Workshop on Availability, Interpretation and Use of Environmental Monitoring Data
20 – 21 March 2003, Brussels

Workshop Report No. 1

Brussels, December 2003

ECETOC WORKSHOP REPORT No. 1

The workshop was jointly organised by ECETOC and Euro Chlor to encourage the co-ordinated collection, evaluation and use of monitoring data.

Euro Chlor, which represents the European chlor-alkali industry, has used environmental monitoring data for exposure since 1995 when it initiated marine risk assessments for 25 chlorine-related chemicals. Euro Chlor's science activities aim to provide sound scientific information to stakeholders on chlor-alkali related issues. Examples are Science Dossiers, in depth analyses of specific substances or topics produced for the scientific community, and Key Science Information Sheets, generated to help non-scientists understand specific science issues. Science information can be downloaded from the Euro Chlor website *Chlorine Online* (http://www.eurochlor.org/)

Euro Chlor
representing the chlor-alkali industry

Availability, interpretation and use of environmental monitoring data

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EXECUTIVE SUMMARY

In recent years, there has been a growing emphasis on monitoring chemical substances in the environment, and the need for measured data will continue to increase - the Water Framework Directive (WFD) and the new EU Chemicals Policy will certainly be major drivers. With this in mind, a workshop was organised by ECETOC, the European Centre for Ecotoxicology and Toxicology of Chemicals, and Euro Chlor, the federation representing the European chlor-alkali industry. It focused on application and use, reliability and representativeness, and availability and accessibility of monitoring data. The workshop was held in Brussels, Belgium on 20-21st March 2003 and was attended by 45 delegates representing governments, academia and industry.

Recommendations for the use of existing databases

- The amount of monitoring data increases every year but access to databases is, in general, very limited. The benefits of making the data more easily available are clear and the potential to improve accessibility is great, but to do so will require commitment by stakeholders (industry, academia and Member States). To improve the availability of the data, a meta-database is required. Various organisations could be considered to be suitable to meet the challenge of creating such a system e.g. the EU (EEA), OECD or UNEP.
- The overlay of various databases from different origins and domains should be promoted provided there is consistency of methodology and a holistic approach. The initiatives of Arctic Monitoring and Assessment Programme (AMAP) are a good example.
- Guidelines for a statistical approach to extend the use and interpretation of existing data for intended uses (fit for purpose), should be further developed.

Recommendations for new monitoring programmes

- The importance of the two current main drivers to develop monitoring programmes on a European scale, i.e. the Water Framework Directive (WFD) and the new Chemicals Policy, was recognised.
- The workshop participants agreed that the WFD focuses first on what is impacting the quality of ecosystems, and then on chemical substances and other sources. This increased emphasis on biological monitoring creates an opportunity to develop programmes that combine both chemical and biological information.
- Under the new Chemicals Policy monitoring will become an important risk assessment tool in combination with modelling approaches.

- New monitoring programmes should integrate the knowledge generated in the past and specifically must become more 'fit for purpose', more attuned to the activities and concerns of society. A number of these learnings were listed and discussed, delivering organisational and technical recommendations when developing new monitoring programmes:
  - There should be a better balance between good science and policy making;
  - The setting of policy goals should directly determine minimum requirements for monitoring, ensuring optimum use of resources;
  - The scientific community should communicate this clearly to the public authorities.
- More specifically, monitoring should be organised in a manner that facilitates management decisions and allows assessment of the impact and effectiveness of decisions taken:
  - It should have the statistical power to demonstrate whether changes have occurred and to indicate the effectiveness of management measures;
  - It should measure essential functions of a water body/ecological system to assess quality.
- The skills and specific needs of modellers, biologists and chemists should be integrated into the design and execution of programmes and in the interpretation of the data. Greater effort (via networks possibly) needs to be made to involve various disciplines in the design and execution of monitoring studies. Water, sediment and biota should be considered when choosing sampling sites.
- A tiered approach (screening, surveying, monitoring) to the collection of measured data is recommended. Each tier has a different purpose, defining its specific methodology and degree of accuracy.

Sampling programmes should be managed as dynamic processes. They should be continuously audited and assessed, and changes (e.g. new determinands, sampling frequency adjusted) and improvements made. For example, the collection and analysis of measured data should always involve tracking of unexpected or abnormal results.

A classification system for the reliability of data is needed, which should be implemented into new databases. Guidance for harmonised screening across European countries is also needed. These could be achieved by building on approaches such as that taken by AMAP.

WORKSHOP OVERVIEW

Background

In recent years, there has been a growing emphasis on monitoring chemical substances in the environment, and the need for measured data will continue to increase. The Water Framework Directive (WFD), High Production Volume Chemicals (HPVC) programme and POP/PTB activities, as well as the emerging EU Chemicals Policy will depend increasingly on monitoring data. In risk assessments, exposure is of critical importance and only measured data can ultimately represent a realistic situation. When using models to assess exposure, monitoring data will be essential for validation and to increase accuracy and confidence. The 1998 OECD workshop made a number of recommendations on how to improve the use of monitoring data in exposure assessment for industrial chemicals. It is now time to review progress and to build upon those suggestions. Particular emphasis must be placed on application (model validation, probabilistic approach in exposure assessment, trend analyses, policy compliance checks, etc), reliability and representativeness (sampling strategies, site selection, analytical quality control, treatment of data that falls below detection limits, etc.), and availability and accessibility of monitoring data (data sources, broad access, development of a future European monitoring network, etc). Historically, monitoring has concentrated on chemical analysis. However many of the issues still to be resolved will apply equally to biological monitoring, an area which will become increasingly important as the WFD is implemented across the European Union.

Aims

The general aims of the workshop were to establish the current status of environmental measurement databases and identify methods to improve the understanding of applications.

Specific objectives:

- Suggest how monitoring programmes should be established to support risk assessments for existing chemicals, model validation etc;
- Propose criteria by which the quality of measured data, including reliability and representativeness, can be assessed and applied for specific uses;
- Assess monitoring data availability, recommend ways to share information and improve access to environmental monitoring networks and databases;
- Assess resources needed to improve data availability.

Workshop Structure

Over 40 participants with backgrounds in chemical and/or biological monitoring representing governments, academia and industry met for a 1½ day workshop to address three key topics: application, reliability and availability of monitoring data. Each topic was introduced by a presentation and followed by syndicate sessions. Conclusions were discussed in a plenary session at the end of the workshop.

