

Measuring the turbidity of water supplies

Introduction

Measuring the turbidity of water is an important test of its quality as it is one of the methods of determining whether or not it is safe to drink – pathogens harmful to human health can be suspended in turbid water.

This mobile note is the transcript from the WEDC film of the same title, available from: <http://wedc.lu/measuring-the-turbidity-of-water>



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What is turbidity?

Turbidity is the cloudiness of a liquid caused by particles that are usually invisible to the naked eye.

Turbidity can vary: some waters can be very clear, others can be very cloudy.

For example, the turbidity would be high in a river full of mud and silt where it would be near impossible to see through the water (Figure 1), whereas by comparison, it would be low in clear spring water (Figure 2).

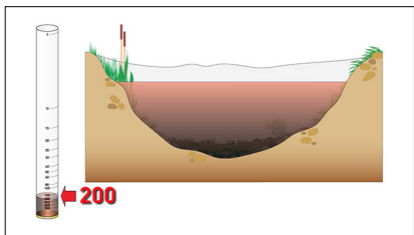


Figure 1. A high level of turbidity

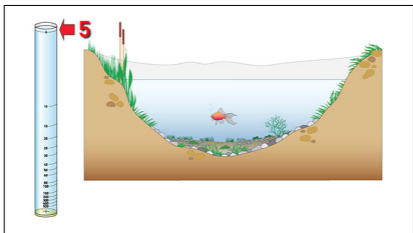


Figure 2. A low level of turbidity

The World Health Organization also notes that managing turbidity affects both the acceptability of water to consumers, and the selection and efficiency of treatment processes, particularly the efficiency of disinfection with chlorine.

Methods of measurement

Three methods of measuring turbidity in the field are discussed in this note:

1. Measuring turbidity with a turbidity tube

2. The Chinese Method
3. Measuring turbidity using a turbidity meter

The first two methods are simple means of measurement. The third involves the use of an electronic device that is more complex to use but is a more accurate means of measurement.

If no equipment is available as may be the case in an emergency, there is an additional method for making a rough estimate of the turbidity levels of water sources. (See the last section of this note: 'If no specialist equipment is available')

The Tyndall Effect

First, however, it may be important to know whether a water sample is a solution or a suspension. There is a rudimentary means of determining whether a liquid is one or the other by

shining a light through it. This is known as 'The Tyndall Effect'.

Named after the 19th-century physicist John Tyndall, The Tyndall Effect relates to the scattering of light by particles in a suspension.

Discolouration in water can be caused either by suspended or dissolved materials.

Dissolved materials cannot be removed as easily as suspended materials that can be removed by filtration or settlement.

If a liquid is a solution, such as a jar containing fluorescein (Figure 3), the light from the laser is not scattered. It passes straight through.

We cannot see the beam of light. The solution is coloured, but the colour doesn't scatter the light.

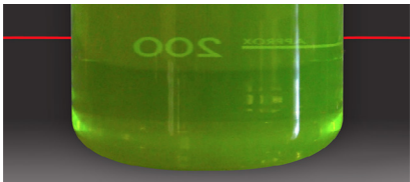


Figure 3. A jar containing fluorescein: light passing through is not scattered

If we look at milk in water, this is not a solution, it's a suspension. There are tiny globules of fat suspended in the water so, as we shine a light through it, we notice the light is scattered, confirming that it's a suspension and not a solution (Figure 4).

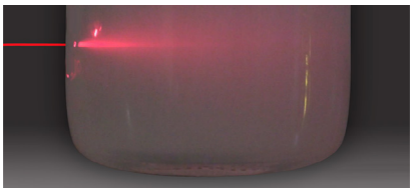


Figure 4. Light is scattered through the suspension (milk)

Figure 5 shows iron in water which is also a suspension. It looks coloured and again, as we shine light through it, the light scatters. It's rather like car headlights on a misty evening. You can follow where your headlights are pointing because the tiny water droplets in the atmosphere scatter the light.

So, with a solution there is no scattering of light. Light is scattered though a suspension.

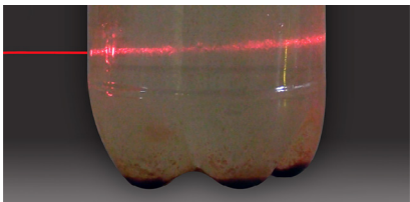


Figure 5. Light is scattered through the suspension (iron)

Whilst the Tyndall Effect is useful for determining whether a liquid is a

solution or a suspension and may help us to decide how to treat the water, it does not tell us how turbid the water is.

