Color measurement

Water color

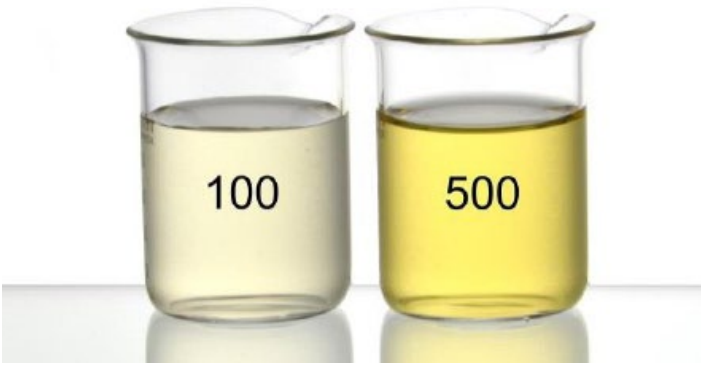
The color of our water is important not only for drinking purposes, but also for aquatic environments, and for home and industrial uses. Color in water can be caused by dissolved and suspended materials. In water and wastewater color measurement, there is a distinction between apparent color and true color[1]. Apparent color is the color of the sample as received and includes color due to both the dissolved and suspended materials in the water. True color is the color in the sample after it has been filtered to remove suspended materials, such as algae and particulates which cause turbidity. True color is the result of only dissolved species in water – natural organic matter, minerals, or chemicals.

Techniques to measure color in water

There are two main approaches to measuring water color:

- Visual methods – a water sample is visually compared to a series of colored standards.
- Spectrophotometric methods - the color is determined by measuring how much light is absorbed or transmitted through a sample at a single wavelength or at a number of certain wavelengths. The results are then compared with a known color standard or used in various algorithms, which are defined by the test method.

Many groups publish methods for measuring color. Examples of spectrophotometric methods are Platinum-Cobalt Color, Tristimulus Values, and ADMI methods[2]. Specific method references for color in water include: APHA Standard Methods 2120; EPA 110.1; DIN ISO 7887 and SAC 436 nm; China MEP GB 11903; NCASI Technical Bulletin 253 or 803; and others.



Color standards and color units

Platinum cobalt color standard and units

The most common color measurement of water and wastewater is Platinum-cobalt color (Pt-Co), also known as APHA color or Hazen color. These names are commonly used in different applications, but they are based on identical procedures. Measurement with the Pt-Co/APHA/Hazen standard is based on the Hazen color scale that was introduced in 1892 by chemist Allen Hazen. The color is a light yellow to brown color. The range is 0–500 Platinum Color Units (PCU). Intermediate standards are prepared from a platinum cobalt 500 ppm stock solution that is available commercially[3] or can be prepared by user[1]. A unit of color is the color produced by 1 mg/L platinum in the form of chloroplatinum ion. The color values measured by comparison with the platinum-cobalt standards can be expressed as PCU, Pt-Co, APHA, or Hazen units depending on the specific procedures. In the United States, the National Secondary Drinking Water Regulation for color is a maximum of 15 color units. The World Health Organization recommends that drinking water color does not exceed 15 true color units.

Other color standard and color units

For samples where the color is different from Pt-Co standards, several different standards and color scales are used such as: ADMI Color (American Dye Manufacturer's Institute), Gardner Color, Saybolt, Rosin, EBC (European Brewery Convention), CIE System, etc.

Platinum cobalt color methods

Two single-wavelength methods are commonly used in the United States to measure water and wastewater color with color characteristics similar to that of the Pt-Co standards:

- **Water/wastewater at 455 nm**–This method utilizes a spectrophotometer to measure the absorbance of light as it passes through a sample at the 455 nm wavelength. This procedure is recommended for water from naturally occurring materials, i.e., vegetable residues such as leaves, barks, roots, humus, and peat materials. If samples are turbid, they should be filtered through a 0.45 µm filter prior to the analysis to determine the true color. To determine the apparent color, non-filtered samples are measured. Samples with a high color (>500 PCU) should be diluted until the color is within the range of the standard curve. Sample pH should not be adjusted as long as it is between 4 and 10.