The workshop was held in Brussels on 20-21st March 2003. It was organized by the European Centre for Ecotoxicology and Toxicology of Chemicals (ECETOC) and Euro Chlor, the federation representing the European chlor-alkali industry.

1. APPLICATIONS OF EXISTING AND FUTURE MONITORING DATA

The objectives of this session were to:

- Identify the problems associated with the use of existing databases and programmes;
- Identify ways in which the design and implementation of new programmes can be improved for use in regulatory exposure assessments, modelling, biological quality assessment.

1.1 Existing databases

1.1.1 Criteria for assessing chemical and biological data

Information about the purpose of the study is needed, and there should be clear quality criteria for assessing data within a database. However data from studies whose purpose is unclear may also be considered, providing they meet the following criteria:

- The sampling strategy is specified, including what was sampled, when and where, how representative the samples were of the local or regional situation, and to what extent they allowed for an assessment of temporal and/or spatial variability;
- The analytical methodology is clearly described, including the limit of detection and the quality of the analytical determinations.

From a biological perspective, the problems can be grouped under limitations in content, species and trophic levels, geographical coverage, number of samples and seasonal fluctuations. In particular, the life cycle and behavioural patterns of the species under investigation need to be considered if the results are to be meaningful.
These criteria are also relevant for the design of new monitoring programmes.

1.1.2 Uses of data

Data quality can be very variable. It is therefore important to assess the quality against the specific purpose for which the data is being used.

Outliers should not always be ignored – it was recommended that they be further investigated to establish why these results are different.

There is a need for statistical evaluation guidelines to be developed such that Type II errors are not missed in the quest to avoid Type I errors.[1] The data quality should be peer reviewed.

Four major uses were considered and key data features identified:

- Exposure assessment - for example as part of risk assessment and trend analysis. The extent to which the data addresses temporal or spatial (local or regional) variability should be defined in detail;
- Compliance assessment - data can be used to address the effectiveness of controls;
- Effects assessment - in particular in the context of the WFD it will be important to establish if any deviation from good ecological status occurs and to establish its cause;
- Model development - the extent to which the data can be used to check, calibrate or assess a given model.

Monitoring data often originates from different laboratories. If the data is to be combined, careful examination of its quality is required. Provided the accuracy remains constant in a given laboratory, the relative accuracy is less important where temporal changes or trends are being investigated.

1.2 Design and implementation of new programmes

The primary goal of a monitoring programme (legal compliance, gap filling, identifying new potential chemicals of concern, etc.) should be clearly defined and taken into account during study design. The resulting data will then be useful, and not simply generated for its own sake. To ensure that the programme is “fit for purpose”, its objectives must be clearly stated, it must be designed to answer relevant questions and to be further refined based on learnings during implementation. The limitations of any programme should be stated up-front to ensure that the stakeholders understand clearly what will be delivered. This will also help build confidence in the results and highlight any uncertainty. However, it is also important to understand the potential for future uses of data and samples, and to consider incorporating secondary strategies into the programme. This is an excellent way of enhancing data usefulness and facilitating sharing of sampling efforts.

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[1] A Type I error in a statistical test occurs when a true hypothesis is rejected; a Type II error in a statistical test occurs when a false hypothesis is accepted.

The cycle of model predictions, data generation and model re-calibration is important and needs to be incorporated into the monitoring programme. The design stage can be guided by existing models, including output from such models, or allowing for feedback and calibration based on initial monitoring results. This requires interaction between modelling and monitoring experts. It may be possible to define a model's domain and applicability, in the same way as for QSAR.

Chemicals to be addressed need to be of interest, focusing on newer chemicals of concern. Very often monitoring programmes investigate the same set of historically interesting chemicals, the 'old favourites'. This approach is gradually changing (e.g. Sweden and Japan have programmes in place looking at chemicals currently of concern. In Japan, for example, monitoring surveys aim to identify new chemicals of concern, and have monitored over 1000 chemicals since 1974).

Confidence is enhanced by having the sampling design and regime tailored to take into account information on the mode of action or degradability. If identification of cause and effect is at the centre of the programme, use of a bioassay may need to be included in the study design. Confidence can also be enhanced by taking an adequate number of samples and the use of standardised methods. EU-wide standards established through CEN are valuable, and UNECE has also developed monitoring quality documents.

Design should take release patterns into consideration particularly where intermittent chemical releases occur. If pollution occurs episodically, the impact may be short-lived. But if the adverse impact remains for a longer period of time, then it may be difficult to establish its cause. The reproductive cycle of species may have an influence on the design and frequency of sampling, even if reproduction itself is not the endpoint.

The possible biological endpoints for use in monitoring programmes are varied, and range from the molecular level to higher level endpoints. Whereas at face value their application may appear to be inconsistent, upon more detailed examination this may be a reflection of different but equally valid goals. Therefore the rationale for the selection of a particular endpoint needs to be clearly supported so that the programme and the data generated can be given appropriate weight and value.

Population variability needs to be incorporated to avoid misinterpretation of results. Ecosystems are dynamic and natural succession is taking place. There are other influences such as climate change that will have an impact and need to be considered in trend monitoring; these could either be a confounding factor or be described as the cause of changes.

It may be more scientifically justifiable to consider quality of the ecosystem and population dynamics than to base judgement on the most sensitive endpoint. For example, the use of biomarkers will certainly be protective – but may be overly protective – and should include evaluation of whether the ecosystem still functions, and whether the functions assigned to the water body will be affected if some species may have been lost. A workshop should be organised to discuss ecological quality, relevance of experimental data and the concept of services.

Whilst most monitoring programmes should be designed for a specific purpose, as advocated earlier, environmental epidemiology is emerging as a new approach. Molecular techniques are being developed for the rapid identification of species, which helps in establishing microbial diversity. The early indications are that promising tools are being developed and their scientific basis is being established. Further work needs to be done to facilitate the development of investigative diagnostic tools, based on expert knowledge, post mortem analysis, etc.

An *a priori* determination of the predictive and analytical power of a programme is often not done. This may limit the usefulness of the data. Sometimes this can simply be a result of not fully realising the consequences of reducing the specifications of the original design. Finally, as discussed previously, all the criteria for assessing existing data should be taken into account when designing a new programme. All future data collected should list the context of the programme and ideally be supported by models to allow better use and extrapolation of the data. The minimum requirements are the x,y-coordinates of sampling points. The criteria for assessing chemical and biological data in existing databases also apply to new monitoring programmes.

