THE ROYAL SOCIETY OF CHEMISTRY

ENVIRONMENTAL CHEMISTRY GROUP

Newsletter

Issue No.11 – January 2000

RS·C ROYAL SOCIETY OF CHEMISTRY

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ECG Newsletter No.11 - January 2000

The contents page of this ECG Newsletter may be seen on the Internet at **http://chemistry.rsc.org/rsc/ecg.htm**

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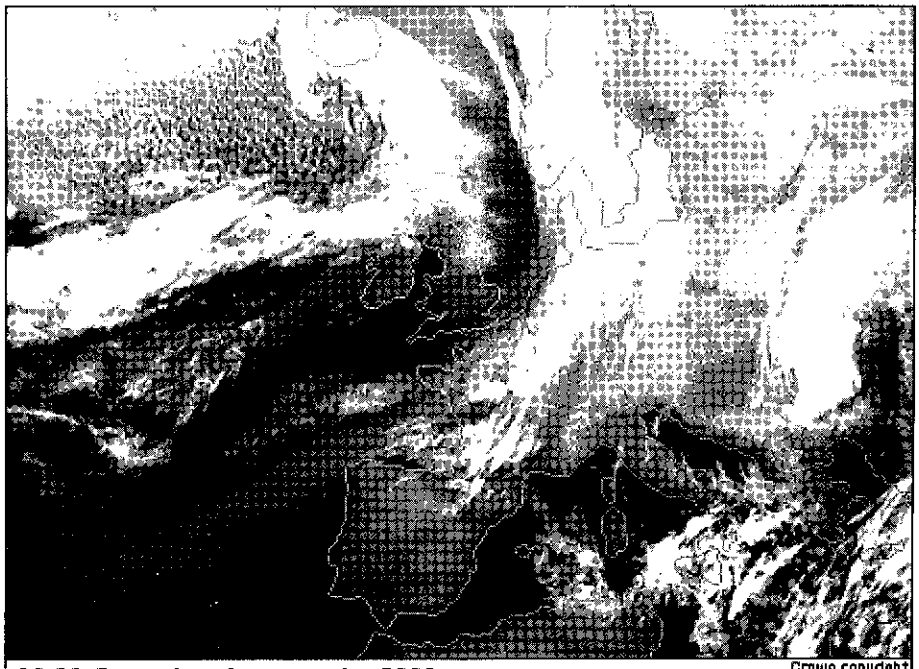

Satellite Image of the UK Weather: First Day of the New Millennium

Distinguished Guest Lecture March 1st, 2000: "Climate Change and its Impact" – see p. 31

(Web site: EPA Global Warming Site: Glossary of Climate Change Terms http://www.epa.gov/globalwarming/glossary.html)

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Chairman's Report on the Group's Activities during 1999

I SUPPOSE it is now a cliché, but welcome to the new millennium! You will now know whether it was the optimists or the pessimists who were correct. (I am writing this in December and awaiting the change to 2000 with interest).

1999 has been another successful year for the Environmental Chemistry Group. We held two interesting and popular symposia in March, as reported in detail in the July issue of the Newsletter. There have been two more excellent symposia – on the analysis of endocrine disruptors in October, and on modelling chemical contaminants in estuaries and coastal waters in November. Reports of both these meetings appear in this issue of the Newsletter.

The committee were also pleased to receive a number of suggestions for future symposia from members. We hope that in 2000 and 2001 these will materialise as "real" meetings. Suggestions of topics are always welcome. Details of the Distinguished Guest Lecture and the associated symposium plus the Group's AGM, on 1 March 2000, are given in this Newsletter. The speakers and topics for the DGL in 2001 have also been finalised. However, we could still do with having more general symposia "on the stocks".

The Newsletter goes from strength to strength due mainly to the efforts of the editor, Dr. Rupert Purchase. He organises members of the committee, and others, to produce articles for what is now the main output of the Environmental Chemistry Group for members. We have previously published the complete Newsletter on the RSC Web site, but have decided that only the contents page will appear there in future. It seems correct that only those who pay to be members of the Group should receive the complete version of the Newsletter. Membership of the Group is open to RSC members by paying a £5 subscription and, for non-RSC members, Group membership is available for an additional premium (at present) of £4, i.e. £9 in total. RSC members should inform the RSC Membership Department at Cambridge if they wish to join the Group. Non-RSC members should send their details to the Group Secretary, Dr Andrea Stroh. The Newsletter is quite expensive to produce and it would be a great help if we could receive sponsorship in the form of advertisements to help defray the costs. Any member who thinks that they might be able to persuade an organisation to provide support should contact the Group Treasurer.

My term of office as Chair finishes at the AGM in March, and I would like to express my thanks to all those on the Committee who have worked so hard to make my two years so fulfilling.

PETER O'NEILL
December, 1999

Plastics Recycling: Building New Opportunities for Post-Consumer Waste Streams

TOM LAWLESS of Oilfield and Environmental Chemical Technology, and who is also a committee member of the Environmental Chemistry Group, outlines an important new R&D initiative supported by the European Commission entitled "Realising the Technical and Market Potential for Post-Consumer Plastics within the Building and Construction Sector."

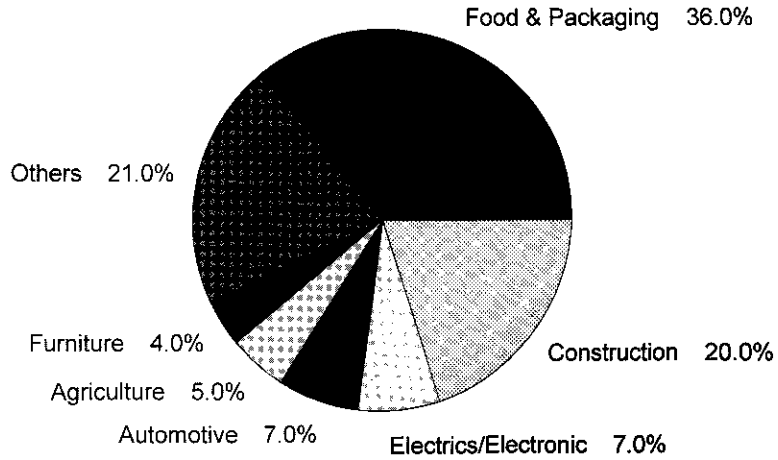
Introduction

Plastics have become increasingly favoured as the material of choice for a range of consumer-led applications (Figure 1), leading to the consumption of some 30 million tonnes of plastics p.a. in Europe (1). Their impressive gains in market share are a consequence of many features, including favourable inherent qualities and ease of commercial processing. Depending upon the plastic type and end application, several processing techniques are employed such as:

- extrusion (tubes and drain pipes)
- injection moulding (containers and frames)
- blow moulding (bottles and containers)
- thermo-forming (set bulky items).

Extrusion and injection moulding are the major processing options (2). A number of different plastic types are commonly available and chosen for varied product applications, although polyolefins dominate sales (Figure 2) throughout the EU (1).

Figure 1 : EU Plastics Consumption By Market



Product lifecycles of plastics are dictated by application and can vary from days (wrapping and bags) to decades (pipes), therefore one may see a variance between consumption rate and waste arising. A survey (3), undertaken throughout the European Union, has established that municipal waste contains, on average, some 7% by weight of mixed plastics (Table 1). If we take this value and further analyse the compositional make-up, then it typically includes (3):

- polyolefins 65%
- polystyrene 15%
- polyvinyl chloride 10%
- polyethylene terephthalate 5%
- others 5%.

Figure 2 : Plastics Consumption By Chemical Form

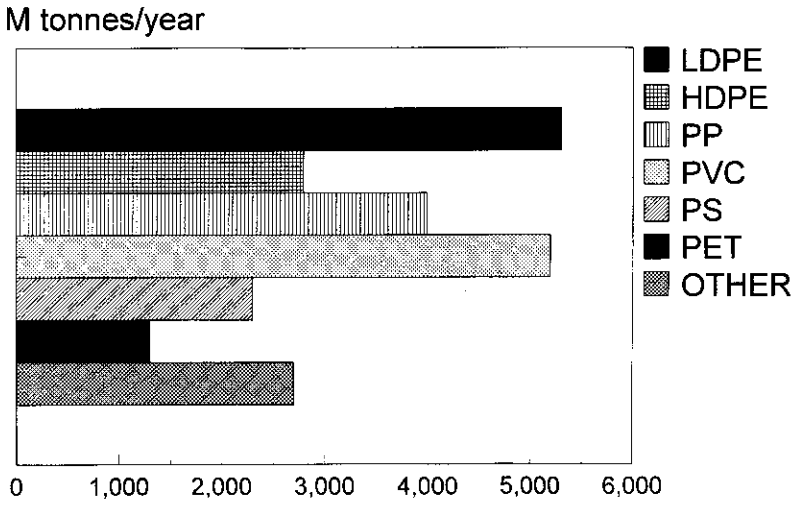


Table 1 *Composition of EU Municipal Solid Waste*

Waste Type	By Volume (%)	By Weight (%)
Plastics	15.6	7
Paper/Cardboard	36.9	25
Metals	14.1	8
Glass	2.8	10
Yard Waste	16.1	-
Food Waste	4.4	30
Dust/Ash	-	10
Textiles	-	10
Others	10.1	-

Reported estimates in 1995 (4), were able to record that some 17M tonnes of waste plastics were produced, with only 6.5% undergoing material recycling (see Table 2 for details). There is a pressing need throughout Europe, and indeed world-wide, to recycle waste materials, this being particularly urgent when waste is plastic, since it has been shown that for every tonne of polyethylene recycled a saving of 1.8 tonnes of crude oil is accrued from life cycle analyses (5). Landfill sites impose a heavy cost burden on authorities and nature itself, thus, it is clear that in the future, government policies will focus on alternative strategies to landfilling. Furthermore, European legislation, allied to the theme of "producer responsibility" has laid down directives to encourage the recovery and recycling of plastics.

Published Directive 94/62/EC aims to harmonise national measures concerning the management of packaging and packaging waste in order to provide (i) a high level of environmental protection and (ii) avoid obstacles to trade and restriction of competition. Agreed national targets within each member state have been made to facilitate this directive. Producer responsibility lies behind the waste regulation directive and in practice each country sets up an agency to handle these obligations and to discharge them on behalf of member companies.

The Directive has set down targets for the UK, which will mean by mid 2001:

- 50-65% by weight of used packaging must be recovered;
- 25-45% by weight must be recycled;
- any difference between the amount recycled and recovered should be made up, if possible, by recovery of energy from combustible use;
- each individual package material must be > 15% recycled.

To facilitate their re-use, plastics have been coded and the agreed EU convention is:

1. polyethylene terephthalate PET
2. high density polyethylene HDPE
3. polyvinyl chloride PVC

Table 2 *Western Europe Post-User Plastics Waste Disposal (1994)*

Disposal Route	(%)	kte
Landfilled/incinerated without energy recovery	75.9	13280
Thermally Reclaimed	16.6	2905
Material Recycling	6.0	1050
Chemical Recycling	0.3	52
Exported Outside Western Europe	1.2	210

Table 3 *Plastics in the Construction Industry*

Use	PVC	PP	PE	EPS	PU	PS	XPS
Window Profiles	□						
Insulation Foams				□	□		□
Flooring	□	□					
Wall Covering	□						
Pipes & Fittings	□	□	□				
Water Proof Membranes	□		□				
Electrical Conduits	□		□				
Facade Clading	□						
Internal Partitions	□				□	□	

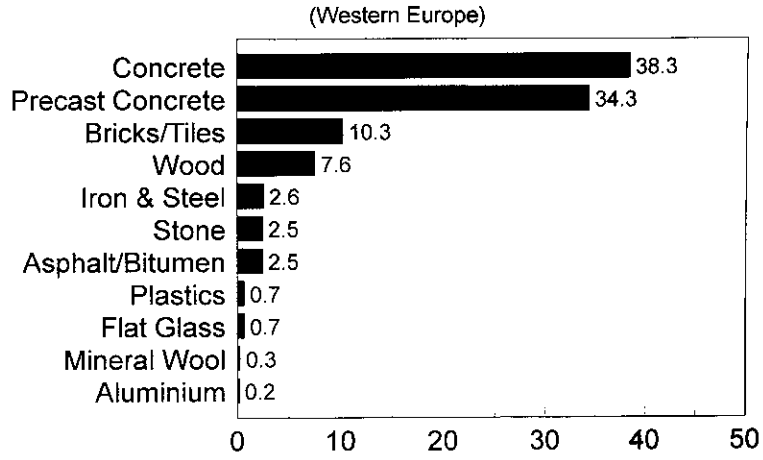
4. low density polyethylene LDPE
5. polypropylene PP
6. polystyrene PS

Dependent on the EU location, source of waste, and operational incentive schemes, plastics may be collected in segregated or unsegregated forms; this ultimately leads to practical economics regarding their fate. The impetus to recycle post-consumer waste plastic is embodied within the EC directive, but how such material satisfies technical and market demands is largely unknown. Direct food packaging cannot contain recycled plastics.

