

APPENDIX 7: INFORMATION ON WATER QUALITY PARAMETERS

Laboratory Analysis: The principal chemical analyses undertaken on most water bodies includes analyses for pH, Biochemical Oxygen Demand (BOD), Colour, Ammonia, Oxidised Nitrogen (Nitrite / Nitrate), o-Phosphate, Chloride, Major Anions and Cations, Hardness, and Alkalinity. Un-ionised ammonia can be calculated from the Ammonia, pH and Temperature. Other specific tests such as trace metals analyses or organic micro-pollutants are carried out in a phased programme of surveillance waters but may be carried out where particular pressures exist. All of the EPA laboratories have been awarded accreditation to ISO 17025 and participate in national and international inter-laboratory performance testing. The parameters covered by accreditation vary between individual laboratories and their respective Scopes of Accreditation may be viewed at www.inab.ie.

Alkalinity: Alkalinity is the measurement of a water's ability to neutralize acids. It usually indicates the presence of carbonate, bicarbonates, or hydroxides. Alkalinity results are typically expressed as mg/l CaCO₃. Alternatively, they are sometimes reported as mg/l HCO₃ and the following relationship applies:

$$\text{Alkalinity (mg/l as HCO}_3\text{)} = \text{Alkalinity (mg/l as CaCO}_3\text{)} \times 1.22$$

In natural waters, there is a close relationship between alkalinity and hardness. Waters that have high alkalinity values are considered undesirable because of excessive hardness and high concentrations of sodium salts. Water with low alkalinity has little capacity to buffer acidic inputs and is susceptible to acidification (low pH). Alkalinity is typically determined using titrimetric methods.

Ammonia: Ammonia occurs naturally in water bodies arising from the microbiological decomposition of nitrogenous compounds in organic matter. Fish and other aquatic organisms also excrete ammonia. Ammonia may also be discharged directly into water bodies by some industrial processes or as a component of domestic sewage or animal slurry. Ammonia can also arise in waters from the decay of discharged organic waste. Natural (unpolluted) waters contain relatively small amounts of ammonia, usually <0.02 mg/l as N.

Ammonia exists in aqueous solutions in two forms, ionised (NH₄⁺) and un-ionised (NH₃) and the un-ionised fraction is toxic to freshwater fish at very low concentration. The relative proportions of ionised and un-ionised ammonia in water depend on temperature and pH and to a lesser extent on salinity. The concentration of un-ionised ammonia becomes greater with increasing temperatures and pH and with decreasing salinity. Un-ionised ammonia in fresh-water is calculated from total ammonia, pH and temperatures using the following formula:

$$\text{UnIonised Ammonia (mg / l NH}_3\text{)} = \frac{\text{Total Ammonia (mg / l N)} \times \frac{17}{14}}{1 + 10^{\left[0.09018 - \frac{272992}{27315 + \text{Temp}^\circ\text{C}} - \text{pH}\right]}}$$

Tables with factors for conversion are available at [Unionised Ammonia](#)

In terms of analytical determination, there are a number of techniques available, the most common of which are colorimetric tests. These tests measure the total amount of ammonia present i.e. they cannot discriminate between the ionised and un-ionised forms.

Ammonia may be reported as mg/l N, mg/l NH₃ or NH₄ and the following conversion factors apply:

Convert From	Convert To	Divide By
mg/l NH ₃	mg/l N	1.22
mg/l NH ₄	mg/l N	1.29

Bacteriological Testing: Bacteriological testing is undertaken on many river and lake waters primarily for Total Coliforms and *Escherichia coli* (*E. Coli*) particularly where water is abstracted for human consumption (i.e. before treatment). They are also routinely monitored as part of the groundwater monitoring programme. In bathing waters, Intestinal Enterococci and *E. Coli* are now monitored.

Coliform bacteria other than *E.Coli* occur in water as a result of run-off from soil or from growth on decaying vegetation. While the Total Coliform count gives an indication of the general level of the microbiological quality of water *E.Coli* is a specific indicator of faecal contamination originating from human or animal wastes and is an important indicator of water quality – especially in waters where sewage or slurry is discharged. Intestinal Enterococci have longer survival times in waters are generally regarded as indicators of past pollution events.