1.3 Interplay between monitoring and modelling

The general perception was that the availability of monitoring data for modelling purposes is very limited. There is a general lack of emissions data. Although some data are available there are several shortcomings in current monitoring data for modelling purposes (application, calibration, validation).

The most common critical shortcomings related to the available data are:

- Lack of information on the context in which the data were generated;
- The quality of data is not indicated and cannot be traced;
- Data presented are aggregated and raw data cannot be obtained;
- It is not clear whether the monitoring data represent hot spots or are representative of background conditions;
- Modelling can be useful to guide monitoring; this approach is not often practised.

Clearly data is being collected for regulatory purposes but little if any of the data is being used for model validation. This is something that could readily be addressed and the opportunity to use the data for model development should be included the design of the monitoring programme. Models should be used to provide working hypotheses, for example specific catchment models are available that could be used to guide monitoring design.

Data requirements will be different for generic multimedia and for deterministic models. To apply, calibrate and validate models, information is needed to interpret the monitoring data. In particular there is a:

- Significant lack of spatial and temporal information;
- Insufficient dilution and advection information at the time of sampling;
- Shortage of good data on substance characteristics that is suitable for modelling;

The representativeness of monitoring data is highly dependent on the goal of the model, local conditions, and the scale to be covered (local, regional, global). There is a need to formulate the model hypothesis, to define the system to consider with its boundaries and the accuracy that is required. However, the accuracy of model results is very difficult to define with certainty. Normally, it is dictated by regulatory decision-making, expectations and specific modelling objectives.

The representativeness of monitoring data for modelling purposes could be guided by analysing which points will react with the highest sensitivity and would contribute significantly to the reliability of the model.

Model validation needs informative numbers and the participants concluded that in this context data below the limit of detection were not very useful.

2. REPRESENTATIVENESS AND QUALITY

The objectives of this session were to identify:

- What constitutes an effective and efficient programme with respect to representativeness (e.g. location, duration, frequency);
- What is considered to be an acceptable level of precision and confidence;
- Ways in which data from different sources can be combined.

2.1 Representativeness

Choices about representativeness (location, duration, frequency) are determined by:

- The objectives of the monitoring programme;
- The characteristics and dynamics of the system;
- The fact that some environmental compartments are consistently underrepresented e.g. the marine environment, compared to fresh waters.

Based on the outcome and an evaluation of the extent to which the programme fulfils the information needs, objectives and design of programme can be adapted (monitoring cycle). Well defined objectives and a sound understanding of the system are mandatory for proper choices with respect to representativeness.

Sentinel species could play a multi-purpose role. Given their habitat requirements, their presence may indicate a certain environmental quality. This may help in communicating the purpose of a management activity into which the monitoring programme fits (e.g. salmon have been used as a valuable sentinel species in monitoring the clean-up of rivers, including the Rhine and the Thames).

Locations

Various factors need to be taken into account when selecting monitoring locations:

- Local/regional locations;
- What is a representative region in Europe?
- Background/hotspots;
- Outlets/upstream;
- Emissions/product use/land use;
- Inclusion of sensitive areas where effects may occur.

The physical structure of the particular section of the environment, for example a stretch of river, determines what species and diversity can be present. There is a need to provide an idea of background or reference sites; it is assumed that they exist, at least for comparative purposes, or that they can be unequivocally defined. In the context of the Water Framework Directive adequate reference information is crucial in demonstrating divergence from 'good ecological status'. RIVPACS is a good example of a well established predictive bioassessment tool, which may be useful in this respect.

Duration and frequency

The sampling frequency must address temporal variability of sources and system dynamics e.g. seasonal patterns of emissions of agrochemicals or antifouling agents. Indoor concentrations are also highly variable and appropriate use of time integrated sampling approaches is recommended.

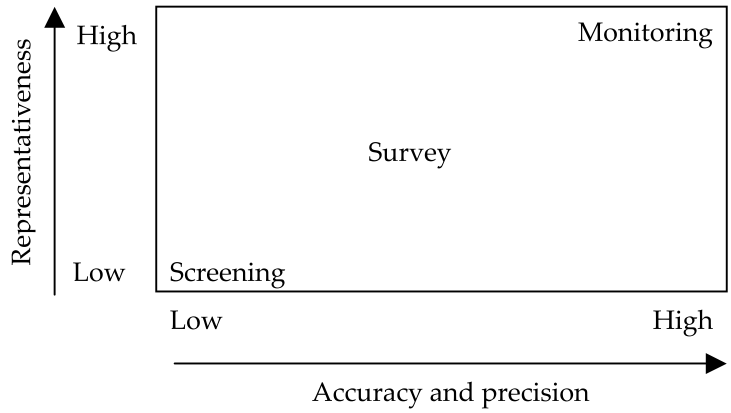
Long-term data series have great value even if at present such value is not always acknowledged. This has been shown by the data and tissue banks such as the Continuous Plankton Record. Equally, schemes that have been designed for one purpose, but include the taking of larger samples that have subsequently been stored for any future use, may prove to be valuable.

2.2 *Precision and accuracy*

The required degree of precision and accuracy, and other performance characteristics (e.g. limit of detection), are dependent on the objectives of the programme. The degree of accuracy and precision needed for decision-making is not always clearly identified. Stakeholders should be encouraged to direct effort towards the formulation of agreed criteria.

In general, if (predicted) environmental concentrations are close to effect levels or quality objectives, a higher degree of precision and accuracy is required than in the case where (P)ECs are orders of magnitude below effect levels or quality objectives. To establish PECs the approach should begin with a screening exercise (over a short period) followed by a long-term monitoring programme.

Figure 1: Relationship between accuracy, precision, representativeness and level of tier of monitoring



If the order of magnitude of environmental concentrations is required, a *screening* exercise should be carried out since the required precision and accuracy is less stringent, compared for example to those needed for compliance monitoring.

For long-term *monitoring* of temporal trends, consistency of methods may be of more importance than accuracy. For example: for the analysis of trends in PCB levels in fish in Sweden since the early 1970s a traditional packed column GC method is used in addition to the modern methods (capillary GC-ECD/HRMS) which have much more favourable performance characteristics.