- **Pulp mill wastewater at 465 nm**–This method utilizes a spectrophotometer to measure the absorbance of light as it passes through a sample at the 465 nm wavelength. This method is adapted from the NCASI Technical Bulletin 803 for pulp and paper effluent[4] (which supersedes NCASI Technical Bulletin 253). The true color is determined in a sample with the pH adjusted to 7.6 +/- 0.05 pH and then passed through a 0.8 µm filter. The apparent color is determined in the original sample. Samples with high color should be diluted to fall within the range of the standard curve.

There are also multiple-wavelength methods, which are recommended for color measurement in waters and wastewaters having color characteristics different from, but not excluding, platinum-cobalt standards. Such a method is SM 2120D-2001, which is used to calculate Tristimulus Values and ultimately values for the dominant wavelength, hue, luminance, and purity of a sample[2]. According to this method, the spectrophotometer examines a number of points (e.g., 10 or 30 points) in the range from 400 to 700 nm to determine the transmittance at each wavelength and uses the obtained values to calculate color by the published computation method. A modification of the Tristimulus Method that is used in water and wastewater industry is based on the measurement of percent transmittance at three wavelengths (590, 540, and 438 nm)[5].

Range, detection limit, and sample cell size

Accuracy, precision, and detection limits that can be obtained by a specific color measurement procedure depend on the quality of the instrument optics and the sample cell (cuvette) path length.

- Spectrophotometers allow for more accurate and precise results than colorimeters, but are more expensive. Lowest detection limits and better accuracy at low levels can be achieved on a spectrophotometer by choosing a sample cell with a longer cell path length.

- Colorimeters are useful for testing outside the laboratory and indicate relative color intensity. Color values determined on a colorimeter may differ from color values determined on a spectrophotometer, especially when the colorimeter wavelength does not match the wavelength used on the spectrophotometer.

- Sample cells for color testing are made of glass. Glass is suitable for testing in the visible wavelength range. A round glass 24 mm or 25 mm cell gives satisfactory results. For best accuracy and precision at color levels that are lower than 15 color units, a rectangular glass 50 mm cell is recommended. The 10 mm sample cell size is not recommended for color testing.

Turbidity effect on color measurement

When measuring "true" color, turbidity must be removed, since it can cause light scattering and increase the color value. Turbidity may also affect the precision of the measurement. Figure 1 demonstrates that filtering reduces the color reading – the more turbid the sample, the more significant the effect. Figure 2 shows that the filtered sample generally shows better precision, especially for turbid samples.

Figure 1. Color of unfiltered and filtered turbid sample by using NCASI 71.01 method at 465 nm