Opportunities in the Building and Construction Sector

The building and construction sector is an important and growing market for plastics, where they have established a quality reputation and performance; a necessary specification for success. Annual materials consumption by the building and construction sector within Europe has been recorded at some 728 million tonnes (see Figure 3 for breakdown), with plastics achieving a 0.7% share, constituting some 4.9 million tonnes (1). Compared to other materials, the total volume of plastics appears to be small, but their consumption equates to some 20% of total plastic sales (1). Versatility, combined with durability, strength, cost effectiveness, low maintenance and corrosion resistance make them a resource efficient choice (see Table 3 for applications).

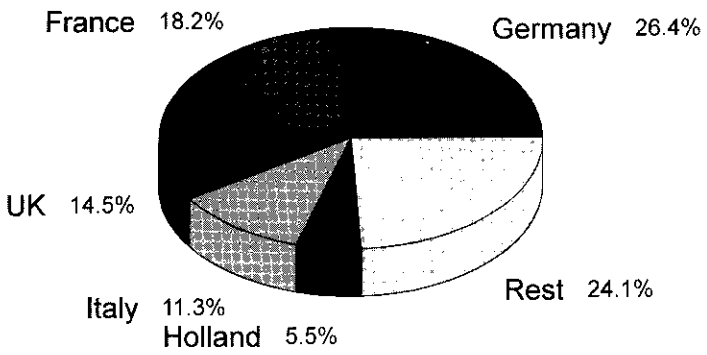
Figure 3 : Building and Construction Materials Consumption



Within Europe, the German building and construction industry is the largest individual user of plastics, followed by France, the UK and Italy (see Figure 4). Climatic and traditional architecture demands can influence market opportunities, although each plastic type has different properties that produce benefits right across this sector. Polyvinyl chloride (PVC) dominates the market, accounting for 55% by weight, with expanded polystyrene (EPS), extruded polystyrene (XPS), polyurethane (PU) and polyethylene (PE) achieving sizeable shares (Figure 5) (1). The physical properties associated with each polymer type enable application opportunities to be confidently realised within an ever-widening scope. Indeed, PVC consumption, through UPVC glazing fixtures, rose from 12,000 tonnes in 1970 to 600,000 tonnes in 1995, whilst plastics in pipes and ducts rose from 0.66M tonnes to 1.93M tonnes over the same period (1). Plastics consumption by application sector are given in Figure 6.

The building and construction sector itself, however, is also a source of waste,

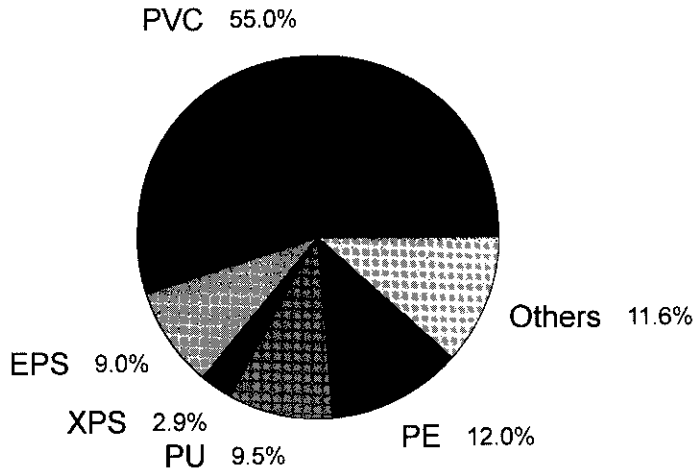
Figure 4 : Plastics Consumption By Country in Building and Construction Sector



Western Europe Annual Use = 4.9 M tonne

some 291 million tonnes for Western Europe in 1995 (1) from construction and demolition sites. Concrete, ceramics, metal and wood constituting the four largest sources of waste, with plastics accounting for only 0.3% of this total, some 841,000 tonnes. This figure may, in part, reflect market penetration, life cycle and historical aspects of plastic use within the building industry. Due to the multi-decade life span of plastics and their increasing use within building projects, it can be forecast that waste arising from near term demolition will be relatively deficient in plastics content, when compared to consumption. Nevertheless, current recycling of plastic waste from sites is poor, with more than 95% being directed to landfill.

Figure 5 : Plastics Consumption By Type



Total Annual Consumption = 4.9 Million Tonnes
Others = PA, PMMA, PC, Amino, ABS etc

Market Acceptance of Recycled Plastics

The plastics' recycler is usually faced with a raw material supply unlike any other industry. Colour, size, shape, plastics compositional make-up, a variety of previous containment contamination and other unwanted "matter", may be present. Any other process industry would have definite control specification on material supplies in order to function effectively and efficiently, and yet waste seems to escape normal business practice. In reality, however, different schemes operate, some taking the time to source specific material and duly segregate, whilst others collect bulk post-consumer plastic waste (P-CPW) for subsequent segregation or compatibilisation/ agglomeration. Segregated plastic streams are shredded, chopped, washed, dried, compounded and pelletised to yield a form for commercial use. Such products can achieve ~ 70% market price, compared to virgin materials. The recycled pellets may be used directly, mixed with virgin or co-extruded (recycled plastic layer sandwiched between virgin).

Different plastic types found in waste are incompatible with each other during melt conditions and show no miscibility. Typically P-CPW is compatibilised or agglomerated by batch containment, high speed shearing/chopping which causes frictional heat, raising the temperature to circa 150°C, inducing melt conditions, then cooled with water and broken up to yield physically compatibilised plastic waste (polyolefin matrix encapsulating other plastic entities). This product typically finds its way into commodity items such as street bollards and palisades or to the incineration plant for energy recovery.

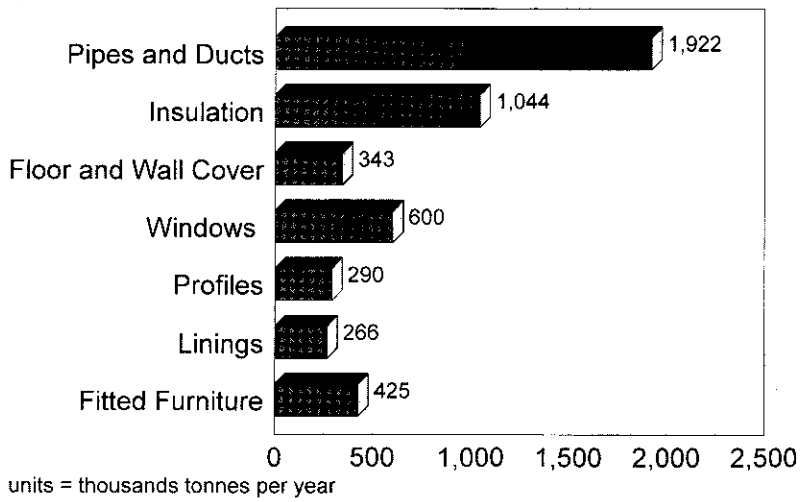
Retailers and consumers demand performance, quality and recognised specification, but also expect a cheaper price for recycled materials. It is possible to chemically compatibilise/alloy polymer mixtures to form new polymeric composites, and these could be particularly attractive for certain mixed waste streams. However, the lack of a code number (see earlier EU Convention) for such plastics and their non-conformance to documented (plastic specific) criteria will hinder acceptance. It is possible to ask if such standards serve as a barrier to innovation or are a necessary guard. Here, both are valid, and it is thus important to evaluate standards and performance requirements.

Standards and Specifications

It is possible to turn waste into products that can be used for secondary applications. The imitation of wood and resulting products, such as garden furniture and road side bollards are well known examples. The market for such products is limited because of their heterogeneous nature and inherent mechanical properties. The ability to chemically compatibilise waste plastics leads to fresh opportunities, but these and other produced formulations must have clear QA/QC specifications.

The British Board of Agrément (BBA) provide certification on manufacture, specification and purchase of building products, and may be a precursor to a

Figure 6 : Plastics Consumption By Application Sector



units = thousands tonnes per year

British Standard. Such certification records a successful comprehensive assessment, including laboratory testing and site evaluation. Construction products have certain unique characteristics and often have a very long working life and must therefore record compliance with building regulations. The BBA serves to demonstrate fitness for purpose, ongoing assessment of durability/performance and change in specification.

The BBA can furthermore issue European Technical Approvals (ETAs) to products which have no mandated and harmonised European standard, to allow manufacturers to affix the CE mark and market them throughout Europe. The CE marking shows that it meets six essential requirements:

- mechanical resistance and stability
- safety in case of fire
- health, hygiene and the environment
- safety in use
- protection against noise
- energy economy and heat retention

Eventually most ETAs will be issued on the basis of common methods and published as European Technical Approval Guidelines, and will presumably result in the phasing out of BBAs and British Standards.

Thus, it is clear that controlled technical specification/performance, price and market acceptability are inextricably linked to volume sales. It is the technical challenge of assessing the opportunities for mixed plastic waste that is a key objective of this applied research programme and will ultimately dictate whether or not segregation is the only viable (product orientated) route to follow.

The Programme

An eight member consortium, spanning three EU member states (UK, Belgium and Germany), are engaged in an 18 month programme (6) to tackle five key work packages, which will identify the potential for post-consumer waste plastics.

1. Mixed Plastic Compositional Requirements: To determine physico-chemical performance characteristics associated with compounded plastic compositions ranging from post-consumer through to segregated streams:

- statistically determine sample compositional needs
- prepare samples *via* physical and chemical compatibilisation routes
- undertake physical and chemical testing of compounded plastics
- segregated model blends, compatibility and testing.

2. Prefabricated Waste Plastic Board Development: To quantify new opportunities for waste plastics as either full compositional components or partial ones in a range of binder systems including resins. Basic in-house boards to structural requirements for pre-fabricated buildings will be examined:

- surface modifications to plastic wastes
- structural engineering design requirements
- supply of prefabricated boards for dwelling use
- laboratory physical testing
- composite resin bonded plastics.

3. Cementituous Formulations: To establish the physical and chemical nature of plastic waste products that satisfy added value performance to cement formulations:

- surface nature and physical form of plastic waste
- laboratory evaluation of cement formulations.

4. Legislation and Standards: To identify barriers to acceptance of post consumer plastic waste. Across the EU different standards and national legislation exist that may unnecessarily hinder the prospects for market accessibility, especially if performance criteria, product suitability and standards are detrimental to non-virgin sourced products:

- information collection
- evaluation and analysis
- cement formulations
- engineering considerations
- marketing and sales considerations.

5. Economic Assessment of Recycling Initiatives: The true market potential of any developed process will have to be financially scrutinised in respect of all the parameters governing viability. Market evaluation, investment needs, forecasts and market place sensitivities will be necessary outputs from this economic modelling exercise:

- model development and refinement
- data input
- model analysis and simulations.

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3. "Plastics Recycling from Cradle to Grave," Geschundt, S, Ward M, Infonet Publication, 1993 (ISBN-1-874682-00-3).

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6. "Realising the Technical and Market Potential for Post-Consumer Plastics Within the Building and Construction Sector," Lawless, T A, Smith, R N, Brite-Euram EC Programme No. BRST-CT98-5289.

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Environmental Chemistry Research at the University of Paisley

DR. ANDREW HURSTHOUSE describes how the research programme at Paisley University addresses the environmental concerns of the local community and industry and benefits both.