It is important to note that the precision and accuracy of the determination of common correction parameters (SPM, lipid, Org-C) in some cases may be poor, leading to large errors in corrected concentrations. This was demonstrated in some recent international projects (e.g. Quash, Quasimeme).

Criteria for evaluation of reliability

Criteria for evaluation of reliability include:

- Application of state-of-the-art GLP and QA/QC (see e.g. ICES documents);
- Participation in international intercalibration and proficiency testing exercises;
- Analysis of CRMs (certified reference materials from e.g. BCR, NIST, IAEA, Quasimeme).

The workshop participants recommend that a classification system for the evaluation of the reliability of new programmes and databases should be developed.

Combining data from different sources

Sources considered include survey data from electronic databases, peer reviewed publications, confidential company data and PhD theses.

The issues associated with combining data from various sources were identified as:

- Data quality – in many cases monitoring programmes/databases have no classification of data reliability;
- Different countries, locations, laboratories, periods of time;
- Changes of instrumentation over time (for long time trends);
- Differences in sampling methods, units, correction methods, etc;
- Weighting often necessary, e.g. for stratified sampling;
- Kriging techniques[2];
- Need for information to understand and categorize the main emission sources (e.g. diffuse, point, wide dispersive).

Many anecdotal examples exist of temporal trends in historical data, which are in fact artefacts reflecting improved detection limits, blank contamination control, and accuracy over time. To overcome these problems it is advisable to use the same technique throughout a trend analysis exercise rather than change to new methods as they become available.

Proposed criteria for new monitoring programmes

When designing new monitoring programmes, there is a need for:

- Consistency of methodology (within and between participating laboratories) and performance characteristics (e.g. precision, accuracy, sensitivity);
- Similarity of monitoring and sampling strategy;
- Consistency of units and reporting format.

[2] Kriging is a method of interpolation named after a South African mining engineer named D. G. Krige. Over the past several decades kriging has become a fundamental tool in the field of geostatistics and can be used for spatial estimation applications.

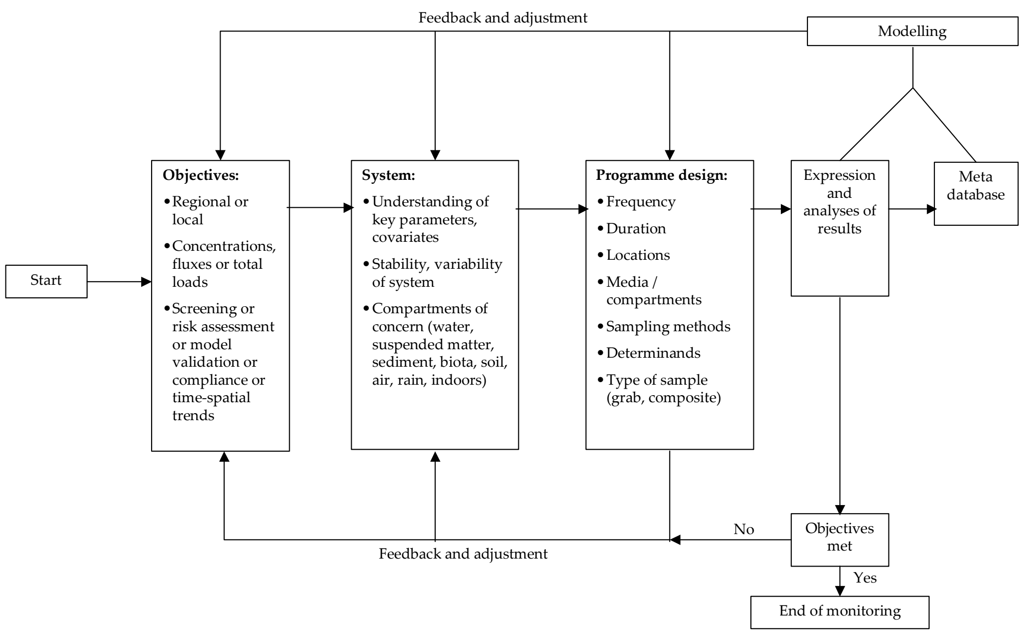
The workshop participants agreed that expert evaluation or classification of reliability of data from different sources is required. After this, existing statistical approaches such as those presented at the workshop can be applied. Archival samples are important to validate questions relating to consistency of methods.

The workshop welcomed the concept behind the WFD and supports the use of biological and chemical monitoring as a tool to underpin the WFD and the new EU Chemicals Policy but recognise that compliance has been based historically on total values, not the 'true' concentration based on speciation and bioavailability. The issue to be addressed is what is the most toxic species of the chemical and how does the environment affect this concentration.

The workshop participants concluded that new monitoring programmes should integrate the knowledge generated in the past, and become more 'fit for purpose'. Future programmes should be rationalised, streamlined, and "information rich" rather than "data rich", thus improving cost-effectiveness. The design, quality control and statistical power should allow management to assess the effects of decisions taken; this may not always have occurred in the past.

The steps and considerations in the design of monitoring programmes are illustrated in Figure 2.

Figure 2: Design of monitoring programmes



Since resources will be limited, it will be necessary under WFD to redirect attention from the current monitoring of contaminants, towards the proposed assessment of the quality of environmental ecosystems. Changes in quality and values of the ecosystem should particularly be monitored in future.

To have quality data available, efforts by all stakeholders (industry, academia, authorities) need to be re-organised. New diagnostic methods that measure parameters that are relevant for society should be used.

Data collection should be co-ordinated throughout Europe and data sharing should be structured through meta-databases via the web to ensure broad accessibility.

The planning of monitoring programmes should 'think multi-media' (i.e. include water, air sediment, soil and biota) when choosing sampling sites, time, duration and frequency. There should be greater interplay between chemists, biologists and modellers. Team composition should reflect the needs and considerations of the different disciplines.

3. AVAILABILITY AND ACCESSIBILITY OF MONITORING DATABASES

The specific objectives of this session were to identify:

- The barriers to making data more readily accessible;
- Ways in which data from existing and future programmes conducted by countries, industry and international bodies can be made more widely available;
- Ways in which the execution of monitoring programmes and the generation of data could be harmonised;
- Financial implications and sources of financing;
- Who should participate.

