WEDC

MOBILE NOTE 17

Measuring chemical concentrations in water

Introduction

To ensure that water is safe to drink, it is important to eliminate any harmful micro-organisms that may be present in the water. It is important too, to limit the concentrations of chemicals that could also be present in the water.

This note is a transcript of the WEDC film of the same title available here. The film looks at how chemicals in water can be measured, using chlorine, nitrate and iron as examples.

Contents

Although the examples shown in the film were undertaken in a laboratory, with portable test kits, these methods can be used in the field too.

Chemical concentrations in water

While not all chemicals present in water are necessarily harmful to human health, a chemical can become so if concentrations of the chemical are too high. On the other hand, if chemicals such as chlorine are used to disinfect water, it is important to ensure that *sufficient* concentrations are present.

So measuring chemical concentrations in water is an important activity in discerning whether water is suitable for human consumption.

Chemicals that are of particular concern are chlorine, iron, nitrate, fluoride and arsenic; each having an increased level of complexity.

In some instances, the presence of heavy metals may be a problem.

Water samples suspected of containing heavy metals require specialist examination in a laboratory, which is not covered here or in the film.

Chlorine

As chlorine concentrations in water reduce over time, it is important to check concentrations of chlorine in drinking water periodically. The quickest and simplest method for testing chlorine concentrations is an indicator test, using a comparator (Figure 1).

For this method, a tablet of chemical reagent is added to a sample of water, colouring it red (Figure 2). The strength of colour is measured against standard colours on the comparator's chart to determine the chlorine concentration. The stronger the colour, the higher the concentration of chlorine in the water.

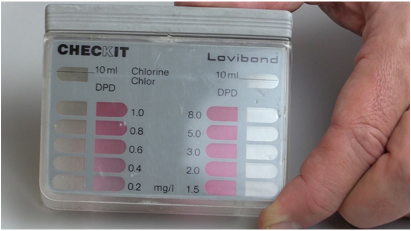

Figure 1. A comparator

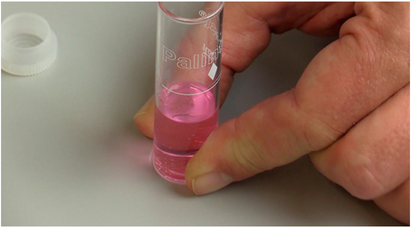

Figure 2. A sample of water, coloured red

Several kits for analysing the chlorine residual in water, such as the one pictured in Figure 1 are available commercially.

Here's an overview of the process:

Inside the comparator are three chambers: a central one, and two smaller ones, one on each side (Figure 3).

The chamber on the left is a test chamber for measuring 0.2 to 1.0 milligrams of chlorine per litre. The chamber on the right is for measuring 1.5 to 8.0 milligrams per litre.

The central chamber (CC) is used for a control test.

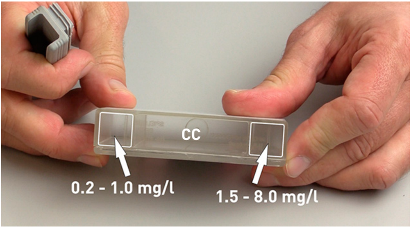

Figure 3. The three chambers of the comparator

It is important to make sure that it is the quality of the water sample that is tested and not any residual water left in the comparator, so first **rinse out the comparator** three times with clean water from the sample to be tested (Figure 4).

Figure 4. Rinsing out the comparator

Next, take one of the tablets and then very carefully — without touching anything else — **place the tablet into the left hand chamber** (Figure 5).

Pour a little water into the left hand chamber and **crush the tablet** with a sterilized plastic spatula. Put the comparator on a firm surface so that you don't push the bottom out (Figure 6).

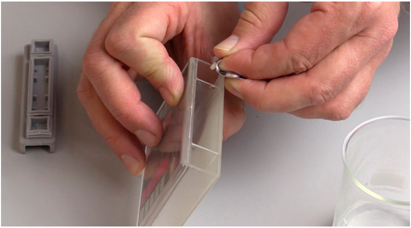

Figure 5. Placing the tablet into the left hand chamber

Figure 6. Crushing the tablet

Top up the chamber to the 10 millilitre mark with more of the water sample (Figure 7).

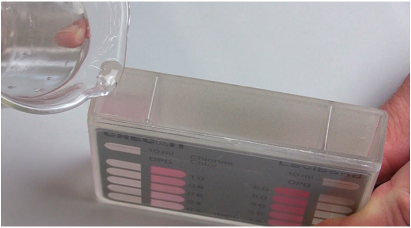

Figure 7. Topping up the chamber

Put the lid on and give it a good shake.

The sample has turned slightly pink on the scale so we can tell that there is a very low concentration of chlorine in the water.

As it is outside the colour range on the scale we know that this sample has less than 0.2 milligrams per litre (Figure 8).