Drinking water Regulations may be located here [DW Regulations](#).

Biochemical Oxygen Demand (BOD): When biodegradable organic matter (including organic waste) is present in waters it provides nutrient for the growth of bacteria and other microorganisms causing them to multiply and, where bacterial numbers are sufficient causing a depletion of dissolved oxygen in the water. The BOD (5day) test is a measure of the amount of oxygen consumed by microorganisms in breaking down the organic matter. Where a nitrification inhibitor is not used, this test measures the total BOD. Where a nitrification inhibitor (such as allylthiourea) is used in the test, it is referred to as Carbonaceous BOD or CBOD.

The BOD value in rivers often increases during periods of heavy rain and high river flows - as organic matter is washed in from the land and farmyards. Examples of typical BOD concentrations for potential pollution sources are given below:

Sample	Typical BOD mg/l O ₂
Treated UWWTP sewage	10 to 40
Untreated domestic sewage	300
Cattle slurry	12,000
Pig slurry	30,000
Silage effluent	60,000

Biological Quality Ratings (Q-Values): The biological classification of river and lake water quality used in Ireland is based mainly on the presence or absence of various macroinvertebrate fauna (crustaceans, insects, worms, molluscs, leeches, etc.) - some species being sensitive to pollution while others are tolerant. This is discussed in more detail in the main report. Biological testing is normally carried out on a 3-yearly cycle and the most recent biological rating (or Q-Value) is given for each sampling station.

Chloride: Chloride occurs naturally in river waters. Some industrial and sewage treatment plant effluents may contain elevated chloride levels and changes in concentrations may be an indicator of pollution. Elevated levels may be seen occasionally in winter when salt is used to de-ice roads. Very high levels of chloride may be seen especially in the lower reaches of rivers where a tidal influence exists. Its presence in lakes adjacent to coastal areas is generally due to saline deposition from rainfall and is correlated with sodium concentrations. Chloride is typically determined using colorimetric or chromatographic methods and reported as mg/l.

Colour: Colour is a measure of the dissolved colouring compounds in water. The colour of water is attributed to the presence of organic and inorganic materials. It is expressed as Pt-Co units according to the platinum-cobalt scale. It may also be expressed as Hazen units which are equivalent to mg/l Pt-Co. Water colour can naturally range from 0-300 mg/l Pt-Co with higher values being associated with swamps and bogs due mainly to the presence of complex organic molecules such as humic acids. It may be reported as Apparent Colour (unfiltered) or True Colour (filtered) and is commonly measured using a UV spectrophotometer.

While colour is not generally considered to be a detriment to aquatic life, increased colour may interfere with the passage of light, thereby impeding photosynthesis. Where water is abstracted for human consumption and chlorinated, the chlorine can react with the organic materials to produce undesirable Trihalomethanes (THMs) in the drinking water.

Conductivity: Conductivity is the measurement of the ability of water to conduct an electric current - the greater the content of dissolved ionic salts in the water, the more current the water can carry and the higher the conductivity. It is often used as an alternative measure of dissolved solids and it is often possible to establish a correlation between conductivity and dissolved solids for a specific body of water.

Conductivity is normally reported as microsiemens per centimeter ($\mu\text{S}/\text{cm}$) and is typically reported at 20°C or 25°C. The following relationship applies:

Conductivity @ 20°C = Conductivity @ 25°C * ((1+0.0191*(20-25)). This equates to:
Conductivity @ 20°C = Conductivity @ 25°C x 0.9045

Dissolved Oxygen (DO): Dissolved Oxygen is essential for the survival of fish and other aquatic life and is an important indicator of pollution and/or eutrophication in rivers. The solubility of oxygen in river waters depends mainly on the water temperature and salinity. Water in equilibrium with air is normally saturated with oxygen (i.e. at 100% Saturation) and DO can be expressed either as % Saturation or in concentration terms as mg/l O₂. The maximum solubility of oxygen (fully saturated) ranges from approximately 15 mg/l at 0°C to 8 mg/l at 25°C (at sea level). Several factors can cause deviations in DO from equilibrium conditions and there can be a time lag before the equilibrium is restored.