3.1 Barriers to data availability

The group reviewed a number of problems with monitoring programmes and their output and concluded that current monitoring programmes are characterized by being data rich, but information poor. It made recommendations on how to bridge this gap:

Databases: There are a number of problems with databases. First, there is a tendency for the data to be closed, with no access to the owners or providers. The format of the data in databases is often not standardised, but varies from database to database. Often the data in databases is limited due to ownership issues, be it academic, government or industry. Finally there are often technological barriers and in some cases, e.g. data on the internet, concerns about both quality and resource.

Quality: If the quality of data is not clearly detailed then this becomes a barrier to availability and use. Information relating to the nature of the samples assessed, the type of analysis performed and the QA in the process must be available. Similarly there was agreement that a common quality ranking process is required. The Dutch database for physico-chemical data, AQUAPOL, has such a ranking scheme for scoring quality which might serve as an example. There was also the issue of historical data *versus* data generated in the future by different and probably improved methods. It was very clear that there should be a link back to the data producer.

Diffuse nature of data: Frequently the data required e.g. for chemical assessment is spread over many organisations and is difficult to obtain. This has a negative impact on the usefulness of combining/overlaying of data. Monitoring data from different sources can be combined through overlay of databases from various compartments and domains. Whereas this demands some flexibility and consideration from the outset by the original database designers, there is much to be gained both in the short term as well as in the long term by this approach. Furthermore, biological monitoring should be part of an overall monitoring programme of activities connecting with and encompassing chemistry, land-use, hydrology, climate, etc. In the short term the linkage between biological and chemical monitoring should be enhanced. Subsequently the spatial dimension requires attention to allow for wide applicability of the results. Certain specific areas have been overlooked, but there is a growing area of molecular biology and microbiology-based tools in development for monitoring and diagnostic purposes. They may prove to be particularly useful in non-conventional compartments such as groundwater.

Finance and related problems: When public bodies carry out monitoring programmes, the results should be made freely available without adding cost as another barrier. Problems can also be related to administrative demands and responsibilities and they should be addressed.

3.2 How to increase harmonisation and availability

To improve harmonisation and increase availability, the use of pre-set data formats was recommended. Harmonisation is, for example, part of the WFD and full advantage of this approach should be taken. An agreed 'common' format that can account for the future generation of data is needed. The extent to which this can address existing data may need to be addressed. Other organisations are working in this area, e.g. the Exposure Assessment Task Force (OECD) is generating ideas for this, for use after a SIDS exposure assessment. However, it is very generic. If possible, efforts should be made to extend the WFD approach and protocols into chemical regulation (i.e. REACH). SOPs/QA/QC, including reference materials and intercalibrations of different methods should be established. Harmonisation of reporting will facilitate information exchange. Harmonisation of methodology could be achieved through development of readily-accessible international reference books covering, for example, sampling and analytical methodology and taking into account international frameworks etc. To a certain extent this would be easier for a 'stationary' matrix e.g. soil, than for water. The possibility of mimics for fish (e.g. C18 - SPME) was identified as a potential alternative assessment method.

The use of such methods for normalising biota responses was also discussed. Other approaches should be assessed e.g. OSPARCOM (international framework) programmes are an example of such an approach.

Archiving samples to allow for further analysis in the future was suggested. In this way it would be possible to leverage monitoring studies. But there was also a need to be careful with respect to what was measured *versus* stability. Also the cost of archiving needed to be taken into consideration. Archiving would also help in trends analysis by providing samples with a historical perspective.

Finally with respect to increased harmonisation, there is a need to rationalise the approach and reduce/cease monitoring by some countries of some "old favourites", to free up resource should there be a move to address different chemicals.

Possible solutions for harmonisation may be:

- Inventory of existing databases in order to create a meta-database;
- Establish data centres responsible for maintenance and update of databases and for ensuring standardisation and harmonisation of data;
- Make data accessible *via* modern electronic means, to create a 'one-stop-shop' for easy access and develop easy navigation to find specific items;
- Cross-match policy priority chemicals with monitoring programmes;
- Monitoring networks should be established (chemists, biologists and modellers).

To improve the availability of the data, a meta-database is required. Various organisations might be able to meet the challenge of creating such a system e.g. the EU (EEA), OECD or UNEP.

Potential barriers to these newly proposed solutions are:

- A 'one-stop-shop' may encounter difficulties in maintenance and administration costs;
- Electronic systems can break down resulting in data loss;
- Funding is often short term (i.e. one to three years);
- Data ownership issues;
- Commercial competitiveness issues.

One solution could be to set up a global network of regional centres instead of one central body and ensure long-term funding (independent agency to meet legal obligations). Learnings from the development of the genomics database and the organisation model of AMAP could be valuable. Centres should preferably have multistakeholder support and have finances secured for long periods.

The workshop was advised that OECD is interested in building a meta-database. The group recommended that ECETOC and CEFIC-LRI should investigate this further.

The cost of establishing networks, harmonizing databases or setting up a dedicated centre will be significant. Financial and political support will be needed from all stakeholders. Possible approaches could include the establishment of a network of excellence as described by the 6th Framework Programme. Such networks would certainly help with harmonisation of methods. However, they could also be helpful in promoting the collection of data for assessing global change and biomonitoring. Within the EU the lead for participating is the EEA, but Member States should also be included. Some governments are already involved in exercises of this type; however, this will need expansion. Industry is likely to want to be involved addressing emission estimates of specific chemicals, e.g. under REACH. Among industry bodies, the likely candidates are the CEFIC-LRI and ECETOC, with involvement of other industrial sector groups. There will also be a role for the international community, e.g. OSPARCOM, the OECD and UNEP and the research community e.g. SETAC.

CONCLUSIONS AND RECOMMENDATIONS

Significant resources continue to be used across Europe to measure the concentration of chemicals and the impact of chemicals in the various environmental compartments. Much of this effort has resulted in "data rich but information poor" data-sets of often limited value. The concept of structured, iterative, information-need driven monitoring – termed "appropriate monitoring" - was discussed. Programmes should use a tiered approach and build in a degree of flexibility which is linked to the results being generated. The process should be audited, and collection and analysis of samples be amended as necessary (modify determinands to exclude those which are of no further interest and include new potential substances of concern). To optimize the use of resources, programmes should be routinely reviewed for continuing relevance, and discontinued if no longer appropriate. Modellers, biologists and chemists should not work in isolation. Their skills and specific needs should be integrated into the design and execution of programmes and in the interpretation of the data. Greater efforts (via networks possibly) need to be made to involve the different disciplines, and programme designers/managers should be encouraged to consider multimedia approaches when choosing sampling sites.