We turn now to the three methods of measuring turbidity.

The turbidity tube

We'll look at the first means of measuring turbidity using a conventional turbidity tube.

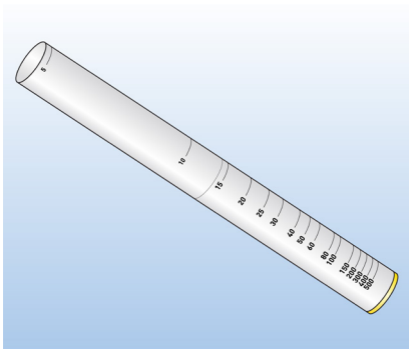


Figure 6. A turbidity tube

Figure 6 shows what a turbidity tube is — a long thin transparent tube made of two parts that fit together so that it is easy to carry.

Note that once it has been assembled, it should always be held by the bottom section to prevent the connection coming loose (Figure 7).

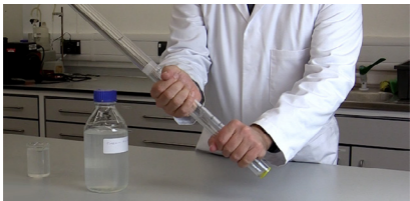


Figure 7. Holding the tube by the lower section

Nephelometric Turbidity Units

Note from Figure 6 that there are graded marks etched on the tube. This scale is not linear. The distance between 5 and 10 is much more than between 100 and 200. This is a scale we use for

taking a reading using the turbidity level. A typical unit of measurement is the Nephelometric Turbidity Unit or NTU. There are others units of measurement, but we use NTU here, as WHO make recommendations for drinking-water quality based on the NTU scale.

For example, WHO recommend that, for all processes in which disinfection is used, the turbidity must always be low — preferably below 1 NTU, and it is recommended that, for water to be disinfected, the turbidity should be consistently less than 5 NTU.

Low values of NTU are an indicator of clear water.

The black mark

An important component of a turbidity tube is a 'black mark' – usually a cross or a circle marked on a yellow or white background located inside the tube at the base of the lower section (Figure 8).



Figure 8. A black cross marked at the base of the inside of the tube

The way we measure turbidity is simply to see at what level the cross or the circle becomes invisible to the naked eye (Figure 9).



Figure 9. Checking to see whether the black cross is visible

We do this by adding incremental amounts of turbid water into the tube until this point is reached (Figure 10). If the water is very turbid, the depth of the water column inside the tube will be much shorter than if the water has low turbidity (Figure 1 and 2).



Figure 10. Adding incremental amounts of water

The Chinese Method

The Chinese turbidity tube is slightly different in that it uses a standard depth

of water rather than changing depths of water. The advantage here is that the tube can be much smaller than the conventional turbidity tube, although it may be less accurate (Figure 11).



Figure 11. The Chinese turbidity tube

A panel of alphabetic characters of decreasing point size is used over which the tube is placed (Figure 12).

If the water is very turbid, it may not be possible to read any characters; and if the water is very clear it will be easy to read even the smallest characters.



Figure 12. The panel of letters for use with a Chinese turbidity tube



Figure 13. Placing the tube over the panel

To use this method, place the tube filled with your turbid water on top of the supplied chart of letters, then lean over and look through the tube at the visible, larger characters printed on the chart (Figure 13 and 14).

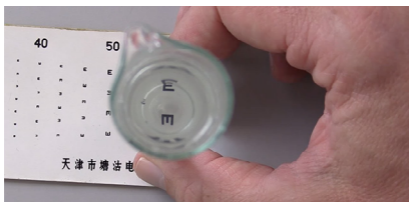


Figure 14. Looking through the tube to view the characters

Next, slide the tube carefully across the chart towards the smaller characters until the characters can no longer be seen (Figure 15).

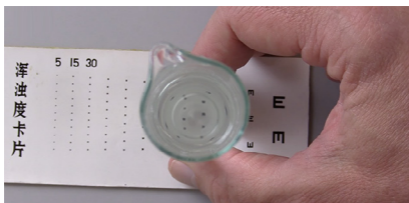


Figure 15. The characters can no longer be read

Take a reading from the chart at this point. In this example the reading suggests that the turbidity is somewhere between 40 and 50 NTU (Figure 16).