Such variations can be caused by:

- River morphology e.g. rapids or other areas of turbulence.
- Seasonal changes in temperature.
- Consumption of oxygen by microorganisms in the breakdown of organic matter present. This can lead to an oxygen sag where a sufficient amount of organic matter is present.
- Eutrophication - the exchange of oxygen between plants and water in eutrophic waters can cause diurnal variations in DO leading to high (frequently super-saturated) levels of dissolved oxygen during the day but dissolved oxygen levels can decline seriously during the hours of darkness with the critical period for dissolved oxygen in eutrophic waters occurring just before dawn (i.e. after maximum hours of darkness).

Dissolved Inorganic Nitrogen (DIN): This term is generally used in the assessment of saline waters where nitrogen is the more limiting nutrient. It is a measure of the sum of Ammonia and Total Oxidised Nitrogen. The EQS is salinity dependent e.g. SI 272 of 2009 sets the following boundaries for DIN in coastal waters:

0 psu Good status $\leq 2.6\text{mg/l N}$

34.5 psu Good status $\leq 0.25\text{mg/l N}$ (with linear interpolation for other salinities)

34.5psu High Status $\leq 0.17\text{ mg/l N}$.

Fluoride: Fluoride may be present as the result of the natural decomposition of rocks, or when present in treated drinking water supplies, as the result of a local water fluoridation programme. It prevents tooth decay; however excessive amounts of fluoride can result in mottled tooth enamel. The maximum acceptable concentration in drinking water is 0.8 mg/l F for fluoridated supplies and 1.5 mg/l F for supplies with naturally occurring fluoride, not needing further fluoridation.

It is also listed as a specific pollutant as per Schedule 3 of the EC Environmental Objectives (Surface Waters) Regulations, S.I. 272 of 2009 with an Annual Average EQS of 0.5 mg/l F for inland surface waters and 1.5 mg/l F for other waters.

Hardness: The hardness of water is generally due to the presence of calcium and magnesium in the water. Other metallic ions may also contribute to hardness. It is normally expressed as mg/l CaCO₃ but may be reported in alternative units as given below:

Convert From	Convert To	Multiply By
mg/l CaCO ₃	mg/l Ca	0.4
mg/l CaCO ₃	Clark Degrees	0.07
mg/l CaCO ₃	French Degrees	0.1
mg/l CaCO ₃	German Degrees	0.056

Water hardness is typically classified according to the following table:

Hardness	mg/l CaCO ₃	mg/l Ca	Clark Degrees	French Degrees	German Degrees
Soft	<50	<20	<3.5	<5	<2.8
Moderately Soft	50 - 100	20 - 40	3.5 – 7.0	5 - 10	2.8 – 5.6
Slightly Hard	100 - 150	40 - 60	7.0 – 10.5	10 - 15	5.6 – 8.4
Moderately Hard	150 - 250	60 - 100	10.5 – 17.5	15 - 25	8.4 – 14.0
Hard	250 - 350	100 - 140	17.5 – 24.5	25 - 35	14.0 – 19.6
Excessively Hard	>350	>140	>24.5	>35	>19.6

Harder water has the effect of reducing the toxicity of some metals (i.e., copper, lead, zinc, etc.). Soft water may have corrosive effect on metal plumbing, while hard water may result in scale deposits in the pipes.

Hardness is typically determined using titrimetric methods. Where the water hardness is due to the presence of calcium and magnesium, it may be calculated using the following equation:

$$\text{Total Hardness (mg/l CaCO}_3\text{)} = 2.497[\text{Ca mg/l}] + 4.118[\text{Mg mg/l}]$$

Kjeldahl Nitrogen: This is a measure of both the ammonia and the organic forms of nitrogen. Organic Nitrogen is a measure of that portion of nitrogen that is organically bound. It includes all organic compounds such as proteins, polypeptides, amino acids, and urea. While excess ammonia contributes to the eutrophication of water bodies and therefore results in prolific algal growths that have deleterious impacts on other aquatic life, organic nitrogen is not immediately available for biological activity. Therefore, it does not

contribute to furthering plant proliferation until decomposition to the inorganic forms of nitrogen occurs.