Cost-effective programmes linked to management actions based on results should be encouraged. Through improved design of monitoring programmes where causes can be linked with effects, or use of diagnostic tools which identify the causes of any divergence from expected levels, programmes will become more useful and credible.

Monitoring programmes require involvement of a large number of stakeholders from start to finish. This must be part of a wider effort to ensure that the benefits of monitoring programmes are broadly recognised. Acceptance of the outcome is normally determined by politicians, but influenced by the public and NGOs. Sound science has a key role to play here. But science alone is not sufficient. To ensure stakeholder support, the value of science must be clearly demonstrated (or communicated).

APPENDIX 1: LIST OF PARTICIPANTS

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APPENDIX 2: WORKSHOP PROGRAMME

Thursday 20 March 2003

08:30 – 09:00	Registration	
09:00 – 09:10	Introduction to the workshop	W. Verstraete

Theme 1: Applications of monitoring data

09:10 – 09:30	Monitoring and modelling for environmental exposure assessment	M. Matthies
09:30 – 09:50	Exposure monitoring: lessons learned from a case study of the occurrence of phthalate esters in the Netherlands	W.Peijnenburg
09:50 – 10:10	Effects monitoring	M. Crane

Coffee break

10:30 – 12:00	Syndicate session I	
12:00 – 13:00	Feedback and conclusions from syndicates	W. Verstraete

Lunch

Theme 2: Reliability and representativeness of monitoring data

14:00 – 14:20	Estimation of regional distributions of concentration levels of chemical substances	B. Govaerts
14:20 – 14:40	Biological monitoring	J. Gray
14:40 – 16:00	Syndicate session II	

Coffee break

16:15 – 17:15	Feedback and conclusions from syndicates	W. Verstraete
17:15 – 18:00	Poster Session	

Evening Dinner

Friday 21 March 2003

Theme 3: Availability and accessibility of monitoring data

08:30 – 08:50	Arctic monitoring and assessment programme	L.-O. Reiersen
08:50 – 09:10	A 'new information system' for chemicals exposure data	D. Gee
09:10 – 09:30	LRI environmental monitoring database	P. Leonards
09:30 – 10:45	Syndicate session III	

Coffee break

11:00 – 12:00	Feedback and conclusions from syndicates	W. Verstraete
12:00 – 13:00	General conclusions and closure of the workshop	W. Verstraete

Lunch

APPENDIX 3: PRESENTATION ABSTRACTS

Monitoring and modelling for environmental exposure assessment - Two sides of the same coin -

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Since the 1998 OECD workshop in Berlin considerable effort has been made to gain a better understanding of the spatial and temporal environmental exposure patterns by means of a combined modelling/monitoring approach. Examples are the POPCYCLING-Baltic model and various GREAT-ER projects. Monitoring delivers information on the occurrence of chemicals in the environment whereas modelling condenses the knowledge on the causal relationship from the production and uses of a chemical through the various flows and elimination processes to the distribution and ultimate fate in the environment. This paper focuses on local and regional aspects of monitoring and modelling and how a quantitative comparison of measured and simulated concentrations can be carried out. Both modelling and monitoring are two sides of the same coin, namely the realistic determination of the exposure, expressed as PECs, required for regulatory risk assessment. Instead of a comprehensive review, several important aspects of modelling and monitoring will be discussed and supported by the experience from various own projects:[3]

1. Comparison of measured and calculated concentrations derived with generic and realistic scenarios for EUSES regional distribution model shows that concentrations in air, water, sediment and soil are mostly overestimated. However, in some cases underestimation occurs, so that conservative exposure estimation is not generally guaranteed.
2. Carefully designed and performed monitoring studies can be used to calibrate and validate geo-referenced models within an acceptable range of accuracy (see GREAT-ER).
3. Monitoring databases from state or federal agencies can contain unrepresentative or uncertain data without giving any indicator of the data quality. A validated model can help to identify these inappropriate data.
4. Models can only fulfil their purpose if emission data of good quality are available or delivered by industry. Emission data should be classified into exposure related types. For waste water discharges, per-capita related and area-related discharges are superimposed by point sources from producing and processing industry. Models can support the identification of additional, unknown or unreported discharges.
5. Monitoring data can be used to reduce the uncertainty of model calculations by consideration of seasonal variations, improved fate process descriptions and data quality assurance. Research is needed to develop better fate process models which have to be evaluated by monitoring studies.
6. By means of a geo-referenced approach "geographic areas of concern" can be identified, e.g. local exposure vs. wide-spread distribution, or small stream pollution vs. large river loads.

7. Some recommendations are made for the reduction of model uncertainty by better emission data supply, an improved monitoring design for river basins, and how validated exposure models can be integrated into a decision support system for river water quality management.

[3] The support of the German Federal Environmental Agency (Umweltbundesamt) is gratefully acknowledged.

Exposure monitoring: lessons learned a case study on the occurrence of phthalate esters in the Netherlands

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The multi-media model Simplebox is, amongst others, used to derive 'coherent' sets of environmental quality objectives (EQOs) for air, water, and soil. Simplebox predicts ratios of intermedia steady-state concentrations (SSCRs). These SSCRs are compared with ratios of independently derived EQOs to provide an indication of the likelihood that a pair of EQOs is both protective (also for an adjacent compartment to which a chemical may migrate) and manageable (in terms of realism). A special Committee of the Dutch Health Council agreed in 1995 with the proposal of taking the transport of substances between compartments into account when setting EQOs for water, sediment, soil and air. The Committee considered Simplebox to be a potentially useful model for intercompartmental harmonisation of EQOs. However, it recommended validation of the procedure, including sensitivity and uncertainty analysis and, in particular, validation of the model as a whole. We therefore investigated the uncertainty of SSCRs predicted by Simplebox by means of a comparison between predicted and measured concentration ratios for two phthalate esters monitored in various compartments in the Netherlands in the period 1997-2001.

The two phthalate esters, di(2-ethylhexyl) phthalate (DEHP) and di-n-butyl phthalate (DBP), are high production volume chemicals (HPVC) and measurable concentrations could be found in most environmental "compartments". Compartments sampled include: fresh water, fish, sediment, soil, vegetation, milk and air. In view of the intention of validating ratios of SSCRs, the aim was to determine concentration ratios for the phthalate esters in the various compartments at the same spot and at the same time. For pragmatic reasons, it turned out not to be feasible to fully meet these criteria. Instead, sampling at each site was carried out during a limited amount of time.