Introduction

Research in Environmental Chemistry at the University of Paisley has developed over the last nine years through interdisciplinary and interdepartmental activities of staff in the faculties of Science, Engineering and Applied Social Studies. It forms a key part of a broader initiative in Environmental Technology and Waste Management, which is co-ordinated by Dr Andrew Hursthouse and Professor Peter Tucker who are both from the Department of Chemistry and Chemical Engineering. Research projects cover a wide range of themes, broadly focusing on the cycling of elements and chemical species under surface and sedimentary conditions. The underlying aim of the group is to improve our understanding of the environmental impact of waste discharges to air, land and water bodies and the implications for industry and public health.

The projects that have been developed involve aspects of environmental sampling and data collection through to laboratory-based experimentation and pilot/full scale process development to treat/manage environmental impacts. The development and application of robust chemical analysis methods is crucial to the projects and forms a significant component of our work. We apply a wide range of chemical analysis methods including atomic spectroscopy, chromatography and physical techniques such as SEM to derive data. Brief details of the main areas of activity are summarised below:

Research Projects

1. Biogeochemical Cycling of Inorganic and Organic Contaminants in Estuarine Ecosystems

This area focuses on the assessment of the distribution, mobility and ecological significance of inorganic and organic contaminants in estuarine ecosystems. Work has concentrated on studies of heavy metals, polyaromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) in the Clyde Estuary. In particular, we have investigated the significance of historical levels of metals on a simplified food web for intertidal sediments (1,2) and on the mobility of locally significant contaminants such as Cr and its cycling in this dynamic system.

Recently, work on PCB distribution and mobility has highlighted diverse sources of contamination (3). Figure 1 summarises some of the initial findings of this project, where a number of different industrial sources that are responsible for polluting the estuary with PCBs have been identified. Geochemical associations are being investigated to elucidate factors controlling mobility in the estuary and uptake within the food chain.

Funding/Collaboration: FRS - Marine Laboratory, Aberdeen

2. Air Quality and Health

Our work started in collaboration with Renfrewshire Council, to establish monitoring techniques for a variety of priority pollutants (primarily PM_{10}, lead, benzene) and develop techniques for the survey of other air quality parameters (PAHs, $PM_{2.5}$) likely to be included in future air quality guidance (4). Whilst of legislative concern, these parameters offer an opportunity to study urban geochemistry on a large scale. In the case of benzene this study has highlighted the impact of traffic management on urban air quality in the district, in particular the broader than expected geographical influence of traffic volumes and changes in flow for a relatively small urban centre.

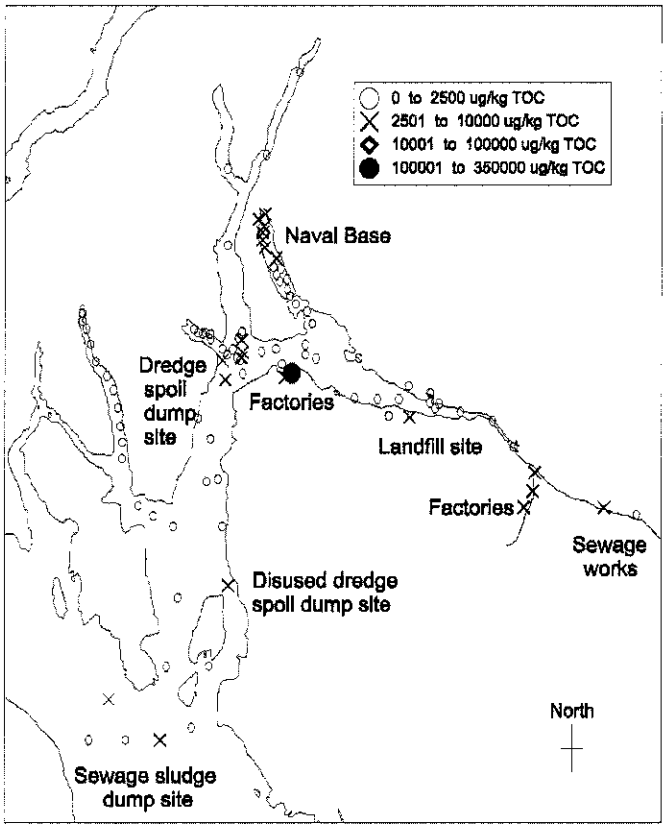

Figure 1. Levels of 21 chlorinated biphenyl (CB) congeners in sediment of Inner Clyde Estuary. Results normalised to total organic carbon (TOC).

By including a number of other parameters, in particular soluble cations and anions and multi-element data, the unique geographical situation of Paisley lends itself to the development of methods for the source-apportionment of particulate matter.

Another related project is working on high-resolution personal sampling and analysis of particulates with a view to improving risk assessment models for ambient urban environments and the relationships between indoor and outdoor composition.

Funding/Collaboration: Renfrewshire Council, SURRC

3. Contaminated Land – Risk Assessment and Remediation

We have been involved in a number of projects studying the speciation and mobility of Cr from contaminated sites in Central Glasgow (5), methods for the treatment of metal-contaminated ground and surface waters and the development of decision support tools for site investigation and evaluation (6).

More recently, work has begun on the development of large-scale assessment and environmental impact of wastes from metal production. This involves geochemical, hydrogeological and ecological aspects and involves collaboration with industry and other research groups in the UK and abroad. The sites being studied show a varying degree of natural regeneration and we are concentrating on the development of a variety of investigative, monitoring and management techniques to assist in minimising future environmental risk from these sites. The work also supports studies on contaminant mobility and an experimental programme is planned in this area, utilising our new pilot scale facility.

Funding/Collaboration: Dames & Moore, City of Glasgow Council, British Steel plc, MAFF, Universities of Glasgow, Strathclyde & Turin, Shell.

4. Radionuclide Mobility in Terrestrial Systems

This work develops a theme integrated with our research on contaminated land. It focuses on radionuclide behaviour in soil profiles and in particular the factors responsible for the mobilisation and redistribution of inputs. The project has concentrated on actinide discharges from Sellafield (7,8) and radiocaesium from Chernobyl (9). In particular, the role of clay minerals in controlling the redistribution of atmospheric input has been highlighted to be significant in alpine pastures.

Funding/Collaboration: Universities of Turin & Manchester

5. Pilot Scale Experimental Facility for the Risk Assessment of Wet Particulate Waste

This project, funded by the Scottish Higher Education Funding Council, recognises the University's capabilities in environmental and waste management research. The new facility features an eight m^3 experimental tank and associated process control options. This will allow long term studies of the behaviour of waste materials to be undertaken, and will yield valuable information about processes under more realistic conditions and at a much larger scale than previously possible.

The facility has been designed to maximise experimental flexibility and provide a variety of environmental simulations. Key features include:

- an 8 m^3 active volume,
- temperature control over the -10°C to 70°C range,
- surface irrigation and the ability to recycle or remove leachate,
- to be run under aerobic or anaerobic conditions,
- establish contact between a landfill liner and mixed waste materials,
- provides a range of sampling ports to remove material or insert monitoring devices,
- allows long experimental runs of many months duration.

A series of commissioning experiments are planned to start in autumn 1999 and will include studies of the behaviour of wastes from the paper industry; contaminated land risk assessment; climatic influence on pollutant migration; and the development and evaluation of new monitoring techniques. The overall

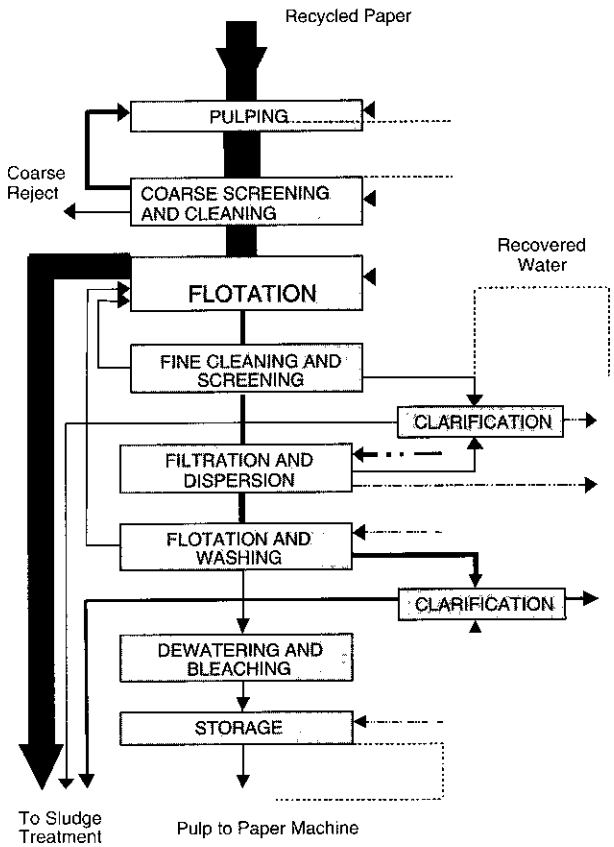

Figure 2. Copper pathways through a de-inking plant. Flows shown as solid lines are pulp flows; flows shown as dashed lines denote water streams.

aim is to exploit the facility to explore new waste management technologies and produce information on processes at a large scale, of more direct relevance to industry.

Funding/Collaboration: SHEFC, British Steel plc, Newspaper Industry Environmental Technology Initiative

6. Newspaper Industry Environmental Technology Initiative

An industrial consortium of 9 multi-national companies are sponsoring a five-year rolling research program focusing on two key areas of particular environmental relevance to the newspaper industry:

(i) the recovery of post-consumer waste towards a best practicable environmental option (BPEO);
(ii) the generation and utilisation of de-inking sludge towards a BPEO.

The research is aimed at developing and disseminating accurate, timely, and representative new data that are relevant to the recycling stage in the newspaper life-cycle. Also to enhance and furnish increased confidences in life-cycle assessments (10). Specific projects undertaken to date include:

- developing a material balance of heavy metal flow through a newspaper de-inking plant (see Figure 2);
- research into the bio-degradation and environmental fate of news inks;
- identification and quantification of heavy metal levels and their sources in the printed newspaper (11);
- and predictive modelling of post-consumer fibre recovery.

The fibre recovery (recycling model) integrates a process simulation of material flow through the household with a social simulation of the psychology of recycling behaviours (12). The next stage in the investigations of the environmental fate of de-inking is a programme on controlled pilot-scale experimentation, using the new 8 m^3 facility being commissioned at the university. The research will address the optimisation of pre-treatments for agricultural application of the sludge, and predictions of its leachability, degradation and environmental fate.

Funding/Collaboration: Bridgewater Paper Co. Ltd., Daishowa Forest Products Ltd., Donohue Inc., Holmen Paper AB., Manders Oil Inks Ltd., Norske Skog, StoraEnso, Sun Chemical Inks and UPM-Kymmene (Shotton Paper).

7. Industrial R&D towards Integrated Pollution Prevention & Control

Our other activities to support industry focus on the provision of scientific research for SMEs to develop the company resource base and improve business performance. A significant part of this activity has addressed issues of compliance with current and impending Integrated Pollution Prevention & Control legislation. Since 1994, three industrial units within the Faculty have managed the programme: the Centre for Particle Characterisation & Analysis, the Centre for Environmental & Waste Management and the Biotechnology Transfer Centre, with additional support from European Regional Development Funding. The innovative problem solving R&D activities established at Paisley have made a significant impact on the sustainability and growth of the regional economic base. By applying the basic principles of chemical analysis, technology and management, we have helped to promote process efficiency and waste minimisation with real impacts on company business performance. One example is a current TCS/industry-funded programme to develop new treatment technologies for bulk chemical wastes from the process industries.

Funding/Collaboration: ERDF, industry, the Teaching Company Scheme

8. The Behaviour of Manganese in Water Treatment Works

This project has isolated and identified a manganese oxidising bacterium, effective at low temperatures and low nutrient conditions. The study has applied SEM and routine chemical analysis to assess the effect of this bacterium on manganese deposition on the surface of PVC and HDPE pipeline materials. The first literature report of micro-nodule formation was recently published (13) and shows Mn and oxide enriched nodular deposits of 8-10μm in diameter associated with the low temperature biofilm. The work has considerable implications for the treatment of Mn-rich drinking water supplies, where deposition of oxidised Mn not only causes aesthetic problems but can lead to substantial reductions in pipe diameter and associated problems in the processing of water supplies. Work is under way to evaluate the mechanism for nodule formation.

