the residue. Remember: Don't touch the beaker with your bare hands.
- 2.8. Subtract the initial weight (in grams) of the empty beaker from the weight of the beaker with residue to obtain the increase in weight, or weight of the residue.
- 2.9. Convert the weight of the residue into mg/l using the following calculation

$$\frac{\text{Weight of residue}}{100 \text{ ml}} \times \frac{1000 \text{ mg}}{1 \text{ g}} \times \frac{1000 \text{ ml}}{1 \text{ L}} = \frac{? \text{ mg}}{\text{L}} \underline{\hspace{1cm}}$$

3. Representative Results: Interpreting Impact on Water Quality

- 3.1. The table below is used to convert amount of reagents into the turbidity units (JTU). (table 1)

TURBIDITY
Excellent < 10 JTUs
Good 10 – 20 JTUs
Fair 20 – 90 JTUs
Poor > 90 JTUs

- 3.2.** Total solids can be assessed using the Water Quality Monitoring Quantitative Analysis categories for total solids measurements.

TOTAL SOLIDS (mg/L)

Excellent <100

Good 100 – 250

Fair 250 – 400

Poor > 400

- 4. Applications:** High turbidity levels and total solids in surface water make water unpalatable for human use and can also disrupt ecosystem functioning by blocking light and interrupting photosynthesis and limiting oxygen production. High amounts of suspended solids can also become lodged into gills of oxygen-breathing animals in the water. Turbidity and total solids both increase at times when algal growth is high or when sediment is lifted up into the water during a storm. Both can also increase in response to human activity such as water pollution including industrial, agricultural, and residential runoff. Wastewater from sewage systems, urban runoff, and soil erosion from development can also contribute to high levels of turbidity and total solids. Easy to conduct at the site of water collection, these two simple measurements are broad indicators for a wide range of threats to water quality, all of which render surface water less useful for human purposes and also less able to support itself as an aquatic ecosystem.

Legend:

Figure 1: Turbid creek water caused by heavy rains (*Larry D. Moore CC BY-SA 3.0*)

Figure 2: The modified Secchi disk design used in freshwaters

Figure 3: Different Kinds of Secchi disks

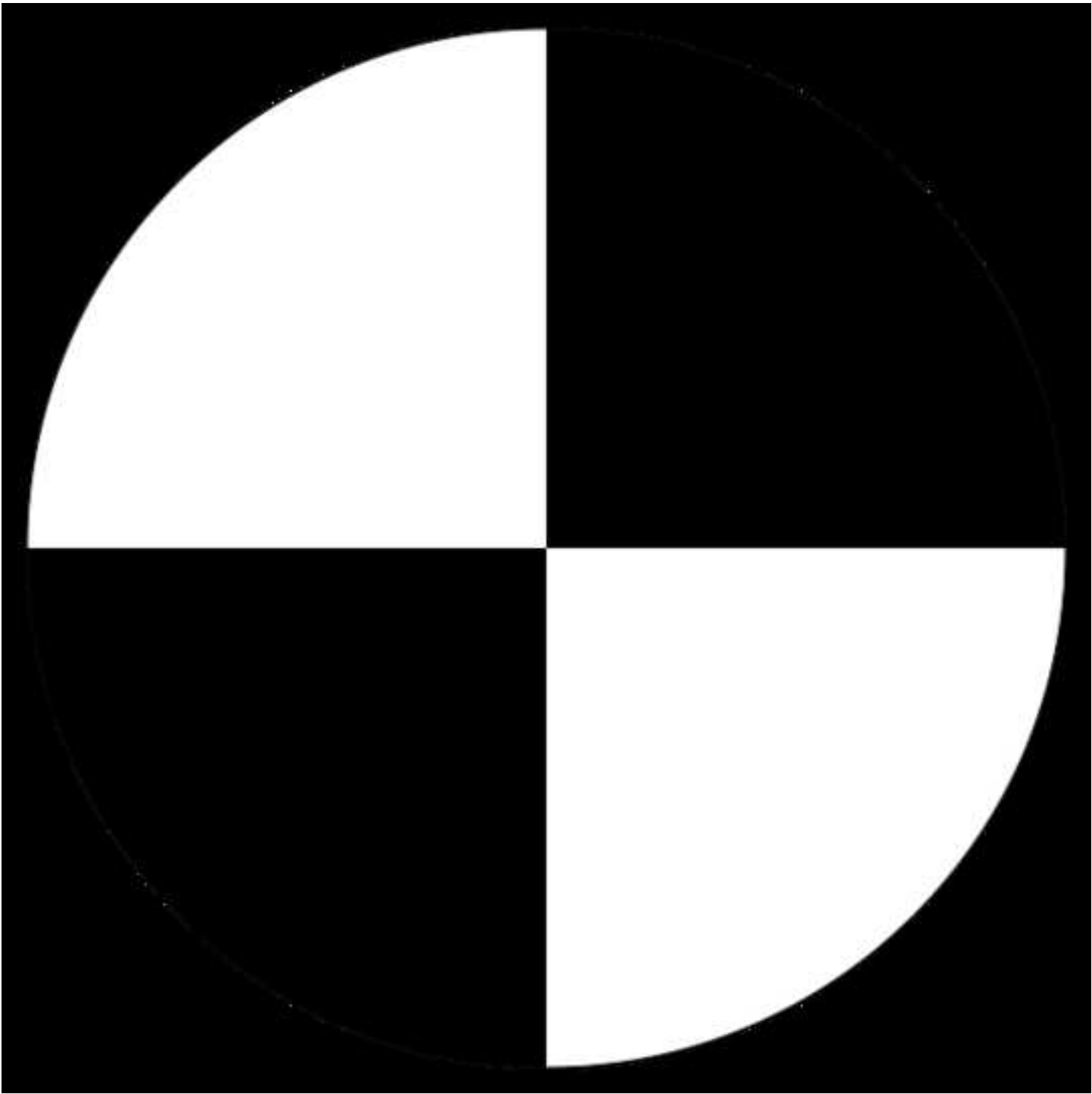
A marine style one on the left and the freshwater version on the right

