WEDC Developing knowledge and capacity in water and sanitation

GUIDE 31

Measuring the turbidity of water supplies

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, whereas by comparison, it would be low in clear spring water.

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 guide is the transcript from the WEDC film of the same title, available from this address: http://wedc.lu/measuring-the-turbidity-of-water

Contents

WHO 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.

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Introduction

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

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 guide: '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 1), 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.

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 2).

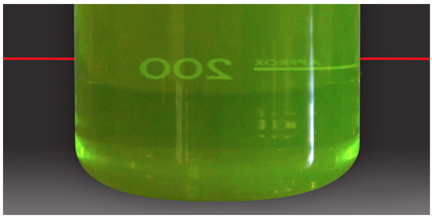

Figure 1. A jar containing fluorescein: light passing through is not scattered

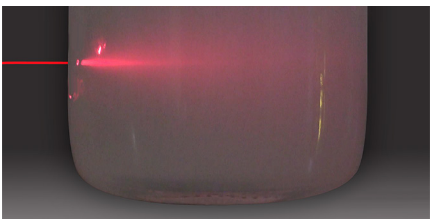

Figure 2. Light is scattered through the suspension (milk)

Figure 3 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.

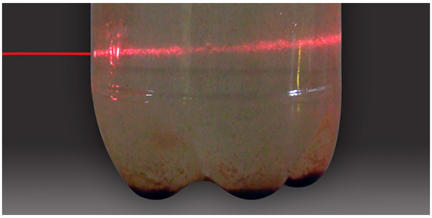

Figure 3. Light is scattered through the suspension (iron)

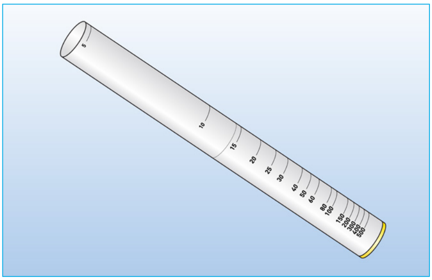

Figure 4. A turbidity tube

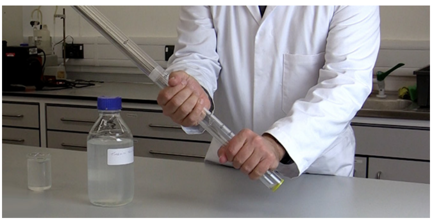

Figure 5. Holding the tube by the lower section

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

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.

Using a turbidity tube

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

Figure 4 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 5).

Nephelometric Turbidity Units

Note from Figure 4 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 6).

The way we measure turbidity is simply to see at what level the cross or the circle becomes invisible to the naked eye (Figure 7). We do this by adding incremental amounts of turbid water into the tube until this point is reached (Figure 8). 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 9).

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 10).

Figure 6. A black cross marked at the base of the inside of the tube

Figure 7. Checking to see whether the black cross is visible

Figure 8. Adding incremental amounts of water into the tube

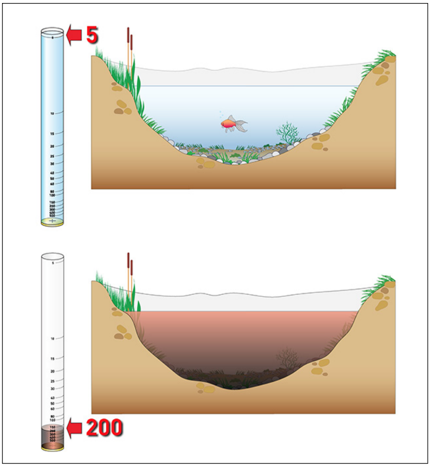

Figure 9. Low and high levels of turbidity

A panel of alphabetic characters of decreasing point size is used over which the tube is placed (Figure 11). If the water is very turbid, it may not be possible to read any characters but if the water is very clear it will be easy to read even the smallest characters.

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). Next, slide the tube carefully across the chart towards the smaller characters until the characters can no longer be seen (Figure 14).

Figure 10. The Chinese turbidity tube

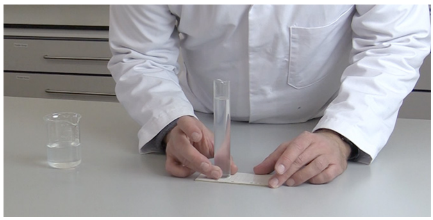

Figure 12. Placing the tube over the panel

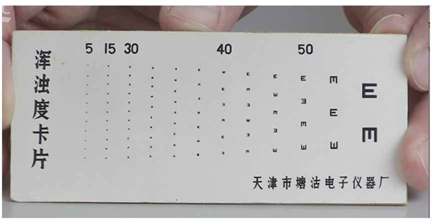

Figure 11. The panel of letters for use with a Chinese turbidity tube

Figure 13. Looking through the tube to view the characters

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 15).