Funding/Collaboration: West of Scotland Water.

Undergraduate and Postgraduate Course Provision

At Paisley we offer a range of fully validated, taught degree programmes, which support the training of students in the environmental sciences. A major strength of these programmes is a focus on practical aspects through strong laboratory components and inclusion of industrial placements, lasting up to one year. Lectures from practising industrialists and site visits are also an important part. The courses available in full and part time modes are:

BSc/BSc (Hons): Environmental Chemistry, Environmental Industrial Chemistry, Environmental Science & Technology, Environmental Biology, Biology/Chemistry/Physics with Geology, Water & Environmental Management, PGD/MSc: Industrial Chemistry, Environmental Management, Safety/Waste Management with Environmental Management.

We welcome contact from anyone interested in finding out more about our activities. For further details on any of the above please contact:

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Environmental Analysis and Accreditation in the Former Soviet Union

Dr. ALAN ROWLEY, the Senior Partner of *Alan Rowley Associates*, has had considerable experience over the last twenty years in installing and implementing quality control systems in analytical laboratories, including laboratories that specialise in environmental analysis and monitoring. In a good proportion of this work, Dr. Rowley has worked with overseas customers. In this article he shares his experiences of the concepts of accreditation, validation and audit as seen in present-day Russia, from where he has recently returned.

Working in Russia, and more recently in the Ukraine, with laboratories carrying out environmental monitoring has proved to be a challenging experience. The first thing that I had to learn was that 'accreditation' means something a little different in Russia and has a critical role in laboratories that provide input to the regulatory process.

The formal situation is simply described by saying that all testing for regulatory purposes must be carried out in an accredited laboratory, using an officially certified method and on equipment that has been certified. Method certification is particularly important. You can forget about 'documented in-house methods' as we understand the concept. If a method is not officially certified then, for regulatory purposes at least, it effectively does not exist. It comes as something of a culture shock when you are told that a method such as the US EPA Method 524.2 for analysis of volatile organics in waters is completely unacceptable and will have to be validated to demonstrate its suitability for 'Russian conditions'!

All Russian laboratories, of course, formerly came under the State and the concept of a commercial testing laboratory is only just beginning to emerge. Even now commercial testing tends to be carried out by the State laboratories as a sideline cost recovery exercise. This can be very important to the laboratory staff since effective cost recovery may mean their getting paid. Under the State system the relevant committee formally approves the laboratory and its methods. In the case of environmental work this means the Oblast (an Oblast is effectively a county) Environmental Protection Committee which derives its powers from the State Environmental Protection Committee. However, the Committee does not have the power, or ability, to accredit the laboratory and methods itself. This is the responsibility of an appropriate technical body operating as an agency of the national standards body, which is called GOSSTANDART.

GOSSTANDART is the formal accrediting body and actually promulgates the accreditation standards

but it does not become involved in the accreditation process. The actual inspection and assessment of laboratories is devolved to a whole range of bodies with appropriate technical expertise. These are normally metrology institutes or suitable academies.

The key body for accreditation of chemical testing laboratories in Russia, for example, is the Urals Scientific Research Institute for Metrology which is located in Ekaterinburg. The main work of this organisation is research into methods of chemical measurement, development of reference materials and evaluation of chemical testing instrumentation. The set-up is rather as though UKAS confined its activities to developing the accreditation standard and then engaged the Laboratory of the Government Chemist as an agency to actually do laboratory assessments and empowered it to award accreditation. This would, of course, cause a conflict of interest in the UK but this is of no concern in Russia. Not because conflicts of interest do not occur, they are simply of no concern! Commercial science is such a new concept that the ethical background that goes with it is largely undeveloped. Until recently everyone had only one client or customer, the State, so such considerations were irrelevant.

The key standard for laboratory accreditation in Russia is *System of Analytical Laboratory (Centre) Accreditation in the Russian Federation,* although there are a number of related standards specific to particular types of laboratory including one for environmental laboratories. However, almost as important as the accreditation standards is the standard for method certification, GOSSTANDART 8.563-96. This standard actually only describes the basic requirements and there are supporting standards dealing with specific validation requirements, for example, for chromatographic data. These are all quite specific in their requirements both with respect to the validation data to be collected and how it is to be processed.

The content of *System of Analytical Laboratory (Centre) Accreditation in the Russian Federation* is effectively the Russian version of ISO Guide 25 (ISO 17025), but its approach is somewhat different. Whereas the ISO system for accreditation focuses on the structure of the quality management system and its monitoring by internal audit, the Russian standard emphasises quality control and checking of data. ISO Guide 25 does not ignore data quality, of course, but absolute competence of laboratories is generally approached through the medium of interlaboratory proficiency testing and measurement of reference materials. The laboratory effectively monitors itself, under the ISO system, and is expected to take corrective and remedial action to deal with any problems that turn up. Assessment and surveillance by the accrediting body then checks to ensure that this process is being operated properly and that remedial and corrective action is implemented as appropriate. Poor performance in a proficiency round is not, in itself, a non-compliance, but failure to respond with appropriate action assuredly is.

Under the Russian system, however, the first step in assessment is for the laboratory to be sent reference samples relevant to all the official methods for which it is seeking accreditation. It must perform to a minimum specified standard of accuracy and precision on these samples before it can even be considered for further assessment. Surveillance of the laboratory also involves the accrediting body sending further reference samples, and accreditation will be withdrawn if results are unsatisfactory.

This emphasis on quality control and monitoring of absolute performance extends to the role of the Quality Manager under the Russian system. The term Quality Manager is not actually used but the nearest equivalent role is that of the laboratory metrologist. The terms metrology and metrologist have a much broader interpretation in Russia than as used in the West and are not restricted to the study of the detail of measurement. Chemical metrology, in the sense of quality control expertise and knowledge of method validation, is a recognised specialisation within analytical chemistry and the in-house metrologist appointed as part of the laboratory quality system will be required to hold a formal qualification in this area.

Under the accreditation system this in-house metrologist is expected to check all data and to monitor the laboratory by, for example, submitting blind quality control samples. The role is much more like that of the quality control department under a GLP system than that of the ISO Guide 25 or UKAS Quality Manager. The concept of audit in Russia follows through in the same vein. Rather than being a process of checking the correspondence between documented procedures and actual practice, as under the ISO system, audit is taken as describing the monitoring of data carried out by the metrologist. In other words audit refers strictly to measurement audit rather than quality system audit.

Documentation equivalent to the ISO Quality Manual is required by the Russian system but the scope is rather different and, in the absence of a requirement for quality audit, the emphasis on documentation of administrative and organisational procedures is much less than under the ISO system. The manual is mainly required to specify the laboratory organisation, equipment inventory, staff establishment and procedures for quality control. In this respect it is orientated to being a source of information for the accrediting body and a document which commits the laboratory. It is not primarily intended as a working document for use by the laboratory staff.

A major divergence from ISO is with respect to training and training records. Russian laboratories are exclusively staffed with the equivalent of graduate chemists who are automatically deemed capable of conducting any officially certified methods for which the laboratory holds accreditation. There is, therefore, no perceived need for in-house training or review of competence other than the monitoring of the data quality by the metrologist already discussed. The assessment process simply involves an evaluation to establish that the laboratory has an appropriate number of staff and that they have the required formal qualifications.

Calibration is approached through the medium of the equipment certification system. In principle any piece of equipment must be certified, normally by one of the bodies which also accredits laboratories. The evaluation of the equipment for certification includes the preparation of a documented calibration regime by the certification body. This then becomes an effective state standard

for calibration of that equipment and must be adhered to by all accredited laboratories using it. In theory the system is not generic in the sense that the certification applies only to a particular make and model of instrument. In practice the equipment certification system has been relaxed. There is such a diversity of Western analytical equipment entering Russia that individual evaluation prior to certification is impracticable. Certification of an instrument now usually involves payment of a fee to obtain the appropriate paperwork with, of course, the obligatory official stamps.

Method certification also operates through the laboratory accrediting agencies. If a laboratory wants to submit an in-house method for certification, it approaches the metrology institute with a method validation plan. This will cover the data to be collected and the details of the statistical evaluation intended. The plan must comply with the method certification standards. The metrology institute then reviews this plan and eventually approves it. The laboratory now carries out the validation and submits the results to the institute for review. Assuming all goes well, the laboratory then documents the method, the documentation approved by the institute and the method certified. All this requires fees to be paid to the metrology institute for their services so the laboratory incurs real costs. These can sometimes be recovered because the laboratory now has proprietary rights to the method and can charge fees to license its use by another laboratory. There are, however, compilations of methods which are effectively public domain so it is not always necessary to pay for the use of a method. This fee structure for method certification is a major stumbling block to the introduction of new methods and new techniques for use in regulatory laboratories in Russia. Under the current economic conditions laboratories have no money to pay the certification fees so new methods cannot be introduced. The same economic conditions result in the certification bodies resisting relaxation of the requirements for method certification in order to protect their own source of income.

Russia, through the Urals Scientific Research Institute for Metrology, is actively engaged in trying to harmonise its laboratory accreditation system with ISO practice and so join the bulk of the rest of the world. In fact, although the way quality management operates in practice in Russia differs from the West, compliance with ISO Guide 25 would not present a major problem. Expansion of the Quality Manual, introduction of quality audit, and the implementation of formal training records would bring most laboratories close to compliance. They could also retain their existing practices with respect to quality control and direct evaluation of competence, so remaining compliant with their national standard. This would simply be adding extra requirements over and above those in ISO Guide 25. Where the Russians have a problem is in recognition the other way. They perceive ISO Guide 25 as setting a lower standard than the GOSSTANDART, especially with respect to assessment of the absolute competence of laboratories. In this respect they have a difficulty with mutual recognition agreements with Western laboratory accreditation bodies since this would involve accepting data from ISO Guide 25 compliant laboratories. From a Russian standpoint such laboratories can use any old method and have never been checked to make sure they get right answers!

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The Centre for Environmental Research at Brunel University

THE Centre for Environmental Research, at Brunel University, is based at the Uxbridge Campus in West London. The Centre has been operating since 1991 and is involved in research, postgraduate Masters degree training and consultancy.

The Centre has one of the fastest growing research teams dedicated to tackling environmental problems for industry. It has strong links with industries world-wide in collaborative research, consultancy, and input to the MSc teaching programmes. The industrial links have included those with Shell, Nestlé, Meldform Metals, Twinstar Chemicals, ICL, Nortel, Fluid Dynamics, RTZ, Mott MacDonald, Jesse Brough Metals, Preminco, The Environment Agency and The Cobalt Development Institute.

The Centre provides rigorous postgraduate Masters degree training in the principles and practices needed to assess and control Man's impact on the environment. This is aimed at understanding emissions to air, land, water and the effects of pollution, and the legislative framework in which they are set.

The balance between pure and applied research and teaching ensures the quality and importance of the work of the Centre whose graduates have an excellent record of obtaining employment in industry, government, regulatory bodies, universities and environmental consultancies.

Research

The Centre currently consists of 40 research active workers including three post-doctoral assistants and 30 research students. Since 1991, the number of students who have been awarded PhD degrees is 24. The group includes research workers from Pakistan, Syria, Brunei and Iran who are being sponsored by agencies of their governments as part of the Centre's activities, in pollution prevention and control world-wide. The main contributors to the research of the Centre include Professor John Donaldson, Dr. Sue Grimes, Dr. Steve Mullins, Dr. A.J. Chaudhary and Dr. Zaib Hussain. The lead research workers in the group are Professor Donaldson and Dr Grimes.

The Centre has current research funded programmes amounting to more than £750K from EPSRC, government etc. £340K of this is EPSRC funding.

In addition to research at MPhil. and PhD level, the Centre, since 1993, has been training some of the UK's first research engineers in environmental engineering through the Parnaby Eng.D programme.

