The potential of Whole Effluent Assessment

To date effluent discharges have largely been assessed and regulated on the basis of physical and chemical properties, such as chemical oxygen demand (COD), biological oxygen demand (BOD), suspended solids, pH and concentrations of specific hazardous substances. These properties provide a sound basis for controlling effluents containing relatively few well-characterized contaminants with well-defined and understood toxicological properties. However it is sometimes difficult to assess the environmental significance of complex and variable effluents on the basis of their composition and physico-chemical properties alone.

As an alternative, the Whole Effluent Assessment (WEA) concept proposes the direct measurement of eco-toxicity of effluents as part of an integrated approach to protecting and improving surface water quality. Work is in hand in a number of international bodies to develop an internationally harmonized approach to bioassay requirements, which would be recognized by national agencies and supported by industry. The approach has also recently been recognized by its inclusion in the BAT[1] Reference Document for waste water and waste gas treatment in the chemical industry.

Eco-toxicity assessment provides an additional and perhaps more direct means of assessing the potential impact of effluents on the aquatic environment. It is likely to play an increasing part in the regulation of discharges, supplementing and possibly replacing the traditional yardsticks of effluent quality in environmental monitoring and risk assessment. Cooperation and mutual understanding between the regulators and the industries concerned will be essential to ensure that control of chemically complex discharges remains cost-effective and meets the relevant environmental objectives.

In developing and establishing such an approach it is important to recognize that the choice of bioassay methods depends on the application, i.e. whether results are to be used for risk assessment, monitoring or compliance. Bioassay methods for different applications will have different requirements.

Risk assessment is concerned with evaluating the potential effects of a specific discharge to a receiving environment. Assessment should commence with standardized laboratory bioassays to determine the acute toxicity of the effluent to a range of relevant species. The species should be selected on the basis of existing knowledge of their susceptibility to known toxic effluent components or as representative of important functional groups in the receiving environment. The bioassay results can then be combined with predicted or measured dilution patterns in the receiving water to assess potential risk. In cases where this assessment shows that the expected effluent concentration in the receiving water is close to the no-effect level, further work may be required to assess the level of risk posed by a discharge. This may also be the case when there are concerns over the potential for longer-term effects resulting from the presence of persistent and toxic effluent components.

[1] *BAT: Best Available Technique*

Bioassay methods for monitoring effluents differ from those used in risk assessment in that they should provide a convenient mechanism for assessing the variability of effluents being discharged and give a warning if the effluent toxicity has altered significantly. Monitoring techniques need not be the most sensitive, but they have to be capable of detecting changes in relative toxicity which can be correlated with the results of assessment or compliance tests. To be useful these test methods need to be inexpensive, fast, relatively portable and easy to conduct. Field monitoring studies can be used to provide a mechanism for checking that discharge consent parameters are achieving the degree of control and protection envisaged. Monitoring studies should, where possible, include pre- and post-discharge assessments (in both time and space). These will ensure that changes in status attributable to the effluent can be confidently identified.

Bioassays conducted for compliance purposes need to be of a statistically robust design, yield unambiguous results and be reproducible and robust to the closest scrutiny. Without this, site operators risk finding themselves quite unjustifiably liable to legal penalties when it is the test method rather than their performance which is at fault. Such tests should always be carried out by approved laboratories with quality control accreditation. Tests used for this purpose need to have proven test performance criteria and be based on methods that are applicable internationally. The most likely tests for adoption will be adaptations of methods currently required for regulatory chemical hazard assessment.

Both chemical analysis and ecotoxicity assessment of effluent have their own relative merits and disadvantages.

In principle, chemical analytical methods allow calculation of total pollutant load per substance and show whether any particular problem-substance is present. This is, however, only true if all components are measured, which is rarely the case. The presence or absence of any listed substance can be confirmed. Data can also be provided for calculating regional and national contaminant loads, e.g. for monitoring progress towards reduction targets for discharges into a body of water such as the North Sea. The disadvantages of analytical methods are that they are time-consuming and increasingly expensive for effluents containing large numbers of substances. Even with full chemical analysis adequate toxicological data on all the substances is usually not available to allow a reliable assessment of the environmental hazard of the effluent.

The advantages of ecotoxicity assessments are firstly that they provide a measure of the combined effects of all the components in a complex effluent, thereby taking account of any additive or synergistic effects. Secondly they add a degree of biological relevance which can help public understanding of the impact of an effluent and demonstrate the distinction between contamination (substances present at concentrations too low to cause harm) and pollution (substances present at concentrations likely to cause harm). Ecotoxicity assessment provides a mechanism for evaluating the environmental significance of a complex effluent that is usually quicker and cheaper than extensive chemical characterization. Bioassay methods can also be used to assess the quality of receiving waters and for identifying toxic components of an effluent and

tracking their origins within a multi-plant site by carrying out the tests on samples taken from various points in the sewer system.

It is widely recognized, however, that there are currently considerable difficulties and limitations in the application of ecotoxicity testing. Perhaps the greatest difficulty is deciding which bioassays are appropriate for each situation. Consideration must always be given to probable differences between environmental effects indicated by laboratory bioassays and the subsequent effect of an effluent in the aquatic environment. Natural degradation processes cannot be simulated reliably in the laboratory without elaborate and expensive test procedures. There is great uncertainty about the precision of results. These are influenced by effluent sampling methods, sample storage conditions, time between sample collection and biological testing, inter- and intra-laboratory variability, effluent variability, level of understanding of the local receiving water conditions, and the influence of the latter on effluent toxicity to resident organisms. These aspects must be carefully examined to ensure that any ecotoxicity assessment scheme is both scientifically sound and practicable.

Research is currently being undertaken to develop reliable and cost-effective methods for the toxicity assessment and monitoring of effluents. Some of the techniques (e.g. bio-sensors) have considerable potential, but they are not currently at an advanced stage of development.

The limited state of development of bioassay methods and the inherent variability of biological testing indicates that ecotoxicity assessment methods currently available are not sufficiently reliable to be used as a compliance criterion in terms of a limit in a discharge permit which triggers legal action if exceeded. Ecotoxicity assessment can be used most effectively as an action level to initiate investigation, identify sources of toxic discharges, prioritize toxicity reduction measures, plan toxicity reduction programmes and monitor improvements both at the end-of-pipe and in the quality of the receiving water. However, it is costly and time-consuming and should be applied only when appropriate to the risk, and the results used only if unambiguous.