Concentration ratios, with emphasis on air/water, were compared to model output (SSCRs) because this specific model output is used for harmonising environmental quality objectives (EQO). Predicted and measured air/water concentration ratios did not differ by more than a factor of 10. Although phthalates are chemicals that are not really representative of the group of (semi-)volatile chemicals to which the Simplebox coherence test procedure was first applied, the results of this validation study not only supported the use of multi-media environmental fate models for harmonising EQOs, but they also confirmed the necessity of carefully preparing a well-designed monitoring campaign in order to meet the pre-set goals of the study.

In conclusion, there are no reasons for rejecting this specific use of Simplebox as long as there is no scientific alternative. However, further validation research is necessary to gain confidence in applying multimedia environmental fate models for regulatory purposes.

Availability, Interpretation and Use of Environmental Monitoring Data: Effects Monitoring

M. Crane
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Effects monitoring programmes assess environmental quality by measuring responses in biological receptors. This might include surveys of species assemblage structure, indicator species responses, or Direct Toxicity Assessment. The Water Framework Directive requires Member States to perform monitoring for surface and groundwaters. Effects monitoring of biological 'quality elements' is fundamental for most surface waters, but is not required for groundwaters. Most Member States have at least some expertise in the use of benthic invertebrate surveys for assessing the quality of rivers, but similar expertise is patchy for other biological quality elements and aquatic habitat types.

Even in the case of benthic invertebrate surveys, there are difficulties in performing diagnostic, investigative monitoring for identifying cause and effect. This is illustrated by a case study on investigative monitoring of the effects of pesticides in rivers in the East of England. Multivariate analyses suggest that pesticide exposure may be responsible for structuring benthic invertebrate assemblages. However, only a small percentage of overall variability can be explained by measured pesticide exposure, and many other potential stressors co-vary with pesticide concentration. The design of the monitoring programme for benthic invertebrates and chemical stressors means that it is not possible to know whether these results provide reassurance that pesticides are not a major problem, or are simply an artefact of the survey design.

Although benthic biomonitoring is widely used in many Member States, even this well-developed technique is currently unable to fulfil requirements for investigative monitoring for episodic pollutants such as pesticides. This need can be met by i) a statistically-based monitoring programme that more effectively links biological, chemical and physical monitoring, and ii) experimental studies with laboratory or *in situ* bioassays to demonstrate cause and effect.

Estimation of regional distributions of concentration level of chemical substances in surface water on the basis of monitoring data

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During the last decade, the assessment of concentrations of chemical substances in the environment has become a major concern, both for health risk exposure and industry which is facing potential economical penalties. Currently, different approaches are proposed for this task. The first one, widely used, relies on multi-media fate models. On the other hand, monitoring data are also beginning to be used and are gathered in huge international databases but few methods have been developed to validate and summarize them adequately at a local or regional level.

This presentation gives details of a methodology to summarize monitoring data on concentrations of chemical substances in surface water (rivers mainly) both at a local and regional level. The aim is to estimate, from data collected over time in sampling stations located along rivers of a given region, a regional statistical distribution of concentration. Such distribution gives a representation of the spread of concentrations observed over a period in a given region and allows derivation of statistics such as mean, standard deviation and percentiles.

Various problems have been tackled to allow such regional distribution to be derived:

The first step consists of estimating a statistical distribution of concentration for each sampling station taking into account the fact that many observations are below the detection limit of the measurement device and, in consequence, excluded. Empirical distribution, parametric gamma and log-normal distributions have been tested and compared in this context. The statistical distributions obtained from the original data and also from limited information (summary statistics) are compared and discussed.

The second step aims at aggregating estimated local distributions to a regional one and deriving statistics such as mean, variance and percentiles from it. In this aggregation, different approaches are discussed taking into account geographical and hydrological information in the weighing of local distributions.

The various methods have been compared and applied to several chemical substances in European rivers. This research was supported by Euro Chlor.

Biological Monitoring

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Chemical monitoring alone may not tell you that a substance is having a biological effect. Alternatively it may be very expensive to monitor chemicals, which are unlikely to pose effects such as dioxins. Therefore, monitoring biological responses is often more sensitive and cost-effective. Yet care must be taken to ensure that Type-II statistical errors are taken account of. That is reducing the risk of accepting that a pollutant is not harmful when it is. Analyses of current monitoring techniques have shown that sampling rather than analytical variability is the major problem to overcome. Biological effects monitoring techniques will be illustrated and the limitations and advantages discussed.

The Arctic Monitoring and Assessment Programme (AMAP)

L. Reiersen
AMAP Secretariat
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In 1991, Ministers of the eight Arctic countries (Canada, Denmark, Iceland, Finland, Norway, Russia, Sweden and USA), adopted the Arctic Environmental Protection Strategy (AEPS). To implement part of this strategy, the Arctic Monitoring and Assessment Programme (AMAP) was established and requested by Ministers to "*examine levels of anthropogenic pollutants…from any sources…and to assess their effects in all relevant compartments of the Arctic environment*". In 1996 the AEPS, including all its working groups, was reorganized under the newly formed Arctic Council.

Between 1990 and1992, experts from the eight Arctic countries designed the first detailed AMAP monitoring programme. Representatives from Arctic Indigenous Peoples' organizations were also involved in this work. At the beginning of the 1990s, few international monitoring and assessment programmes included more than one ecological system, e.g. the marine or terrestrial environment, and possibilities to follow contaminants from their sources through the environment to their ultimate fate were very limited. AMAP was thus one of the first international monitoring programmes to be designed and implemented covering all major ecological systems (atmospheric, marine, freshwater and terrestrial - and humans), and all major contaminant groups in one programme, and at the same time fully integrating its monitoring and assessment activities.

Based on the data gathered, the first circumpolar assessment was presented by AMAP in 1997, "Arctic Pollution Issues", (www.amap.no). An updated programme for phase 2 of AMAP was developed in 1997-98, "the AMAP Trends and Effects Programme". This programme has been the basis for the second AMAP assessment presented in October 2002, "Arctic Pollution 2002" and this assessment had a much better circumpolar coverage, including input from Alaska and Siberia.