Areas of recent research and consulting include:

Waste and Wastewater Treatment

Fundamental properties of pollutants in dilute concentration
Removal of heavy metal and toxic impurities
Destruction of organics and haloorganics
Simultaneous removal of metals and destruction of organics
Decolourisation of dye effluents
Sewage treatment
Solid organic waste treatment & composting
Leachability of heavy metals from secondary sources

Clean Process Technology

Development of concentrator technology
Development of separator and membrane technology
Recovery, reuse and recycle technology
Energy efficiency through prevention of chemical scale
'State of the Art' clean-up technology
Recovery of metals as value-added chemicals
Organic synthesis

Process Technology

Effects of applied fields on processing of soft solids including fats, petroleum waxes, hydrocarbons.
Effects of applied fields on crystallisation processes, flocculation, emulsification, and chemical reactions.

Pollution Measurement and Control

Soil remediation
Characterisation of species transported through soils
Development of particulate and air quality analytical methods
Control of emissions from vehicles and industrial sources
Dispersion of powders to reduce dust hazards

Environmental Management

Life cycle analysis in manufacturing industries
Life cycle costing
Community pollution measurement and assessment
Definition and control of Basel Convention wastes
Control of hazardous and special wastes
Effects of UK, European and international legislation
Environmental Review and Audit processes

Toxicology

Endocrine disruptors
Bioaccumulation of chemicals
Bioadsorption of chemicals
Environmental impact of chemicals
Speciation of endocrine disruptor chemicals

Research Supervisors

Professor John Donaldson is Director of Research. He has published more than 250 publications in the refereed scientific literature and more than 80 research workers have obtained doctorate degrees working under his supervision. He is Deputy Chairman of WAMITAB and chairman of Hopeman Associates Ltd, a company which provides scientific environmental consultancy to a wide range of companies on E.I.A., Audit, compliance, contaminated land, effluent and water treatment and control of atmospheric emissions.

Dr. Sue Grimes is Head of the Centre for Environmental Research at Brunel University and Director of the Environmental Masters Degree Courses. She is an experienced research supervisor of industrially and academically based research projects and has published over 100 papers in the scientific refereed journals and has supervised over 30 research workers. The combination of her science base with her MBA degree make her particularly suited to research projects in environmental topics that require both technical and business expertise. She was a member of The Royal Society of Chemistry's working party for the accreditation of environmental auditors, verifiers and assessors.

Drs A.J. Chaudhary and Zaib Hussain both obtained their doctorate degrees in The Centre for Environmental Research and are responsible for the day-to-day supervision of many of the research projects within the Centre.

MSc Courses

The Centre currently offers four MSc degree courses which can be taken on a full-time or part-time basis. The latter option can be completed in two academic years. Full-time students can complete all the course requirements in one academic year.

The MSc courses currently offered are:

Environmental Pollution Science;
Environmental Science with Legislation and Management;
Environmental Science with Occupational Health;
Environmental Management.

In the year 2000 the Centre will introduce the following Masters degree with the support of the Waste Industry:
Waste Management and Control.

Currently over 80 students are registered on the MSc courses and a total of 46 students graduated with Masters degrees in July 1999 along with Dr Gallagher of the Environment Agency, who was awarded an honorary Doctor of Science degree.

Graduates from these Masters courses have an excellent record of obtaining employment in industry, government, regulatory bodies, universities, and environmental consultancies.

The tutors to the MSc course are drawn from the staff and associates of the Centre and include visiting lecturers from the Environment Agency, Environmental Consultancies and industry.

MSc Degrees in Environmental Pollution Science / Environmental Science with Legislation and Management, and Environmental Science with Occupational Health

Three of the Masters degree courses, in Environmental Pollution Science, in Environmental Science with Legislation and Management, and in Environmental Science with Occupational Health, are designed to allow those students whose career choices lie in the field of environmental science, regulatory processes and health protection to acquire a broad-based knowledge of the concepts involved. The courses are vocational and provide effective entry into all professions related to environmental pollution, assessment and control.

The taught modular MSc courses provide a rigorous academic treatment of the fundamental scientific principles and practice of assessing and controlling the extent of environmental damage by Man's activities. The courses emphasise the processes and techniques related to the reduction of emissions to air, land and water, and the effects of pollution together with the legislative framework in which they are set.

The core material for all courses is concerned with the fundamental principles of environmental science. In the MSc in Environmental Pollution Science, this is backed up by a practical laboratory component. In the MSc in Environmental Science with Legislation and Management, the practical component is replaced by lectures on environmental legislation and environmental management. In the MSc in Environmental Management with Occupational Health, the practical component is replaced by lectures on topics in Environmental Health.

The courses are structured around a programme of formal lectures, practical laboratory work, workshops, directed reading and participation in seminars, discussions and site visits. The students are able to specialise in an area of particular interest to them by careful choice of their dissertation topic which accounts for four of the twelve modules required to complete the Masters degree. Students on all courses benefit from lectures given by external speakers from the regulatory authorities, governmental departments, local authorities, waste management companies, water companies, environmental consultants and solicitors.

The taught part of these courses comprises a formal programme of lectures, participation in tutorial and practical classes, directed reading and industrial site visits. There are also two practical-based modules in monitoring and control for students undertaking the EPS course. Students undertaking the ELM course will take one module in Environmental Management and one in Environmental Legislation. The courses have six core modules in dealing with environmental science

MSc in Environmental Management

The Masters course in Environmental Management is designed primarily for in service training to provide managers, intending managers and environmental specialists with the knowledge, understanding and skills that will enable them to guide their organisation's policy and practice towards environmentally sustainable modes of operation, in response to the developing social, legal and market demands. To this end, the course aims to equip candidates with a knowledge and understanding of:

- the sources and effects of environmental damage at all stages of the product life cycle;
- the managerial and technical approaches to the control of pollution and the waste;
- the developing body of UK and EU law;
- the implications of environmental sustainability for corporate strategy and policy;
- environmental management systems and assessment methods and their place in management;
- in-depth aspects of selected managerial, technical or functional areas of environmental management, through the specialist optional modules.

The course combines the long-standing experience of Brunel's Masters courses in Environmental Science with its strong links with industrialists and practitioners in the field. This combination gives students access to a unique nationwide network of academic and practical expertise.

The Masters degree in Environmental Management concentrates on the importance of both technical and managerial knowledge and contains the following six core modules:

- Environmental and Business Strategy: How environmental strategy and policy relates to corporate strategy, strategic environmental opportunities and risks; the meaning of sustainable development for business; developing an appropriate environmental strategy and policy.

- Systems for Environmental Management: Characteristics of an environmental management system; European and International EMS standards; implications of disclosure; evaluation of environmental effects; emerging systems and criteria for environmental accounting, performance measurement and reporting.

- Environmental Legislation: Environmental Protection Act and Environment Act, IPC and IPPC, COSHH and CIMAH regulations and other relevant UK, EU and international legislation, and powers of regulatory authorities.

- Environmental Audit and Operations Management: A practical module based on a full environmental review of part of an actual site. Provides insight into the operational issues involved in environmental management of a site, including control of emissions effluent and ground contamination, waste management, the site's environmental setting and on-site implications of legislation and the environmental management system.

- Waste and Land Management: Technical and managerial problems of waste control; classification of waste; nature and control of solid, liquid and gaseous wastes; landfill; re-use and recycling of materials; packaging; role of Local Authorities; hazardous and toxic waste.

- Life Cycle Analysis: Quantifying environmental burden of a process, activity or product from raw material

extraction to disposal; life cycle inventory, impact analysis, data collection and energy balance; evaluation and presentation of results. The module includes carrying out an actual life cycle analysis.

Candidates for the Masters degree in Environmental Management have come from a wide range of companies including: BAT Industries, Ernst & Young, KPMG, AEA Technology, British Airways, Rhone Poulenc, Environment Agency, Rover, RAF, Grundons, Jaguar, MOD, ICL, and TNT.

Facilities

The Centre has access to a wide range of analytical facilities including:

- X-ray diffraction
- X-ray fluorescence
- Scanning electron microscopy
- Transmission electron microscopy
- Gas chromatography with MS detection
- High performance liquid chromatography
- Infra-red Spectroscopy
- UV-visible Spectroscopy
- Atomic absorption spectroscopy
- Ion Chromatography
- X-ray diffraction
- Thermogravimetric analysis

There are also excellent computational facilities available on campus along with access to a campus library and sporting facilities.

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Clean Air for Europe: The New European Framework for Air Quality

DR. JOHN HOSKINS, a committee member of the Environmental Chemistry Group, gives a personal view of the European Union's attempts to formulate a strategy for improving air quality.

Introduction

The European Union (EU) is big, unwieldy and inhomogeneous and so is the environment. Nevertheless as part of its aims to facilitate political and economic harmonisation where appropriate, the EU is determined to shape the environment. The work environment has benefited enormously from EU legislation. So have safeguards on the quality of our food and water. Air quality, however, is one of the biggest challenges still facing the community, and the legislation to tackle this issue is only now falling into place.

Clean Air for Europe: The New European Framework for Air Quality

One of the ways in which the EU addresses a problem is to produce comprehensive but skeletal legislation to deal with it known as a 'Framework Directive'. Such Directives lay the groundwork. The detail is subsequently filled in by a series of daughter Directives. All these are legally binding on Member States.

One such Directive is the Ambient Air Quality Framework Directive (Directive 96/62/EC), which has been summarised in a booklet produced by the European Commission called 'Clean Air for Europe's Cities' [1]. A shorter version of this booklet has the title *The European Commission Directive on Ambient Air Quality and Assessment. 96/62/EC.*

Directive 96/62/EC on ambient air quality assessment and management, known as the Air Quality Framework Directive, aims to set the basic principles of a common strategy which:

- defines and establishes objectives for ambient air quality in the EU in order to avoid, prevent or reduce harmful effects on human health and the environment as a whole;
- assesses the ambient air quality in Member States on the basis of common methods and criteria;
- produces adequate publicly available information about ambient air quality and ensures that it is available to the public by means of, for example, alert thresholds;
- maintains ambient air quality where it is good and improves it in other cases.

Member States are responsible for:

- implementing the directive;
- assessing ambient air quality;
- ensuring the accuracy of measurement;
- approving measuring devices;
- analysing assessment methods;
- co-ordinating on their territory the EU quality assurance programmes organised by the Commission.

The Framework Directive will set key pollution management parameters for the private sector. New standards will be adopted under the directive that will replace earlier directives concerning sulphur dioxide, particulates, lead and nitrogen oxide. Over a period of ten to fifteen years, optimal ambient air quality limit values, margins of tolerance, assessment procedures and reporting requirements will be established for individual pollutants through a series of daughter directives. The first of these daughter directives concerning sulphur dioxide, oxides of nitrogen, particulate matter and lead was adopted in 1998.

At that time Britain had the Presidency

of the European Union, and John Prescott, MP, the Minster for Environment and Transport reaffirmed, "...that the air quality daughter directive is a main priority [of the British Presidency]." It should be noted that Britain had already pre-empted some other countries by publishing the booklet *Air Quality: Meeting the Challenge* [2].

There are several key British people who have been involved in the legislation – three women in particular stand out. *Lynne Edwards* from DGXI and formerly from the UK DoE (DETR) was concerned with drafting the Framework and Daughter Directives and considering their implications at City and Regional Level. Also, *Anita Pollack*, MEP for London SW, who was the Rapporteur on the Ambient Air Quality Directive. She has as one of her prime concerns health effects, particularly in vulnerable populations, although she is also concerned with other adverse effects of pollution on the environment and on the built environment. And a politician from the home team, *Angela Eagle*, MP, at the time Parliamentary Under Secretary of State, DETR.

The EU intends to produce long-term air quality directives. New directives are needed to ensure comparable strategies for air quality in the various member states. These member states at present should be working towards sustainability of the action they have said they were taking – then, with luck some of the targets that had been agreed could be reached by the year 2000. From a world-wide perspective, Europe is very active at producing legislation about ambient air. The EU (probably through DGXI) is looking forward to the next daughter directive on air quality, which will deal with ozone, benzene and heavy metals.

The Framework and Daughter Directives – Will They Work?

Existing legislation dates from 1980 and, because of the construction of the present Framework Directive, needs revision. To accommodate this a new framework has been devised, which should have been implemented by the governments of member states by March 1998.