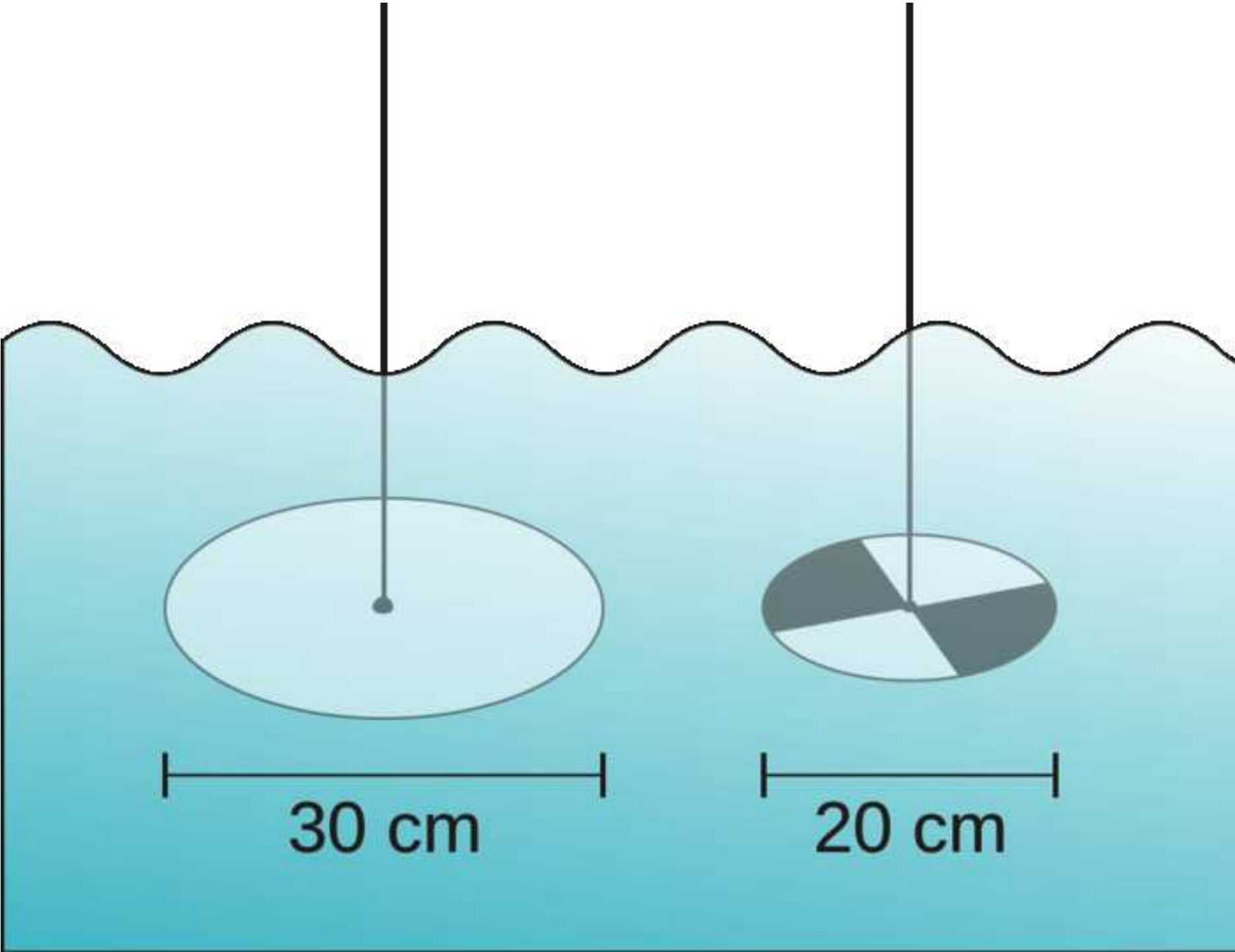
Table 1. Turbidity Test Results Table to convert number of drops (turbidity reagent) to turbidity units (JTU) and the Water Quality Monitoring Quantitative Analysis categories for turbidity.