A key feature of the implementation of AMAP has been that the programme could be initiated in a step-by-step manner. This gave the eight Arctic countries the freedom to adapt or develop their national programmes based on AMAP's recommendations, and adjust them according to their own priorities and financial and scientific possibilities. As a part of its general strategy, the AMAP programme builds on ongoing (national and international) research and monitoring activities, e.g. NCP in Canada and the European Monitoring and Evaluation Programme (EMEP). Thus, from the outset, AMAP recognized that research (in addition to national monitoring work) would provide much of the relevant information necessary for assessing levels and pathways of contaminants and their effects in the Arctic. In order to address quality assurance issues, AMAP encouraged all participating laboratories to join appropriate international QA/QC programmes and, where relevant, adopt existing international recommendations for methodology and parameters to be analysed. Of special importance has been the implementation of the AMAP Ring Test (Round robin) among laboratories involved in analysing human blood samples. This has been organized by Institut national de santé publique du Quebec and the Norwegian Institute of Air Research (NILU). This exercise has on one side upgraded several laboratories among which some in Russia (capacity building) and made AMAP able to compare the levels of contaminants observed in the different countries of the Arctic at lower latitudes.

Chemicals in the European Environment: A survey of monitoring and exposure information

D. Gee
European Environment Agency
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Following an initial presentation of the EEA report "Late lessons from Early Warnings: the Precautionary Principle 1896-2000", the presentation will summarise the EEA/ESF report on chemicals monitoring/exposure information. The objectives of the joint EEA/ESF project (1999-2002) were to (a) review chemicals monitoring programmes and data availability on exposure to selected priority chemicals, including endocrine disrupting substances (EDSs), with a particular focus on the chemical exposure of sensitive groups such as children; and (b) to provide useful information about chemical exposures for the upcoming debates on new chemicals policies. The report was prepared on the basis of studies performed by the EEA Water ETC and the Fraunhofer Institute.

The report's conclusions focused on three types of monitoring:

- 'Macro-monitoring', which addressed the question: 'what are the flows of potentially hazardous chemicals?' e.g. total production flows of persistent, bio-accumulative and toxic chemicals (PBTs);
- 'Media-monitoring', responding to 'where are chemicals going in the environment?' e.g. PBTs chemicals in water; and
- 'Micro-monitoring' which addresses the question: 'what are the chemical concentrations in sensitive biological/ecological systems and tissues?' e.g. brominated flame retardants in breast milk.

The presentation summarises the report's general conclusions which were:

- Monitoring is partial, uncoordinated, sometimes out of date, and, on many occasions, irrelevant to current policy needs;
- Centralised knowledge about chemical monitoring activities is incomplete;
- There is a lack of integrated exposure assessments that considers all relevant exposure routes;
- There are huge data gaps in information on chemical exposures and impacts, especially concerning vulnerable groups and ecosystems;
- Filling the exposure data gaps adequately, *via* conventional approaches, would take several decades and millions of Euro.
- Existing monitoring systems can be streamlined and 'mined' for further exposure data.

Proposals are summarised for starting to fill the data gaps, including a need for some improvements to the conventional media monitoring systems and the wider adoption of new approaches and techniques that focus on macro- and micro-monitoring.

LRI Environmental Monitoring Database

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A number of CEFIC-LRI environmental projects aim to improve existing, or develop better models for estimating the exposure of the environment to chemicals. The LRI projects require measured data to validate the exposure models. In addition, in various programmes (e.g. Water Framework Directive) there is a need for information on concentrations of chemicals in marine and fresh waters, sediment, and biota. To fill the data gaps (analytes, compartments) additional sampling and analysis are may be required. The main objectives of the current project are:

1. To identify on-going and planned European field monitoring programmes, including the Arctic. The focus is on national and regional monitoring programmes;
2. To review and catalogue available measured environmental concentration data for selected organic chemicals in water, sediment and biota from the fresh and marine environments;
3. Creation of a user-friendly, freely accessible electronic database for the monitoring programmes and the measured analytes.

The monitoring programme database can be used for joining on-going and planned monitoring campaigns that will maximise the amount of data and limit the number of samples. The measured concentration database for the selected chemicals can be used for retrieving background concentrations, geographical distribution, and temporal trends of the analytes.

The project is separated in two phases:

1. Broad screening of analytes and monitoring programmes;
2. In-depth study of specific analytes and collection of detailed information of the monitoring programmes.

In the first phase the following parameters are collected with regard to the monitoring programmes: title, description, status of the programme, area (sample location), analytes, compartment, frequency of sampling, source (contact person, address, email, phone, fax, publications, database), access availability. For the measured concentration database the following parameters are collected: analyte, compartment, sampling location, year of sampling, type of data, sources, access availability.

To date, more than 170 European national and regional monitoring/survey programmes have been identified. The list of chemicals for which measured environmental data has been found includes more than 350 analytes for water, 230 analytes for sediment, and 170 compounds for biota. The second phase, with the in-depth studies, will start soon. The database will be completed by the end of 2003.

APPENDIX 4: LIST OF ABBREVIATIONS

AMAP	Arctic Monitoring and Assessment Programme
BCR	Bibliographical Center for Research
CEN	European Committee for Standardisation
CMR	Carcinogenic, mutagenic, toxic to the reproductive system
ECETOC	European Centre for Ecotoxicology and Toxicology of Chemicals
EEA	European Environment Agency
EU	European Union
GC-ECD	Gas Chromatography/Electron Capture Detection
GLP	Good Laboratory Practice
HPVC	High Production Volume Chemicals
HRMS	High-resolution mass spectrometry
IAEA	International Atomic Energy Agency
ICES	International Council for the Exploration of the Sea
NIST	National Institute of Standards and Technology
OECD	Organisation for Economic Co-operation and Development
Org-C	Organic carbon content
PAH	Polycyclic aromatic hydrocarbons
PBT	Persistent, Bioaccumulative and Toxic
PCB	Polychlorinated biphenyl
PEC	Predicted environmental concentration
POP	Persistent Organic Pollutant
QA/QC	Quality Analysis/Quality Control
QSAR	Quantitative Structure Activity Relationship
Quash	Quality Assurance of Sampling and Sample Handling
Quasimeme	Quality Assurance for Marine Environmental Measurements
RIVPACS	River Invertebrate Prediction and Classification System
SIDS	Screening Information Data Set
SOP	Standard Operating Procedure
SPM	Suspended particulate matter
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
WFD	Water Framework Directive

APPENDIX 5: ORGANISING COMMITTEE

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