The purpose of the Framework Directive is to discover how polluted an area is and how many people might be exposed. For the purposes of this directive, countries are divided into areas called agglomerations and zones, and there is only one rule, which is that a city of more than 250,000 population must be defined as an agglomeration. Apart from this exception countries may divide their land as they wish. Only in non-agglomeration zones and agglomeration zones where there is no alert threshold are measurements of pollution levels optional. The 'degree' of measurement that has to be undertaken for compliance depends upon the level of pollution. This is where the daughter directives come in – their role is to help decide upon action through defined limit values and/or alert thresholds. The first of these pieces of legislation is the 'First Daughter Directive' which comes into force two years after adoption.

When the Directive comes into force permitted pollution is as follows. First and most important there is the 'limit value'. This is the limit of pollution by a pollutant which will finally be allowed. This can be exceeded by a 'margin of tolerance' which will be decreased with time until the 'attainment date' when the limit value is reached. On this date the limit value must be met by all Member States.

At the present time Member States are divided into three groups:

Group 1 where the level of pollution is still above the limit value plus the margin of tolerance. For those countries in this Group action plans must be sent to the Commission who will tell them that they must meet the limit by the attainment date. They have to report annually and the reports will be published annually. Although at this time there is no intention of taking these States to the European court they have been told they should not assume that the EC has infinite patience.

Group 2 have pollution levels between the limit value and the margin of tolerance, and they will be monitored less rigorously.

Group 3 are already under the limit value. For example, the Netherlands has already succeeded in reducing the levels of the pollutants named in the first Daughter Directive while still enjoying economic growth. However, they are going to find it difficult to maintain this since industry has already done what it can and the volume of motor traffic continues to rise. A major problem admitted by all Member States is that NO_x reduction, in particular, will be very difficult to achieve. The (inevitable) compromise for such cases is to allow Member States to exceed the limits set, called exceedences, a defined number of times so that the legislation fits reality. However it is hoped there will be improvement by 2010 when the legislation becomes law. The long-term health effects of exposure to NO_x, SO_2, and lead still need more research, and Parliament has been called upon to support this. Similarly more PM_{10} research is needed, particularly because there is no accord on a safe level (the more we study this subject the more we wonder if it really is a health problem) and no safe limit has been agreed. Limit values for PM_{10}s will be introduced in two stages which, on a daily basis, are distinguished by the number of exceedences permitted. The reason for this slow introduction is that it no one believes it can be done any faster.

The limits set in the Directive, as in other directives concerned with health and safety, have been based on the precautionary principle. This usually includes an alert level. Although it may be difficult to achieve the limit values in the daughter directive these may still not be strict enough for vulnerable plant populations. Remember VOCs + NO_x + $h\nu$ = ozone and we have to wait for the second daughter directive for VOCs and ozone. Some economically important plants are more sensitive to ozone than are people!

Informing the public is regarded as an important part of the process. Important because the public have to know if there is a risk or if an alert threshold has been exceeded. At the moment there are alert thresholds for SO_2 and NO_x. It is a vexed question as to whether or not information campaigns work. It is probable that some people might seek more information if they were warned about air pollution episodes but whether anybody, for example, would leave their car at home is unknown. Certainly, in the past, when warnings have been given, no discernible effect on traffic levels has been found. Traffic control might be achieved through regulation using, for example, restrictions

according to car number plates. Such schemes largely fail though because people buy 'old bangers' so that they have a full set of plates or just swap plates on the same car.

Away from the politics what is really being done? There have been schemes. A consortium of medium and large towns in Europe worked on 'Good Practice in European Urban Air Quality Management' [3]. This was funded by DGXI through the Eurocities Consortium and co-ordinated through Sheffield. The partners in the project were - Italy (Bolgna), Slovakia (Bratislava), The Netherlands (Delft), Finland (Helsinki), Portugal (Lisbon) and the United Kingdom (Sheffield). Conferences took place in each of these cities. At the meeting in Lisbon it was decided that there was a need for more data on air pollution and so in the various cities in the project parallel measurements were made of several airborne pollutants: CO_2, CO, NO_x, SO_2, O_3, and particulates.

The results of this exercise confirmed there was little doubt that problems in meeting the levels proposed by the daughter directives will arise. The best that could be hoped for was that the cities could keep the *status quo*. It was agreed that they, the cities, would try to stop air pollution getting worse but improving air quality might be a problem. A number of ideas were put forward to help this such as improving underground systems and adding more bus lanes. Also, they would encourage the use of biodiesel and LPG and in time encourage the use of electric cars. We must wait and see.

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Genetically Modified Products and the Environment

RISK ASSESSMENT – in one guise or another – dominated the headlines in the UK in 1999. From the food we eat to our modes of transport, all came under intense public and 'expert' scrutiny. Nowhere have the siren voices been loudest than in the arena of genetically modified (GM) food and in particular the risk from any effects of GM crops on the environment. In this issue of the ECG Newsletter a campaigner for Friends of the Earth summarises the environmental concerns raised by the introduction of GM crops, while an ecologist from one of the main protagonists of GM foods – Monsanto – contrasts national regulatory procedures for the environmental monitoring of GM crops.

Genetically Modified Organisms and Monitoring

Introduction

The genetic modification of organisms for food use has raised serious concern about the potential for adverse effects on the environment, ecosystems and on the health of humans and animals. As a relatively new technology, its impacts remain uncertain but could range from disturbances to the genetic functioning of individual organisms to a reduction in the biodiversity of farmland. As a result, the question of how to monitor for potential impacts is beset with problems. The fact that genetic modification can be used on a range of organisms for a variety of purposes, means that those developing monitoring systems will need to be as imaginative as those developing genetically modified organisms (GMOs).

In the case of GMOs for food use, concern has focussed on the transfer of genes to other organisms, the potential for effects on non-target organisms, or on the health of humans and animals and the likelihood of adverse effects on wildlife due to changes in farming practice. As with other new and unfamiliar technologies, genetic modification is also plagued by the problem of uncertainty. Novel genes are inserted randomly into the genome of the host organisms, and this leads to the possibility of unexpected effects. Unanticipated environmental disasters, such as the concentration of persistent organic pollutants in ecosystems at high latitudes, have highlighted the need for monitoring despite the obvious difficulties inherent in monitoring for unexpected effects.

Monitoring as a Legal Requirement

The regulation of the experimental and commercial release of GMOs is covered in the European Union by Directive 90/220/EEC. This is currently undergoing revision, and the revised Directive will require anyone seeking consent to market a GM crop or food to produce and carry out a 'post marketing' monitoring plan. At present, it is proposed that monitoring will be used as a means of evaluating assumptions made in the risk assessment, and also to identify unanticipated effects as they occur. The second objective poses a serious challenge to both the developers and the regulators of GM crops and foods, begging the question of whether it is possible to establish monitoring systems to look for unanticipated effects.

There are currently twenty applications for consent to market GMOs in the European Union, only a small number of which have actually gained consent. But as more GMOs are released into the environment, the question of how to monitor for adverse effects and what resources this requires will become pressing. The range of organisms that can be modified and genes that can be inserted, combined with the difficulty of predicting what might happen, means that monitoring of GM crops must be clearly defined. The purpose of any monitoring must be to act as an early warning system for adverse effects, and as a basis for action rather than an end in itself.

Monitoring at Present

It is stated in the proposed revision to Directive 90/220/EEC that "experience and data gained through the monitoring experience of experimental releases of GMOs may assist in designing the post market monitoring regime"(1). However, an examination of the current procedure used for monitoring experimental releases shows that there is unlikely to be much data of use for post market monitoring. Oilseed rape *(Brassica napus)* has been shown to be capable of cross breeding with several species of wild and cultivated plant found growing in the UK(1). In particular, wild turnip *(Brassica rapa)* and feral oilseed rape are commonly found growing in, or adjacent to, oilseed rape fields and gene transfer occurs relatively easily. As a result, the risk of gene transfer from GM oilseed rape is significantly higher than for other crops, such as maize, which have no wild relatives in the UK. Despite this, the Government's Advisory Committee on Releases to the Environment (ACRE) has not made monitoring for such events a prerequisite for consent to conduct GM trials. In fact, consent holders have only been required to monitor for GM events occurring in following years, while monitoring for gene flow has been entirely at their discretion.

In the case of GM oilseed rape test sites, the majority of monitoring reports submitted to ACRE read like agronomic studies with detailed provision of information about the growth, development and pest infestations of the crop, but with little to indicate that potential environmental impacts were routinely monitored for. Typical comments from these reports are that *"The agronomic performance of the lines was satisfactory"* or that *"the transformed crop did not look any different to the non-transformed crops."* Out of 25 monitoring reports for GM oilseed rape releases held on the public register at the beginning of 1999, only one consent holder mentioned undertaking botanical monitoring around the release site. And only this consent-holder mentioned removing plant species related to oilseed rape from the vicinity of the trial site. If monitoring programmes for GM crops given commercial marketing consent are to based on experience gained from monitoring around test sites, then the quality and range of this monitoring must improve significantly.

Test sites cover a tiny area in comparison with the area that would need to be monitored if GM crops start being grown on a commercial basis, and to undertake such monitoring on more than a limited scale will require considerable resources. Although the legal responsibility for monitoring plans is likely to fall upon those developing GM crops, at the very least the regulatory authorities will have to authenticate and audit them. However, at present the Health and Safety Executive does not even have the resources to inspect all of the GM test sites for compliance with consent conditions, a simple task when compared to overseeing monitoring programmes.

The Difficulties of Monitoring GMOs

It is suggested in the revision of Directive 90/220 that monitoring programmes should be developed on a case by case basis. But effective monitoring will have to take into account the possible interactions of the increasing range of crops that are being modified and the variety of novel genes that are being inserted. Returning to the example of monitoring for gene flow from a GM crop, the increasing number of genes being inserted will inevitably complicate the task. In particular, certain crops are being modified for a range of traits. In the UK, trials have been conducted of GM oilseed rape varieties that have been modified for tolerance to three different herbicides, for altered oil composition, reduced seedpod shattering, and reduced disease susceptibility. So far, the few monitoring programmes that have been conducted have concentrated on herbicide tolerance, a fairly straightforward trait to screen for, but traits such as disease resistance or reduced pod shattering are not so easy and it may be that the only suitable screening technique will be DNA analysis. This is a costly and time-consuming procedure at present. Finally, compatible plant populations are likely to be exposed to pollen from more than one GM variety of a crop, further complicating monitoring requirements.

Similar difficulties are likely to be faced in attempts to monitor for other impacts. For example, a recent laboratory study by Cornell University found that pollen from maize modified to express a toxin from the bacterium *Bacillus thuringiensis* (Bt) slowed the development and increased the mortality of the larvae of the Monarch butterfly. The Monarch larvae feed on milkweed, a plant commonly found growing adjacent to maize fields in the United States. The study highlights the potential of GM crops to affect organisms other than the pests that they are designed to target. Similar research into 'Bt' maize has indicated that there may be impacts on beneficial insects or invertebrates involved in the decomposition of plant material in soil.

Crop plants are host to a range of pest, beneficial and neutral organisms ranging from the more obvious, such as the

Monarch, to the virtually unknown, such as the micro-organisms which occupy the surface of leaves and roots. Some of these will be more economically important or ecologically vulnerable than others and many of them are poorly understood. It will not be possible to monitor every organism that comes into contact with all the different GM crops that are being developed. Instead, it may be necessary to establish indicator species to be monitored in each region that GM crops are released. However, as more crops are released, it will become progressively more difficult to establish which crop is causing changes that are observed.

Monitoring for health effects on humans looks likely to be an equally complex task. To produce any meaningful results, it will be necessary to establish population groups with varying levels of exposure and then to establish that differences in health indicators are due to the consumption of GM foods. GM products have the potential to be found in a wide range of foods, for example soya is found in 60 per cent of processed foods, and so exposure to GM soya could come from consumption of a range of products. It will be necessary therefore to establish extremely detailed information about purchasing behaviour in order to determine the level of exposure individuals or groups receive. The UK government's Advisory Committee on Novel Foods and Processes (ACNFP) has been considering methods of undertaking such monitoring since 1998, such as using market survey data to establish consumption patterns. However, there are problems with this, such as how representative these data may be and whether it would cover a large enough section of the population to provide meaningful results. In addition, such data only provide brand information and so for the scheme to be successful, manufacturers would have to co-operate and provide accurate information about which GM products were included in their brands. It is proposed that monitoring of food consumption patterns could be correlated with systems already in place which routinely monitor health events such as cancer, congenital anomalies, still births and birth weights.