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 16). Some are hand held for ease of use in the field, but they all work in a similar way.

Figure 17 shows a desk-based turbidity meter, where everything is done automatically, eliminating the subjectivity of the vision of an observer looking through a tube. 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 18).

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 19 and 20). 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 21).

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 22).

Opening the lid of the turbidity meter, place the sample tube into the circular slot provided in the machine (Figure 23), with the white triangle still facing

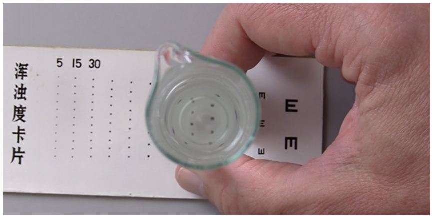

Figure 14. The characters can no longer be read

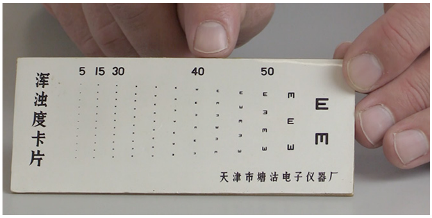

Figure 15. Making a note of the reading

Figure 16. Turbidity meters

towards you, close the lid and wait for the turbidity reading to appear on the display. In this example, its records a reading of 29.4 NTU which is reasonably clear (Figure 24). 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 30 NTU can cause filters to clog.

Figure 17. A desk-based turbidity meter

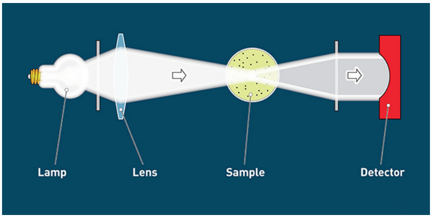

Figure 18. A schematic diagram of how the light in a turbidity meter travels

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 25).

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 26). 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 27). 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 28). 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 19. Filling up the tube

Figure 20. Replace the cap

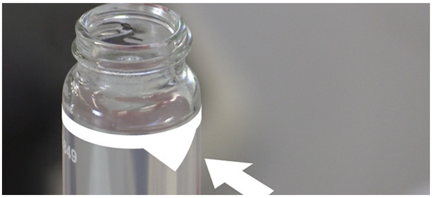

Figure 21. The white triangle should point towards you

Figure 22. Cleaning the exterior of the tube

Figure 23. Placing the tube into the turbidity meter

Figure 24. A reading of 29.4

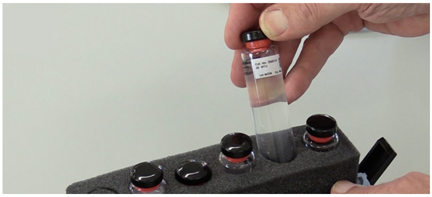

Figure 25. One of the boxed, standard control tubes

Figure 26. Shake the sample well

Figure 27. Face the black triangle towrards you

Figure 28. 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 29a). At regular intervals, wait for the surface of the water to calm and check to see if the coin is still visible (Figure 29b). When it can no longer be seen (Figure 29c), measure the depth of the water (Figure 29d).

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

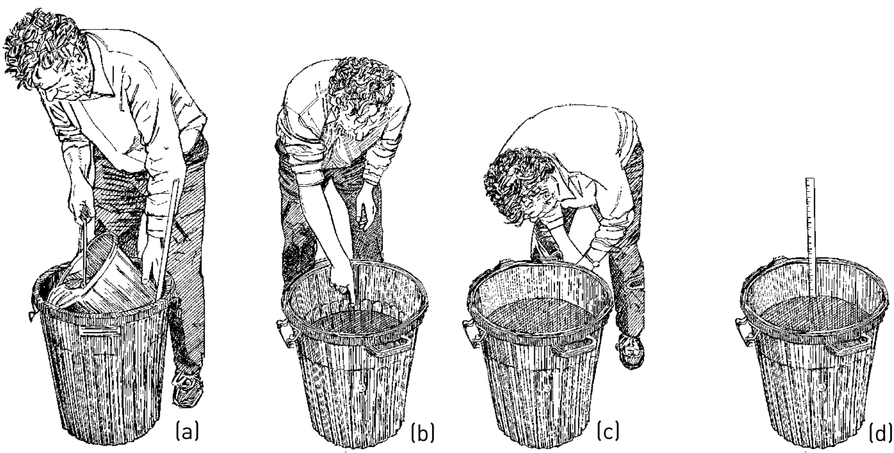

Figure 29. Making a rough assessment of turbidity without specialist equipment

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