Kjeldahl Nitrogen may be determined directly but may also be calculated from Total Nitrogen and Total Oxidised Nitrogen (TON) measurements as follows:

$$\text{Total Kjeldahl Nitrogen (mg/l N)} = \text{Total Nitrogen (mg/l N)} - \text{Total Oxidised Nitrogen (mg/l N)}$$

Nitrite: Nitrite is an intermediate in the oxidation of ammonia to nitrate. Many effluents, including sewage, are rich in ammonia, which in turn can lead to increased nitrite concentrations in receiving waters. Therefore high levels of nitrite in river waters may indicate pollution. This form of nitrogen can be used as a source of nutrients for plants and its presence encourages plant proliferation. Nitrite is also toxic to aquatic life at relatively low concentrations. In unpolluted waters, nitrite levels are generally low (<0.01 mg/l N). Nitrite is normally determined using spectrophotometric methods and may be reported as mg/l N or NO₂. The following conversion factor applies:

Convert From	Convert To	Divide By
mg/l NO ₂	mg/l N	3.28

Nitrate: This is the measurement of the most oxidized and stable form of nitrogen in a water body. It is the principle form of combined nitrogen found in natural waters and results from the complete oxidation of nitrogen compounds. Nitrate is the primary form of nitrogen used by plants as a nutrient to stimulate growth. Excessive amounts of nitrogen may result in phytoplankton or macrophyte proliferations. At high levels it is toxic to infants.

Nitrate is normally determined using spectrophotometric or chromatographic methods and may be reported as mg/l N or NO₃. The following conversion factor applies:

Convert From	Convert To	Divide By
mg/l NO ₃	mg/l N	4.43

Organic Carbon: Total Organic Carbon (TOC) is a measure of the dissolved and particulate organic carbon in water. The bulk of organic carbon in water is composed of humic substances and partly degraded plant and animal materials. Organic carbon is resistant to microbial degradation. High levels of organic carbon coincide with a lowering of dissolved oxygen concentrations. Organic Carbon levels in water abstraction sources are important as those with elevated levels are susceptible to the formation of trihalomethanes (THMs) when chlorinated during water treatment.

TOC is typically determined using a TOC Analyser which uses online sample digestion followed by Conductivity or Infra-Red detection. Dissolved Organic Carbon (DOC) is

measured in the same way, though the sample must be filtered through a 0.45 µm filter prior to measurement. Both TOC and DOC are typically reported as mg/l.

pH: pH is the measurement of the hydrogen-ion concentration in the water. A pH below 7 is acidic and a pH above 7 (to a maximum of 14) is basic. pH varies depending on the geology of the river catchment, on river flow, and on wastewater discharges but is generally in the range 6 – 9. It can also be influenced by biological processes, chiefly carbon dioxide uptake by plants during photosynthesis. In eutrophic waters, diurnal variations of pH may follow the diurnal variations in dissolved oxygen. High pH values tend to facilitate the solubilization of ammonia, heavy metals and salts. The precipitation of carbonate salts is encouraged when pH levels are high. Low pH levels tend to increase carbon dioxide and carbonic acid concentrations. Lethal effects of pH on aquatic life occur below pH 4.5 and above pH 9.5.

Phosphorus: Phosphorus (P) is generally considered to be the limiting nutrient for plant growth in freshwater with small quantities occurring naturally mainly from geological sources. Phosphorus in natural waters & wastewaters is usually found in the form of phosphates (PO_4^{3-}).

- Inorganic form (including orthophosphates and condensed phosphates)
- Organic form (organically-bound phosphates)

Orthophosphate is the most readily available form for uptake during photosynthesis. High concentrations generally occur in conjunction with algal blooms.