A basic problem facing this proposal is that confounding factors such as socio-economic status or the local environment strongly affect health. Although statistical analysis can to some extent account for these, it will still be extremely difficult to relate health events to consumption of specific GM products and show that one is the cause of the other. As the proposal stresses, this is a *"notoriously difficult and complex"* task. The potential for long time lags between exposure and health impacts adds to the difficulty. The paper presented to the ACNFP concludes that the main value of such a system would be that it *"could be rapidly interrogated if some potential health effect came to light, or if some cluster of health events were thought to reflect exposure to novel foods"*(1). In other words, due to the inherent difficulties, a system for monitoring the health impacts of the consumption of GM foods would quite possibly only serve to provide corroboration for health effects which had become apparent by other means.

Some Requirements for Future Monitoring

For the proposed monitoring plans to be of any value, they must be based on a better understanding of the potential risks of GM crops and foods. To start with, a broader scope needs to be given to the risk assessments presented in applications for marketing consent. This will at least provide monitoring programmes with a better starting point. In the case of 'Bt' maize, the laboratory research that highlighted potential adverse effects was undertaken after the GM crop was given consent for marketing in the European Union. It is essential for the protection of the environment that this scenario is not repeated. Companies wishing to introduce GM crops must be more open with their own research and examine more avenues for potential impacts of their crop before it is marketed.

The possible adverse affects of GM crops may take years to become apparent. For example, the transfer of genes from GM crops to natural plant populations will probably take several years, and any resulting changes in natural populations are unlikely to be immediately apparent. In the UK, populations of birds such as the skylark and hedge sparrow have declined in conventional crop farming areas. These declines took decades to become apparent and the exact causes are still a matter of contention. In the case of human health effects, it is quite possible that exposure of foetuses and neonates could lead to health impacts later in life. Based on previous experience and the likely time scale of effects, any monitoring programmes for GM crops that are put into place will have to be maintained for years, if not decades.

It is essential that monitoring programmes do not examine environmental or health impacts in isolation. The patterns of uptake of GM crops by farmers, or of consumption of GM foods will determine where effects are likely to become apparent. Monitoring of the use and consumption of GMOs can be used to determine which species, habitats or groups of the population are especially vulnerable. For example, data showing a high relative consumption of GM foods by certain sectors of the population would allow health monitoring to be strategically employed. Another facet is the necessity to track the changes in agricultural practice and food consumption patterns that are bound to occur regardless of whether GM crops are introduced. Existing monitoring schemes, such as the Countryside Survey, will be invaluable as baselines against which to measure change.

Finally, it must be accepted that monitoring of GM crops and foods will not guarantee their safety, or even that adverse effects will be detected before harm is done. With such a range of GM crops and foods being developed, it is inevitable that exposure will come from diffuse and diverse sources. Even if an adverse effect on health or the environment is detected by a monitoring scheme, establishing its cause or relating it back to a specific GMO is unlikely to be a simple or speedy process. As is highlighted by the Government proposals to monitor for health effects, monitoring will not necessarily prevent serious impacts, and may achieve no more than providing confirmation of an event after it has occurred.

Conclusion

GM crops and foods are highly controversial, and considered by many to pose a serious threat to human health and the environment. It is essential that any

monitoring undertaken is fully resourced, and that it is used as a basis for decision-making and action, rather than as a fig leaf to cover inaction. There must also be acceptance by the developers of GMOs, the public and regulators that monitoring in no way ensures prevention of harm from the release of GM crops and food. The difficulties posed by the monitoring GM crops and foods, combined with the poor understanding of what the results might actually mean, provide a good argument for taking a precautionary approach. It is by no means clear that at present effective monitoring is even possible, and the question must be whether it is appropriate to release GMOs into the environment and our food chain in the first place.

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Environmental Monitoring of Genetically Modified Crops

Summary

Genetically modified (GM) crops are now approved for commercial use in several world areas. In terms of commercial acreage, the majority of these products possess either herbicide tolerance or insect protection traits. Prior to commercialization, each product underwent a country specific review of environmental safety data by independent regulatory authorities. Registration was granted after a review of the data allowed authorities to conclude that the risks were minimal or manageable when balanced with the benefits. As a condition of registration, insect resistance management (IRM) has been imposed for insect protected products in most countries. Other world areas have reviewed similar data packages and have not yet been able to grant registration for commercial release. Post-registration environmental monitoring of GM crops is viewed in some world areas as a means of enabling approvals by addressing uncertainty that exists with this technology. Questions such as, who should monitor and who should pay for it, how should monitoring be conducted, what information is necessary to collect and how long should a given product be monitored are yet to be answered. Monitoring methods could be general (surveys and questionnaires) or specific (scientific studies to address specific questions). Independent research currently underway in countries where GM crops are commercial involves monitoring the benefits as well as the risks of these products. Experience with other products has shown that monitoring of GM crops will be of value only if the questions are clearly defined, the methods are appropriate and the endpoints (data collected) are interpretable.

Introduction

Currently, GM crops of agricultural significance are fully approved for commercial use in only a few countries. By far, the greatest number of GM crops offered for commercial use have been registered (received regulatory approval) in the United States and Canada. Approximately 70% of the acreage of the GM crops grown in 1999 were produced in North America.[1] Monsanto has been one of the leading companies involved in the commercialization of GM crops; offering several Roundup Ready (registered trademark) herbicide tolerant products, and insect protected products that express a protein from the well-known bacterium *Bacillus thuringiensis* (Bt). A summary of GM crops currently being produced can be found from reference 2. More exhaustive surveys of commercially available products derived through biotechnology are available.[1]

Prior to commercialization, all GM crops undergo extensive food, feed and environmental safety evaluations that are a key step in the regulatory approval process. The results and conclusions of these assessments are reviewed by regulatory officials with the responsibility to ensure safety according country or region specific legislation.[3] No comparable regulatory requirement of thorough safety evaluation exists for new crop products or varieties derived through traditional breeding anywhere in the world except in Canada. Scientific experts have developed the data requirements for GM crops. Specific to environmental safety, independent organizations such as the Organization for Economic Cooperative Development (OECD)[4] have developed a data framework, which has been critically reviewed by others.[5]

A significant concern to all stakeholders in biotechnology is the lack of harmony that currently exists around the world in the development and application of regulatory decision processes. This lack of harmony is illustrated in the approval processes in North America compared with the EU. An important difference is the way these regions view risks and benefits of GM crops in relationship to the scientific uncertainty that accompanies the novelty of biotechnology. Post-registration environmental monitoring has been proposed as a means to move the approval process forward and address uncertainty that exists with these products.[6] Experience in agricultural systems has shown that environmental monitoring is an accepted practice that can provide information applicable to risk management. Monitoring results are difficult, if not impossible, to interpret if the monitoring is not science-based.[7] Useful monitoring depends on several

factors: the nature of the question being addressed, the methods used and the ecological significance of the data that are collected, also termed the endpoint.[7] Decisions concerning post-registration environmental monitoring of GM crops must be based on the information provided in the risk assessment. Integrated appropriately with product development, research and public policy, appropriate post-registration monitoring can provide important information to better understand and address significant ecological changes in agricultural systems.

The three aims of this paper are: (1) provide an overview of the ecological assessment framework used by Monsanto's scientists to obtain regulatory approval of its GM crops prior to commercialization, (2) briefly discuss the decision process for post-registration monitoring of GM crops, and (3) discuss some recent data in the scientific literature in the context of monitoring GM crops.

Ecological Risk Assessment Summary

Ecological risk assessment is a science-based process whereby the potential for an ecological hazard to occur is assessed. To be effective, the information and data obtained during this process must enable regulators to make a decision concerning the registerability (approvability) of a product. The process involves characterization of the potential hazard (harm that could result) and the potential for this harm to occur (exposure assessment) (Figure 1). Science-based characterization of risk has two possible outcomes: minimal risk or acceptable risk with appropriate risk management.

Ecological hazard can be broadly defined as a condition that results in ecological instability. For GM crops such as Monsanto's Roundup Ready and Bt products, the ecological risk assessment framework focused on assessing the plant pest potential according to the United States Department of Agriculture, Animal and Plant Health Inspection Service (USDA-APHIS) guidance.[8,9] Four general classifications for ecological harm and potential exposure were assessed as shown in Figure 1.

Figure 1. Ecological Risk Assessment Framework for Bt and Roundup Ready Crops.

Risk = Hazard x Probability of Occurrence (Exposure)

Hazard Characterization	**Data**	**Exposure Routes**	**Data**
Genetic instability	Molecular analysis, efficacy and protein expression	Pollen movement	Outcrossing studies (where relevant) and breeding data
Invasiveness (weediness)	Extensive agronomic and field data including growth, morphology, and yield	Seed dispersal	Biology of crop, morphological data
		Presence of wild relatives	Biogeographical analysis
Non-target effects	Toxicity tests, compositional analyses, bird and fish studies (8 additional lab. tests for Bt crops)	Protein expression	ELISA and/or western blots
Altered interactions with insects and microorganisms	Multi-site field data (baseline resistance data for Bt crops)		

Ecological instability could result if the GM plant were genetically unstable or possessed increased weediness properties as a result of the transformation procedure, the source of the new DNA and the phenotype conferred. Other harmful impacts include negatively affecting non-target organisms or altered interactions with insects or microorganisms. Each potential hazard was scientifically assessed in multiple field and/or laboratory experiments and observations recorded by cooperators conducting field trials (Figure 1). The toxic potential of each protein introduced is a specific potential harm that has been evaluated in mice as well as in feeding studies in quail and fish. Because of the pesticidal properties of the Bt proteins, additional toxicity tests were conducted using purified proteins at levels well above the potential exposures that would be encountered in the field. Table 1 summarizes the toxicity evaluations conducted on the Bt proteins in Monsanto's GM crops.

Table 1. *Additional Toxicity/Feeding Testing of Bt Proteins*
(in addition to mouse, quail and fish tests for all products).

Honey bees	Larvae Adults
Beneficial Insects	Ladybird beetle adult Parasitic wasp adult Green lacewing larvae
Soil Organisms	Earthworms Collembola
Aquatic Animals	Daphnia magna

Having the potential to result in harm (potential hazard in Figure 1) is insufficient to conclude that a risk from a GM crop is unacceptable. Exposure to the hazard agent (the component of the GM plant that presents the potential for harm) is required to result in a risk. An assessment of exposure routes is completed for every GM crop (Figure 1). Pollen movement and the ability to successfully fertilize a compatible plant, seed dispersal, the presence of wild relatives in the regions where the GM plant will be introduced as well as an evaluation of the levels of the introduced proteins in pertinent tissues were conducted for each product unless it were deemed irrelevant (e.g. seed dispersal from Bt potatoes).

Approval decisions are based on an assessment of the potential environmental impact of the GM product compared with its traditional counterpart. A critical aspect of the ecological risk assessment process is gaining agreement about the range of acceptable variation between the GM crop and the control.[10] Each data package included information about the basic biology of the crop in order to establish an accepted range. Invasiveness, pollen flow, seed dispersal data and observations on insect and microbial interactions for the GM crop from field trials were analyzed in the context of the appropriate comparisons with the conventional crop. Numerous parameters were evaluated in comparison to the non-modified counterpart including emergence, growth rate, morphology, yield potential, Mendelian inheritance and susceptibility to insects and pathogens (where applicable). Depending on the biology of the crop and its inherent potential weediness, other data may have been collected such as dormancy and volunteer counts for GM canola (*Brassica napus* subsp. *oleifera*) compared to traditional canola. Each assessment considered the potential for gene flow, its consequence, as well as the impact to non-target organisms. Data were collected over multiple years in field trials representative of commercial production.