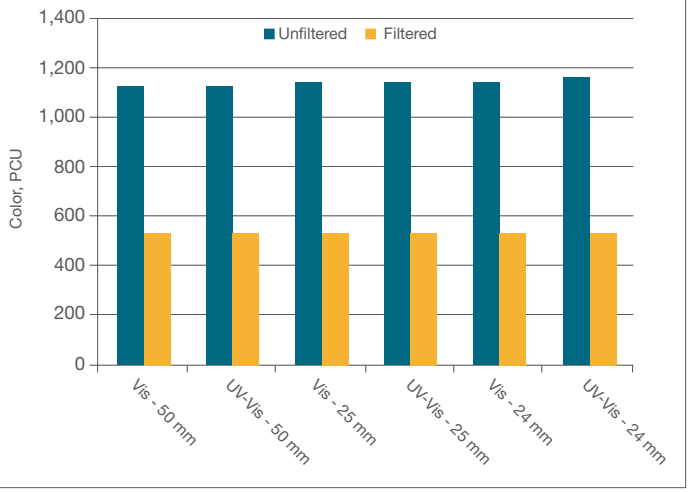
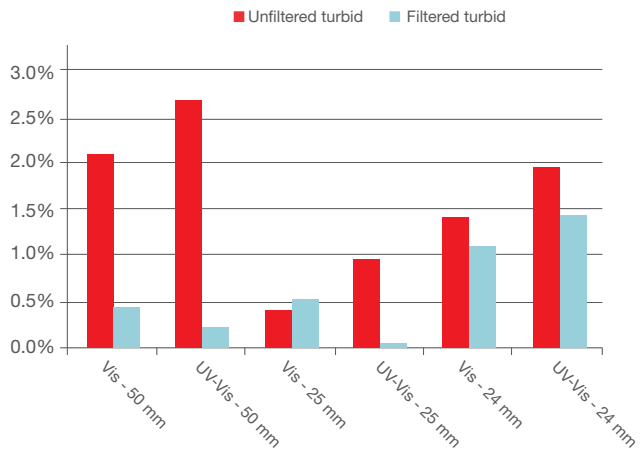


Figure 2. Precision of the color measurement in unfiltered and filtered turbid water sample as %CV



Orion AquaMate spectrophotometers for color measurement

Thermo Scientific™ Orion™ AquaMate™ UV-Vis and Vis spectrophotometers have the required wavelengths to analyze for any color measurement - by preprogrammed methods, by a user-generated standard curve, or by multiple wavelengths, if desired. The Color method measurements table (below) describes some of the color methods which may be tested on the Orion AquaMate spectrophotometers.

Color method measurements

Color method	Preprogrammed name or user defined	Sample cell size	Wavelength(s)	Scope of measurement
Platinum–cobalt color method: absorbance measured at one wavelength. Range: 0-500 PCU	CLRPT50 CLRPT25 CLRPT24 User method	50 mm 25 mm 24 mm 10-50 mm	455 nm	Water and wastewater samples of color similar to Pt-Co color standards
Adaptation of NCASI 253/803: absorbance measured at one wavelength. Range: 0-500 PCU	CLRPTP50 CLRPTP25 CLRPTP24 User method	50 mm 25 mm 24 mm 10-50 mm	465 nm	Color in pulp mill wastewaters
ISO 7887; GB 11903: Water Quality - Examination and Determination of color	User method	50 mm	436 nm 525 nm 620 nm	Raw and potable water, industrial water of low color
Tristimulus values method: transmittance is measured at multiple wavelengths in the 400-700 nm range	User method	10 mm or 50 mm	Multiple wavelengths 400-700 nm range	Water and wastewater samples of color different from, but not excluding, Pt-Co standards

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Application notes

Application notes for color testing are available through your local technical sales representative, our technical service call centers (1-800-225-1480 in the US), our Water Analysis Instruments online library at **thermofisher.com/waterqualitylibrary**, and other Thermo Fisher Scientific web locations. These notes give detailed information on how to successfully test for color on Orion AquaMate Visible and UV-Vis spectrophotometers. Notes available at this time include:

- AN 024, Color of water and wastewater by Pt-Co method at 455 nm.
- AN 025, Color of pulp mill wastewater by Pt-Co method at 465 nm (NCASI method).

References

1. Standard Methods for the Examination of Water and Wastewater, Method 2120B. **standardmethods.org**
2. Standard Methods for the Examination of Water and Wastewater, Method 2120. **standardmethods.org**
3. Available through Fisher Scientific at **fishersci.com**.
4. NCASI, Technical Bulletin No. 253, Dec. 1971. See 40CFR Part 136, Table IB, footnote 18. **ecfr.gov**
5. EPA Color Method 110.1. **https://www.umass.edu/mwwp/pdf/epa110.1colorspec.pdf**

Find out more at **thermofisher.com/aquamate**

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