Water quality monitoring

Using multi parameter probes

February 2014

We currently have a number of probes installed in rivers across the area to examine water quality. This note explains what we are monitoring for, why we look at each parameter and describes the patterns and levels we expect to see. It also answers some frequently asked questions about water quality monitoring using multi-parameter probes.

The probes currently in use return data for Temperature, Conductivity, Dissolved Oxygen (Saturation %) and Dissolved Oxygen (mg/l), pH, Ammonium and Turbidity. A description of each parameter is given below

Temperature

What is a normal range of values?

Temperature in rivers can range from 0 - 25°C. Effluent discharges may be warmer than the receiving watercourse and discharges of groundwater may be cooler than the receiving watercourse. These discharges may distort the normal temperature profile.

What patterns are we expecting to see?

Water temperature changes with the season and will change throughout the day due to ambient air temperature.

The river system tends to buffer changes in ambient air temperature but in some cases this ability is diminished. For example shallow low flowing rivers may exhibit greater daily variation during summer while larger water bodies may display limited variation over the same period.

Don’t worry if...

If readings track and match ambient air temperatures, it can indicate that the probe is not properly immersed in the water. We will sort this out as soon as possible.

Conductivity

This test indicates the total amount of inorganic dissolved solids (salts) in water. Conductivity is a readily measured indicator of water quality and is measured in microSiemens per centimetre (µS/cm).

What is a normal range of values?

- Pure distilled water contains no dissolved salts; similarly rainwater has low concentrations so both have low conductivity. Tap water has a conductivity of 300 – 600 µS/cm
- Conductivity varies in streams and rivers from 300 to 1000 µS/cm. The concentration is affected primarily by the geology of the area – the bedrock through which the water flows.

  - Streams arising in granite bedrock tend to have a lower conductivity because granite is made up of inert materials that do not ionize (dissolve into ionic components) when washed into the water.
  - Streams arising in clay soils tend to have higher conductivity because of the presence of materials that ionize when washed into the water.
  - Streams arising in chalk aquifer similarly have a high conductivity.
- Treated sewage effluent usually has a conductivity of >1000 µS/cm because of the presence of chloride, phosphate, and nitrate.

What patterns are we expecting to see?

The absolute measurement of conductivity is of limited value on its own, but a sudden change of conductivity will indicate a change is dissolved solids content - this may indicate the onset of a polluting discharge, a rainfall event or another input.

For example, in a rainfall event the conductivity may drop due to input of rain, or increase as salts are washed into the river in road run off. Similarly a discharge of sewage effluent may raise the conductivity. Ground water inflows can have different effects depending on the bedrock they flow through.

Don't worry if...

If the conductivity reading drops very low and stays very low, it can indicate that the probe is out of the water. We will sort this out as soon as possible.

Dissolved Oxygen - Saturation % and milligrams per litre (mg/l)

Dissolved Oxygen (DO) is one of the most important indicators of river water quality since it is necessary for aquatic life. The concentration is reduced by the respiration of living organisms and replenished by photosynthesis of aquatic plants, algae and re-aeration from the atmosphere.

What patterns are we expecting to see?

DO levels tend to follow a diurnal (daily), seasonal and event driven pattern. The normal cycle in rivers and lakes shows an increase in DO during the day and a drop in DO at night. Values over 100% can occur when photosynthesis from plants and algae produces so much oxygen that the water becomes super-saturated. This happens in spring, summer and autumn.

- Waste discharges that are high in nutrients and organic matter, such as untreated sewage, slurry or milk, can cause DO to drop in a watercourse as a result of increased microbial activity (respiration). This occurs during the breakdown of the organic matter.
- DO levels are lower in groundwater than in surface water due to lack of aeration in the aquifer. Discharges of groundwater may also cause a drop in DO in a watercourse.

What is a normal range of values?

The DO concentration in unpolluted waters is around 10 mg/l or between 90-110 %. The critical level of DO in water varies greatly between species.

- Concentrations below 5 mg/l or around 50% may adversely affect the functioning and survival of biological communities
- Concentrations below 2 mg/l or around 20% may cause fish to die.

pH

The pH test describes the acidity or alkalinity of a watercourse. The pH scale ranges from 1 to 14. The lower the pH value the more acidic the liquid; the higher the pH the more alkaline. A liquid with a pH of 7.0 is neutral – neither acid nor alkaline.

The pH scale is logarithmic. Water with a pH of 9 is 100 times more alkaline than a pH of 7.

