Compliance Rules for Certain River Chemistry Determinands

Environmental Protection Agency: June 2011

Rivers
Quality Element: **GENERAL CONDITIONS - OXYGEN AND NUTRIENT CONDITIONS**

Method
Oxygen and Nutrient Conditions ('Organic Enrichment') Ortho-phosphate, Nitrate, Total Ammonia, BOD, Dissolved Oxygen

Description
Classify into Good or Moderate-or-poorer – based on being 99% confident that relevant EQS in SI 272 of 2009 are exceeded. ‘Passes’ are not classified as High.

**Statistical method for assessing compliance with SI 272 of 2009**

SI 272 has a provision for the setting of statistical rules for assessing compliance with the Environmental Quality Standards (EQS) that it defines. Most of the standards are evaluated on a simple ‘face-value’ approach – i.e. if a concentration is greater than the standard then it is deemed to have failed. A ‘benefit of the doubt’ approach to compliance with standards is taken, however, in assessing compliance with the environmental quality standards (EQS) for phosphate, biochemical oxygen demand, and total ammonia. In addition a surrogate standard for nitrate\(^1\) was also included in order to maximise the match between the status arising from biological quality elements such as macroinvertebrates and these supporting physico-chemical quality elements.

For more details of the statistical approach used see: Ellis, J.C., 1989. Handbook on the Design and Interpretation of Monitoring Programmes, published by the WRc, in particular pages 4-4 et seq., 6-4 et seq.

The method is described briefly here:

Data are log+1 transformed to ensure normal distributions.

A \((100-2\alpha)\)% confidence interval for the true mean is:

\[
\{\bar{x} - D, \bar{x} + D\} \tag{1}
\]

where

\[D = t(\alpha).s\sqrt{n} \tag{2}\]

and \(t(\alpha)\) = Student’s t statistic with \(n-1\) degrees of freedom corresponding to the a single-tail probability of \(\alpha\), \(s\) is the standard deviation and \(n\) is the number of

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\(^1\) For high status a mean of 0.9 and a 95%ile of 1.4 and for good status a mean of 1.8 and a 95%ile of 2.7 mg N/l
samples.

An $\alpha$ level of 0.005 or 99% confidence interval is calculated. Before an individual determinand is deemed to have 'failed' – i.e. we must be 99% confident that the determinand mean or 95%ile exceeds the relevant EQS. For an individual determinand in the following list: PO4, NO3, NH3, BOD - a site must fail on both the mean EQS and the 95%ile EQS values in SI 272 of 2009 at the above 99% confidence interval.

A failure for an individual determinand EQS is recorded if:

$$\bar{x} > EQS + D$$  \hspace{1cm} (3)

where $EQS$ is the relevant mean or 95%ile concentration in SI 272 of 2009 and $D$ is the 99% confidence interval in equation 2 above. Typically three years of data are used – e.g. 2007-2009.

In addition to a fail of the mean and 95%ile being required for individual determinands, a 50% or greater failure rate is required for the determinands measured (PO4, NO3, NH3, BOD) before the site fails as a whole for the purposes of overall one-out all-out ecological status assessment. Thus, at least two of four parameters must fail before the site fails or two of three if only three are measured. An individual fail will not cause the site to fail unless it is the only parameter measured. Including four determinands rather than three improves the match obtained between biological status and these supporting physico-chemical determinands.

Dissolved oxygen is assessed on a one-out all-out basis using a compliance rule requiring 95% of samples to be $>80\%$ saturation and 95% of samples to $<120\%$ saturation.

A minimum of four values is required for the above benefit of the doubt approach. If there are less than four measurements a 'face-value' approach is taken when comparing results with the EQS – the mean and 95%ile concentrations must be less than the relevant standards.

The above approach is based on a detailed comparison of fails for biological status quality elements and these supporting physico-chemical quality elements – nutrient and oxygen conditions. Due to the one-out-all-out rule it is important not to have a large number of failures in the supporting chemistry that are not borne out by the biological quality elements. This approach produces good agreement, minimising the number of spurious failures for chemistry.

For the purposes of calculating means 'less than' values are treated by taking half the reported limit of detection.

Where a site only has supporting physico-chemical data available – i.e. no results available for any of biological quality elements – ecological status of high or good ecological status is not assigned on supporting physico-chemical data alone. Where a clear failure is seen for 50% of the determinands above a site may be classified as being of moderate ecological status but in general it is preferred that operational and surveillance sites should have results for at least one biological quality element.