Number of Measured Additions	Amount in mL	Turbidity (JTUs)
1	0.5	5
2	1.0	10
3	1.5	15
4	2.0	20
5	2.5	25
6	3.0	30
7	3.5	35
8	4.0	40
9	4.5	45
10	5.0	50
15	7.5	75
20	10.0	100

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High levels of turbidity (fig1) and total solids are caused by soil erosion, waste discharge, runoff, or changes in ecological communities including algal growth or abundance of benthic organisms that can disrupt sediments up into the water. Higher levels of turbidity and suspended solids can lower water quality by absorbing heat causing an increase in water temperature and a decrease in oxygen levels (warm water holds less oxygen). These conditions can also cause a decrease in photosynthesis as less sunlight penetrates the water, making the water unable to support some aquatic life. Suspended solids can also clog gills, smother eggs, reduce growth rates, and disrupt microhabitats of many aquatic organisms.

OneAn alternative method of measuring turbidity includes using a Secchi disk. A Secchi disk is a metal disk with alternate black and white quarters (fig2).- It is attached to a rope that has one foot markings along it. The disk is dropped into water until it can no longer be seen (fig3). -The drawback of this method is that it must be done in the field. and ideal protocol requires sunny conditions and a shaded testing area. In addition, if there is a large distance between the river bank and the water level, it is difficult to use the Secchi disk. By using ~~the~~ turbidity tubes, one can collect water and then perform the turbidity measurements back in the laboratory.

Principles: Turbidity is a relative measurement determined by measuring how much light can pass through the water sample. -The higher the turbidity, the less light will pass through the sample and the "cloudier" the water will appear. Higher turbidity levels are caused by solid particles suspended in the water that scatter light rather than allow it to be transmitted through the water-light.

The physical characteristics of suspended particles can have an effect on overall turbidity. Larger-sized particles can scatter light and concentrate it into a forward direction, increasing turbidity by creating interference with light transmission through the water. Particle size can also affect the quality of light; larger particle sizes tend to scatter longer wavelengths of light more than shorter wavelengths, whereas smaller particles have more scattering effect on shorter wavelengths. Increased particle concentration can also lower light transmission when light comes into contact with an increased

Comment [1]: What is this an alternative from?

Comment [2]: Would day to day changes in available light also be an issue with this method?

Comment [3]: Is there something we should say about particle concentration vs. size and how it relates to turbidity?

number of particles and travels a shorter distance between the particles, causing multiple scatterings with each particle. Darker-colored particles absorb more light, whereas light-colored particles can increase light scattering, and both result in increased turbidity measurements.

The collected unknown water sample is compared to a deionized (DI) water blank sample that represents a turbidity value of zero. A purchased standard turbidity reagent (<1% kaolin, <0.1% magnesium nitrate, <0.1% magnesium chloride, < 0.1-% 2-methyl-4-isothiazolin-3-one, < 0.1% 5-chloro-2-methyl-4-isothiazolin-3-one) is added to the blank test column in predetermined measurements to increase cloudiness in known increments until the blank and unknown sample match in turbidity based on observation of a fixed point on the bottom of two test columns. The amount of reagent required to achieve matching samples can then be converted with a table into Jackson Turbidity Units (JTUs), named after the original method of holding a long glass "Jackson" tube over a lit candle.

Comment [4]: Is this a reagent you purchase, or do you make it in-house?

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TOTAL SOLIDS (mg/L)

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4. **Applications:** Turbidity and total solids are important measurements of water quality, because they are the most visible indicators of how “clean” a water source is. High turbidity levels and total solids can indicate the presence of water pollutants that have an adverse effect on human, animal, and plant life including bacteria, protozoa, nutrients (e.g. nitrates and phosphorus), pesticides, mercury, lead, and other metals. Increased turbidity and total solids in surface water make water unpalatable for human use aesthetically and can provide surfaces in the water for disease-causing microorganisms to grow, harboring water-borne pathogens such as cryptosporidiosis, cholera, and giardiasis. ~~and can also disrupt ecosystem functioning by blocking light and interrupting photosynthesis and limiting oxygen production.~~ High amounts of suspended solids can also become be a problem to other species living in the water if particles become lodged into gills of oxygen-breathing animals. Suspended particles can disrupt light cycles and photosynthesis, altering the concentration of oxygen in the water and disturbing the aquatic system food web. Turbidity and total solids both increase at times when algal growth is high or when sediment is lifted up into the water during a storm. Both can increase in response to human activity, such as water pollution including industrial, agricultural, and residential runoff. Wastewater from sewage systems, urban runoff, and soil erosion from

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A marine style one on the left and the freshwater version on the right

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