Orthophosphate is generally measured colorimetrically using a molybdate based chemistry method and is often referred to as Molybdate Reactive Phosphorus (MRP). MRP is generally taken to be equivalent to orthophosphate though it should be noted that the MRP method may measure small amounts of phosphates other than orthophosphate.

Orthophosphate may be reported as mg/l P, mg/l PO_4 and sometimes as mg/l P_2O_5 . The following conversion factors apply:

Convert From	Convert To	Divide By
mg/l PO_4	mg/l P	3.07
mg/l P_2O_5	mg/l P	2.29

Sulphate: Sulphate exists in nearly all natural waters, the concentrations varying according to the nature of the terrain through which they flow. They are often derived from the sulphides of heavy metals. Iron sulphides are present in sedimentary rocks from which they can be oxidised to sulphate in humid climates; the latter may then leach into watercourses so that groundwaters are often excessively high in sulphates. Sulphate is typically determined by Ion Chromatographic methods and reported as mg/l SO_4 .

Suspended Solids: This is a measure of the particulate matter that is suspended within the water column. High concentrations of suspended solids increase turbidity, thereby restricting light penetration (hindering photosynthetic activity). Suspended material can result in damage to fish gills. Settling suspended solids can cause impairment to spawning habitat by smothering fish eggs. Suspended solids interfere with water treatment processes. Analytically, suspended solids are determined by filtering a known volume of water through a 0.45 µm filter paper and noting the increase in weight of the filter paper. It is reported as mg/l.

Temperature: Temperature affects the solubility of many chemical compounds and can therefore influence the effect of pollutants on aquatic life. Increased temperatures elevate the metabolic oxygen demand, which in conjunction with reduced oxygen solubility, impacts many species. Vertical stratification patterns that naturally occur in lakes affect the distribution of dissolved and suspended compounds. Localised elevated temperatures can occur where there are discharges such as industrial cooling waters.

Total Dissolved Solids: Total Dissolved Solids (TDS) is a measure of the amount of dissolved material in the water column. Dissolved salts such as sodium, chloride, magnesium and sulphate contribute to elevated residue values. High concentrations of TDS limit the suitability of water as a drinking source and irrigation supply. Analytically, TDS is determined by filtering the water through a 0.45 µm filter paper, evaporating a known volume of filtrate in a suitable container and noting the increase in weight of the container. It is reported as mg/l.

Total Nitrogen: This is a measure of all forms of nitrogen (organic and inorganic). The importance of nitrogen in the aquatic environment varies according to the relative amounts of the forms of nitrogen present, be it ammonia, nitrite, nitrate, or organic nitrogen. Analytically, total nitrogen is determined by firstly digesting the sample (online or offline) followed by colorimetric measurement. Total nitrogen is reported as mg/l N.

Total Oxidized Nitrogen: Total Oxidized Nitrogen (TON) is the sum of nitrate and nitrite. It is commonly determined using colorimetric means and because nitrite is generally a very small fraction of the TON concentration in rivers, TON is taken to be equivalent to the nitrate concentration. Like nitrate, it may be reported as mg/l N or mg/l NO₃. Refer to section on Nitrate for the conversion factor.

Total Phosphorus: This is a measure of both inorganic and organic forms of phosphorus. Due to the longer residence time in lakes, total phosphorus rather than just orthophosphate is considered to be the most critical nutrient in most cases. Analytically, it is normally determined by prior digestion of the sample (online or offline) followed by colorimetric measurement. Total phosphorus is typically reported as mg/l P.

Turbidity: This is a measure of the suspended particulate matter in a water body which interferes with the passage of a beam of light through the water. Materials that contribute to turbidity are silt, clay, organic material, or micro-organisms. High levels of turbidity increase the total available surface area of solids in suspension upon which bacteria can grow. High turbidity reduces light penetration; therefore, it impairs photosynthesis of submerged vegetation and algae. In turn, the reduced plant growth may suppress fish productivity. Turbidity interferes with the disinfection of drinking water and is aesthetically unpleasant. Turbidity is normally reported as Nephelometric Turbidity Units (NTU).