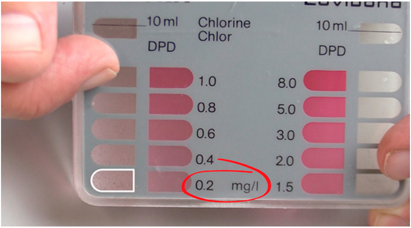

Figure 8. Water with a low concentration of chlorine

If the sample matches a colour on the comparator then a reading can be taken. If the colour is stronger than represented on the comparator then we won't know how much chlorine the deeper colour represents.

In such a case a piece of equipment called a photometer can be used to determine more precisely the concentration of chlorine in the water.

The chemical used for this test produces a colour change if chlorine is present, and the amount by which the water changes colour depends on the chlorine concentration.

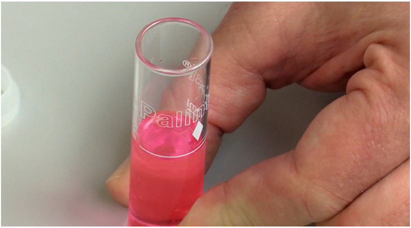

Figure 9. Water with a high concentration of chlorine

Figure 10. A photometer

By comparing the colour against a reference colour, the chlorine concentration can be determined.

When and where should the testing of chlorination take place?

Continuous chlorination is most commonly used in piped water supplies. Regular chlorination of other water supplies is difficult and usually reserved for disinfection after repair and maintenance.

It is common to test for chlorine residual just after the chlorine has been added to the water to check that the chlorination process is working; also:

- at the outlet of the consumer nearest to the chlorination point to check that residual chlorine concentrations are within acceptable limits;
- and at the furthest points in the network where residual chlorine

should be detected, but where concentrations are likely to be at their lowest.

The higher the residual chlorine concentrations in the supply, the longer the chemical will be able to protect the system from contamination.

However, high concentrations of chlorine make the water smell and give it a bad taste, which will discourage people from drinking it. For normal domestic use, residual chlorine concentrations at the point where the consumer collects water should be between 0.2 and 0.5 milligrams per litre.

Nitrate

Nitrate is found naturally in the environment and is an important plant nutrient. It can infiltrate both surface water and groundwater as a consequence of human or agricultural activity.

The problem with water that contains excess amounts of nitrate is that it encourages the growth of algae and the characteristic algal bloom in rivers, lakes and surface reservoirs can lead to many problems of water quality. This is an extreme case, however. What we are going to look at is measuring much lower concentrations of nitrate, which can show whether the water contains nitrate from fertiliser or urine. Figure 11 shows a screw top bottle for testing samples of water containing nitrate.

Figure 11. A screw top bottle for testing samples containing nitrate

The bottle is marked at 5, 10, and 20 millilitre intervals. **Unscrew the top** and **pour in a sample of water** containing nitrate up to the 20 millilitre mark .

Then **add a level spoonful of nitrate test powder**, which comes with the test kit (Figure 12).

Figure 12. Adding the nitrate powder

Together with that, add one nitrate test tablet. It is important to avoid handling this because handling can contaminate the tablet, so **put one tablet in the lid and then tip that into the bottle** (Figure 13).

Figure 13. Adding the nitrate test tablet

Don't crush it, just **screw the top on**, making sure its tight, then invert it and **shake it vigorously** for one minute. Then **leave it to stand** for another minute to allow time for the chemicals to react.

Now **invert the screw top bottle** four times and leave it to settle. This could take a couple of minutes or longer. Particles will be very small so will settle slowly.

Once the particles have settled, **take the top off and wipe around the top**

with a clean tissue to remove any contamination, and **transfer the contents** into a test tube, filling it to the 10 millilitre mark.

Now **add one nitricol tablet**, which comes in a pre-sealed unit. Ease it into the test tube without touching it. **Crush it.** The chemical reaction it produces causes the colour to change (Figure 14).

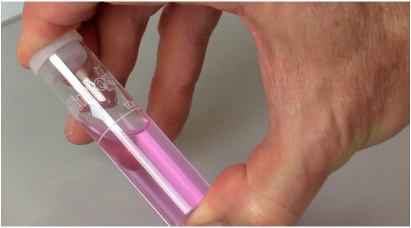

Figure 14. Adding the nitricol tablet will cause the colour to change

Although we could assess the colour visually, as we did for the chlorine test, different people may perceive colours differently. Using a photometer makes the test more objective (Figure 10).

So **place the test tube in the photometer** setting the display to 'Nitrate', and **press the 'OK' button.** The photometer display prompts you to insert a blank sample so that the test sample can be compared against another sample that has not been prepared in this way. The original water sample being tested is used as the blank. **Fill a test tube** to the 10 millilitre mark with the water sample, then **put the top on and wipe it** around the outside of the glass to ensure it is clean.