Figure 16. Making a note of the reading

Turbidity meters

To test turbidity to a high degree of accuracy — less than 5 NTU — then turbidity meters can be used.

There are various types available on the market (Figure 17). Some are hand held for ease of use in the field, but they all work in a similar way.



Figure 17. Turbidity meters

Figure 18 shows a desk-based turbidity meter, where everything is done automatically, eliminating the subjectivity of the vision of an observer looking through a tube.



Figure 18. A desk-based turbidity meter

A beam of light is shone through the water, and the turbidity is calculated by comparing the intensity of the light before and after it enters the water (Figure 19).

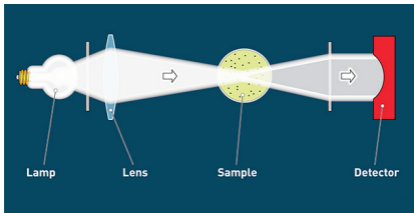


Figure 19. A schematic diagram of how the light in a turbidity meter travels

For this method of testing turbidity you take a sample of the water to be tested, placed into a tube that fits snugly into the machine. Fill the tube with the turbid water up to the white line near the top of the tube, and screw the cap onto the top of the tube (Figures 20 and 21). There is a small white triangle on one side of

the white line. This triangle should point towards you when the tube is inserted in the turbidity meter (Figure 22).



Figure 20. Filling up the tube



Figure 21. Replace the cap



Figure 22. The white triangle should point towards you as you place the tube into the meter

Next, clean the exterior of the tube, as you want to measure the turbidity of the water and not the cleanliness of the glass tube (Figure 23).



Figure 23. Cleaning the exterior of the tube

Opening the lid of the turbidity meter, place the sample tube into the circular slot provided in the machine, with the white triangle still facing towards you (Figure 24). Close the lid and wait for the turbidity reading to appear on the display.



Figure 24. Placing the tube into the meter

In this example, it records a reading of 29.4 NTU which is reasonably clear (Figure 25). Water with a reading less than about 30 NTU could be treated by filtration without causing too many problems. Water having a turbidity of more than about 30 NTU can cause filters to clog.



Figure 25. A reading of 29.4

To check that the meter is calibrated correctly, and therefore to validate the reading for this sample, take the sample out of the machine and check the turbidity meter using one of the boxed standard control tubes, each of which has a different NTU value (Figure 26).



Figure 26. One of the boxed, standard control tubes

This particular standard tube has a turbidity of 20 NTU. First shake it well to make sure that the material causing the turbidity is evenly distributed (Figure 27).



Figure 27. Shake the sample well

Let it stand briefly for any bubbles to disperse, and also clean the glass.

Again, there is a line and a small triangle marked on the test tube —this time in black— and this should face you (Figure 28).



Figure 28. Face the black triangle to you

This standard tube should have a turbidity of about 20 NTU (as previously specified on the label).

Initially it reads 21 but as it settles it decreases towards 20 (Figure 29).

So this standard tells us that the turbidity meter is calibrated correctly.

Turbidity is likely to change, and readings seldom need to be quoted to any great accuracy.



Figure 29. The sample reading

If there is no specialist equipment available

If, in the case of an emergency for example, no specialist equipment is available it is possible to make a rough estimate of how turbid a water source is by using more commonly available items of equipment including:

- a clean container with a dark-coloured interior surface – such as an oil drum or a dustbin – and with a minimum depth of 50cm;
- a bucket;

- a dull brass or copper coin with an approximate diameter of 2.5cm; and
- a long measuring pole or steel tape measure

The method

1. Place the coin in the bottom of the container.
2. Gently add water drawn from the well a little at a time (Figure 30a).



(30a)

At regular intervals, wait for the surface of the water to calm and check to see if the coin is still visible (Figure 30b).

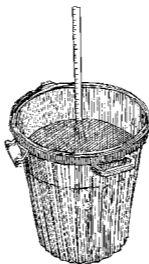


(30b)

3. When it can no longer be seen (Figure 30c), measure the depth of the water (Figure 30d).
- If the depth of the water is less than 32cm, then the turbidity is likely to be greater than 20NTU.



(30c)



(30d)

Figure 30. Checking the turbidity without specialist equipment

- If the depth of the water is between 32 and 50cm, then the turbidity is likely to be between 10 and 20NTU.
- If the depth of the water is greater than 50cm, then the turbidity is likely to be less than 10NTU.

About this note

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