What is a normal range of values?

Unpolluted waters vary in their pH due to the chemistry of the underlying geology and the type of vegetation within the catchment. For example, rivers draining areas of chalk or limestone will naturally have a higher pH than those draining sandstones.

- Typically rivers in the Thames Valley during winter and spring have pH values of 7 - 8.

What patterns are we expecting to see?

We expect to see daily and seasonal changes in pH caused by photosynthesis and respiration from plants and algae. For example:-

- At night, plants and algae respire, consuming oxygen and releasing carbon dioxide into the water. This produces a weak carbonic acid and causes pH to drop.
- In the daytime, carbon dioxide is taken-up by plants and algae whilst dissolved oxygen is excreted; this increases pH levels in the water.

In eutrophic (nutrient rich) waters, these processes are exacerbated. Daytime photosynthesis can cause pH levels to exceed 9.0

Nitrogen, Ammonium and Ammonia

Nitrogen is an essential nutrient for plant and algal growth. It occurs in the environment in a range of states, including nitrate (NO3-), nitrite (NO2-), the ammonium ion (NH4+) and un-ionised ammonia (NH3). Total ammonia is the sum of ammonium and ammonia

Ammonia occurs naturally in rivers as it is excreted by animals and produced when organic matter decomposes. It is also discharged into rivers from a range of sources such as treated sewage effluent, agricultural fertilisers, and some industrial process. In higher quantities the presence of ammonium in river water is an indicator of pollution.

What is the relationship between ammonium and ammonia?

Un-ionised ammonia (NH3) can be directly toxic to aquatic organisms, where as ammonium is not toxic. Our probes measure ammonium (NH4+) as an indication of both ammonium and ammonia. We do this because this is a simple test and there is a known relationship between the two parameters.

The proportion of ammonia and ammonium in the environment depends on the temperature and pH of the water. Un-ionised ammonia (NH3) generally makes up a smaller proportion of total ammonia than the non-toxic ammonium ions (NH4+).

Higher proportions of unionised ammonia (NH3) will occur at warmer temperatures and higher pHs, lower proportions occur at lower temperatures and lower pH's. Under current conditions, NH3 ammonia concentrations are equivalent to roughly 1% of the ammonium concentration.

What is a normal range of values?

- Ammonium concentrations in unpolluted waters range between 0.2 mg/l and 1 mg/l as N.
- Ammonium concentrations in treated sewage effluent can be between 10 and 20 mg/l as N
- Unionised ammonia concentrations of 0.025 mg/l can be harmful to fish
- An ammonium concentration of 2.5 mg/l ammonium (NH_4^+) indicates that ammonia levels could be harmful to fish, under current conditions.

What patterns are we expecting to see?

When interpreting logger results we focus on the patterns within the data. For example daily patterns can be seen in sewage discharges due to changes in water and sewerage usage during the day.

Turbidity

The turbidity test gives an indication of the levels of suspended solids in a river. Our monitoring equipment uses an optical probe to give an instant result in nephelometric turbidity units (NTU). In water samples we measure suspended solids in milligrams per litres. The precise relationship between turbidity and suspended solids concentration can vary.

Turbidity in the form of suspended solids may be undesirable in river water for several reasons.

- Solids can cause abrasion/clogging of fish gills and smother the river bed.
- If the solids contain much organic material, as in the case of sewage effluent, they will make a contribution to the Biochemical Oxygen Demand and reduce dissolved oxygen.

What patterns are we expecting to see?

We expect turbidity to rise in response to rainfall events. For example:-

- Wet weather run-off introduces suspended solids by erosion of the drainage area and,
- The increased rate of flow causes increased turbulence which re-suspends particles from the river bed.

Polluting discharges may also cause turbidity levels in a river to rise.

What is a normal range of values?

Turbidity values will vary greatly from near zero in dry weather to ≥ 500 NTU during heavy rain. Values of 25 NTU are common as background levels.

Don't worry if...

If you see large 'spikes' of turbidity up to 1000 NTU, without a gentle rise before or after, the probe may have had something caught on it. We will sort this out as soon as possible.

Further information

More information about water quality and the role of the Environment Agency can be found on our website: http://www.environment-agency.gov.uk/research/planning/34383.aspx

Reference

Chapman, D., (Ed.), 1998. *Water Quality Assessments: A guide to the use of biota, sediments and water in environmental monitoring*. Oxford: Taylor and Francis.For more information