While keeping the diamond mark on the glass towards you, **insert the test tube**, and **replace the cover** (Figure 15). Then **press the 'OK' button again**. The display now asks you to insert the test sample, so **take the blank out, wipe the outside of the sample test tube** to ensure it is clean, **place it into the photometer** with the diamond mark pointing towards you, and **press 'OK'.**

Figure 15. Inserting the test tube into the photometer

Figure 16. A reading of 0.193 milligrams

The photometer gives a reading of 0.193 milligrams per litre of nitrogen – this test measures the concentration of nitrogen (Figure 16). As there may be other nitrogen compounds present, to calculate the nitrate concentration the measured nitrogen concentration has to be multiplied by 4.4.

So in this case, that's about 0.2 of a milligram per litre of nitrogen, and 0.88 milligrams per litre of nitrate. The concentration of nitrate is greater than the concentration of nitrogen because nitrate molecules contain other elements in addition to nitrogen.

Iron

The human body requires iron to function, so a small concentration of iron in water is not harmful to health. Too much iron can also cause the water to taste unpleasant. The World Health Organization notes that there is usually no noticeable taste at iron concentrations below 0.3 milligrams per litre, although turbidity and its reddish-brown colour may be apparent and be off-putting to some consumers. High concentrations of iron can also stain washing and food, and may deposit a slimy coating on piping, potentially blocking or corroding the pipework of water systems (Figure 17).

Figure 17. High concentrations of iron staining washing

For these reasons it is important to check for iron in water supplies and ensure that that it is limited to an acceptable concentration.

Figure 18 shows a water sample containing a high concentration of iron.

You can just see the suspended particles at the bottom of the sample as they settle.

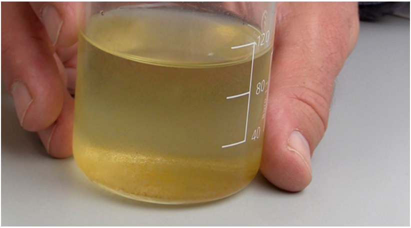

Figure 18. A sample of water containing iron

Figure 19. A sample of water suspected of containing a small amount of dissolved iron

The bottle of water shown in Figure 19 has a much lower concentration of iron in it. No iron particles are visible, but it is suspected that the water may contain some dissolved iron.

Follow this process for testing concentrations of iron in water:

Fill two test tubes to the 10 millilitre mark from the water sample using a pipette (Figure 20).

Figure 20. Two test tubes

There are now two test tubes from that sample. One is the control, so that is put to one side for now. **Add two tablets to the other test tube** – Iron number 1 tablet, and Iron number 2 tablet.

First of all **drop tablet number 1** into the test tube and **crush it.** Then **drop tablet number 2** into the test tube and **crush it** too (Figure 21).

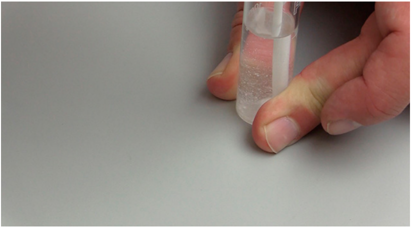

Figure 21. The tablets are added and crushed

The two crushed tablets react in the water and it is immediately possible to see that the colour changes. The extent of the change to the colour depends on the level of concentration of iron in the water (Figure 22). **Wait for 15 minutes** to allow time for the tablets to react fully with the iron.

Figure 22. The two crushed tablets react in the water

Using a photometer, **insert the control test tube**, first giving it a wipe to make sure that the test tube is clean. Then **press 'OK'** and the photometer will prompt you to **insert the test sample** (Figure 23). Give that a wipe too and **place it in the photometer**. **Press 'OK' again** and the photometer shows a reading of 1.06 milligrams per litre of iron in the water sample.

Figure 23. The sample test tube

Figure 24. The final reading

References

Measuring chemical concentations in water, 2017. REED, B.J, SMITH, M.D. and SHAW, R.J. Loughborough University: WEDC / Hallahan and Chatterton.

WHO, 2017. *Drinking-water quality guidelines* [online] [07/02/17]. Available from: http://www.who.int/water_sanitation_health/water-quality/guidelines/en/

See also WHO Technical Note 11: *Measuring chlorine levels in water supplies*. Available in this collection as Note 41.

About this note

Editor:	Rod Shaw
Photos:	Ken Chatterton
QA:	Michael Smith

Designed and produced by WEDC

**Water, Engineering
and Development Centre (WEDC)
School of Civil and Building Engineering
Loughborough University
Leicestershire LE11 3TU UK**

Phone: + 44 (0) 1509 222885
Email: wedc@lboro.ac.uk
Website: wedc.lboro.ac.uk
Twitter: wedcuk
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