Environmental safety data for each GM crop were independently reviewed and approvals had to be obtained prior to commercialization. The potential benefits of the GM crop are either directly or indirectly factored into the approval decision. All GM crops undergo USDA-APHIS review[9] in the U.S. Products that express Bt proteins are also evaluated according to the US EPA proposed rules.[11] The USDA and EPA have different legislative responsibilities and data requirements for GM crops. Both agencies have reviewed the data submitted for each GM crop product in the U.S. and based their approvals on these data. References to the reviews completed by the USDA and EPA have been included below. Likewise, data supporting the environmental safety of a product in a specific region were submitted and reviewed by authorities in each country in which our products have been approved. For example, the Canadian Food Inspection Agency (formerly Agriculture Canada) and CONABIA in Argentina, reviewed data specific for the GM crop of interest in their country.

The environmental safety regulatory reviews completed and approved around the world have resulted in conclusions of minimal risk for Roundup Ready products and Bt products provided an insect resistance management (IRM) plan is approved and implemented for the latter.[12-20] The first approvals of herbicide tolerant products have no post-registration monitoring requirements unlike insect protected products (Bt crops) where IRM is usually required. It has been argued that IRM should not be a regulatory responsibility since resistance development to Bt in an agricultural pest is not viewed as an ecologically significant hazard. Resistance may be better characterized as a product stewardship concern since it could significantly affect product efficacy. In order to best steward Bt technology, an industry-wide effort in corn exists to develop, implement and assure IRM plans in the US are effective and that growers are complying. In the US, the IRM strategies for other crops continue to be evaluated by industry and by the EPA.

Post Registration Environmental Monitoring

Ideally, a decision to require monitoring is based on the scientific information provided in the risk assessment. Where a conclusion of minimal risk is made based on scientific data, no monitoring should be required. In some world areas, GM crops are associated with greater uncertainty, which is affecting the regulatory decision process. From a scientific perspective, uncertainty may be due to data gaps that affect the characterization of risks and benefits, variability, methodology used, or the significance of an endpoint.[21] Social and political factors also affect the perception of risk which in turn impact regulatory decisions. Since risk is culturally dependent, perceptions of risk will affect decisions which ultimately will be based on a balance between science and societal values.

Because of the degree of uncertainty surrounding the risks and the potential benefits from GM crops, some world areas have proposed post registration monitoring as a requirement of registration.[6] The specific requirements will be based on the technical nature of the product and the perceived ecological risks. Significant questions remain to be answered regarding how will monitoring be conducted and what information must be collected, as well as who will do it and who will pay for it.

Post registration environmental monitoring methods for GM crops can be general or specific. General monitoring, or surveillance, is broadly designed to assess trends and opinions associated with a specific product. Information could be collect over a prescribed period of time through surveys administered by agricultural professionals familiar with the potential risks and benefits associated with the GM crop. Economic surveys conducted by the USDA Economic Research Service are a good example of general monitoring. General monitoring is a way of "range-finding" or better defining the nature of a perceived risk and benefit. Specific monitoring is detailed science-based monitoring following a protocol with specific interpretable endpoints used to address well-defined questions. Specific monitoring protocols are designed by scientific experts based on a clear hypothesis. Follow-up action may be required depending on the question being addressed and the results of specific monitoring.

Another important concern, particularly in Europe, is the need for third party involvement in the collection of monitoring data. Finding an available third party possessing the appropriate skills and scientifically credibility is critically important and often complicated.

Ecological Risk Issues for GM Crops

Much debate has centered around gene movement from GM crops (outcrossing) and the potential impact of these products on non-target organisms. A brief discussion of these issues in light of recent scientific publications is presented here in the context of post market environmental monitoring.

Outcrossing is defined here as the movement of transgenes from the GM crop into a compatible relative, which may be a weed, or the crop itself. Crops and weedy relatives have been exchanging genes in the environment throughout the history of agriculture.[22] Research that has been conducted to date on genetically modified crops has shown that the new traits are transferred exactly as other genes in the plants genome.[23,24] Genes from modified crops are transferred to their sexually compatible relatives with the same frequency as any other gene in the plant. In a series of experiments, Joergensen[24,25] demonstrated transfer of a transgene from B. napus to its compatible relative *B. rapa* (a.k.a. *B. campestris)* under field conditions. Snow *et al.* subsequently demonstrated that the novel trait conferred no advantage or loss in fitness to the weed in the absence of the herbicide.[26] Regardless of the source of the gene and the manner in which it was introduced into the plant, in this case, the data show that there is no significant safety consequence resulting from outcrossing. It is highly probable that any potential problems associated with this weedy relative will only be detected in an agroecosystem utilizing the specific herbicide (glufosinate). Since the scientific evidence indicates that there is no ecological significance associated with outcrossing from this product, monitoring weedy populations for this particular trait would be of little value except possibly to the company that markets the herbicide.

'Volunteer canola' is a weed in subsequent small grain crops or fallow wherever it is grown. In granting approvals for both Roundup Ready and Liberty Link canola products, the Canadian and U.S. regulatory authorities acknowledged that outcrossing was likely to occur between canola fields. Their decision documents noted that this would be significant only in agricultural systems, and were not of broad ecological impact. Downey[27] recently investigated a report of outcrossing between large fields in Alberta, Canada where a grower had done a side-by-side comparison of Roundup Ready with another canola variety. After applying Roundup to the adjacent field, tolerant volunteer canola was detected out to 100 m from the GM canola. Downey's study focused on measuring the distance of successful outcrossing and the consequence of this gene flow. His research showed that the putative hybrid plants were readily managed using accepted practices. At the site where the highest level of volunteers were found (in the Roundup Ready canola field), there were no problems in the subsequent rotation because accepted volunteer management was used. Thus, the consequence of outcrossing of a herbicide tolerance trait was readily managed in the agroecosystem. In this case, the post registration monitoring of outcrossing is a matter of product stewardship.

Non-target effects: Field based research completed around the time that Bt crops were undergoing regulatory approval established that there was no impact to the levels of key non-target insects.[28-30] These studies showed that there were no differences in the levels of selected beneficial insects compare to a crop grown without the use of insecticide. Two recent publications described non-target effects of Bt proteins in corn. The first report[31] cited effects on lacewings *(Chrysoperla carnea* (Neuroptera: Chrysopidae)) which were seemingly inconsistent with the field data.[28] The second reference[32] concluded that pollen from Bt corn was potentially harmful to monarch larvae (Danaus flexippus). Scientific responses to both publications commonly noted that these laboratory-based studies were not representative of field conditions.

Laboratory experiments with GM crops have great value if they are interpreted appropriately. A comparative risk assessment for a GM crop requires that the potential for harm be placed in the context of the system in which it will be used. The risks to non-target organisms present from using less selective insecticides and other relevant facts should be factored into the risk equation. As such, using laboratory based experiments to guide decisions concerning monitoring the potential non-target effects of GM crops requires consideration of all the factors that may be influential in a field.

Independent surveillance of GM crop performance is now being published. Since the introduction of Bt Cotton, growers have reduced pesticide applications (number of times a grower goes into a field to apply an insecticide) by approximately 60% to control insects

of the bollworm complex. Data from the USDA[33] has shown that growers went from 4 to 5 applications of pesticides to an average of 1.7 in 1995 and 1996 because of the introduction of Bollgard cotton. These findings have been further supported by a recent publication from China[34] citing: "Compared with the conventional cotton, the usage of insecticide in Bt cotton was decreased by 60%~80%, and number of predators increased by 24.0%, bringing about great economical, social and ecological profits."

Conclusion

Many countries have reviewed risk assessment data for GM crops and granted regulatory approvals for their commercial release into the environment. While Bt crops are usually required to have IRM plans as a condition of registration, there is no world-wide consensus regarding post-registration monitoring of GM crops. The risk assessments completed to date on the GM crops that are commercial have resulted in conclusions of minimal risk. In some areas, enough uncertainty concerning the risks and benefits remains such that approvals are not being granted. Post-registration monitoring is being proposed as a means to address this uncertainty and allowing the careful introduction of GM crops into these markets. Post-registration monitoring could play a valuable if it is conducted appropriately using defined questions and interpretable endpoints. General monitoring or surveillance using surveys could be useful as a range finding technique to obtain more information concerning risks and benefits. Specific monitoring where science-based protocols designed to answer specific questions with clearly defined endpoints may be necessary if the risk assessment indicates. In other areas of the world, a balance seems to have been struck between these same risks and benefits. Scientists are documenting positive impacts to the agricultural systems in which GM crops have been introduced. As such, growers in these areas are enhancing their ability to produce crops in an environmentally better way.

Acknowledgements

We are indebted to Drs. Michael McKee, Michael Horak and Roy Fuchs for their review and comments.

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Web sites:

Genetically Modified Plants: Benefits and Risks: a Web site from the Tata Energy Research Institute, New Delhi http://www.teriin.org/discuss/biotech/benefits.htm

Monsanto: http://www.monsanto.co.uk

Friends of the Earth: http://www.foe.co.uk/index.html

The Federation of European Chemical Societies (FECS) and Environmental Chemistry

JOHN HOLDER, a Committee Member of the Environmental Chemistry Group, reports on the current activities of the FECS Division for Chemistry and the Environment of which he is Secretary.

The Committee met in Bordeaux on Saturday 30th October 1999 following the 17th International Symposium on Polycyclic Aromatic Compounds,* which had been attended by 280 delegates (including many of the FECS Committee) from 35 countries world-wide.

A major theme of the FECS Committee meeting was Green Chemistry. Professor Pietro Tundo, Director of the Italian Inter University Consortium, Chemistry for the Environment (INCA) and Mike Lancaster from the UK Green Chemistry Network made presentations.

Founded in 1993, INCA now has 30 participating universities, and has instigated its own annual Green Chemistry Awards. Much research is promoted, and laboratories have been established in Venice and Catania. Further laboratories in Naples and Turin are planned. Two summer schools on Green Chemistry have been organised. This year's was held in September with 60 postgraduate students and 15 teachers from around the world participating. INCA co-operates with the OECD Sustainable Chemistry Committee and with IUPAC. In July 2001 a conference is planned for Colorado, USA. Further

information on the laboratories, the Consortium, the summer schools on green chemistry, and the OECD Sustainable Chemistry workshop proceedings may be found on the Consortium's Web site at http://www.unive.it/inca.

Funded by the Royal Society of Chemistry and based at the University of York, the Green Chemistry Network (GCN) focuses on developing chemicals and chemical processes which do not cause harm to the environment. A Green Chemistry Conference will be held 3-6 April 2001 in Swansea. Other initiatives of the GCN are the Green Chemistry Journal, and the UK Green Chemistry awards, to be made to industry and to young academics in the UK in 2000. The GCN Web site is: www.chemsoc.org/networks/gcn.

Wolfram Koch was to have given a talk on Sustainable Chemistry in Germany ('Green Chemistry' is an unacceptable term to German industry and the chemical community because of possible associations in the mind of the public with the Green Party) but was unfortunately unable to attend.

Allan Astrup Jensen, the Division Chairman, updated members on progress with the European Green and Sustainable Chemistry Awards. The planning group has met three times. Funding is anticipated from DG11 and the European Environment Agency and a meeting is to be held with the Commission in Brussels in November-December 1999. It is hoped to make the first awards at the 7th FECS International Conference on Chemistry in the Environment to be held in Porto August 27-30th 2000.

The FECS Green and Sustainable Chemistry Committee will be responsible for the evaluation of the proposals. Pietro Tundo and Mike Lancaster were invited to be members and accepted. Present members are Allan Astrup Jensen, Denmark (Chair); Sirpa Herve, Finland; Maria Teresa Vasconcelos, Portugal; Ramon Mestres, Spain; Philippe Garrigues, France; Wilhelm Höfflinger, Austria; Wolfkram Koch, Germany, and members from the industry will also be invited to join.

An editorial, 'The Greening of Chemistry – Is it Sustainable?' by Otto Hutzinger appeared in *Environmental Science and Pollution Research*, 1999, **6**(3), 123. Members agreed that 'Greening' gave a better impression of an ongoing process than 'Green', and this term was also thought to be acceptable to Germany. A further editorial on the subject with contributions from members of the Committee was planned.

The Second Announcement and Call for Papers for the Porto FECS Conference on 'Metal Speciation in the Aquatic Environment' was approved. Further information may be obtained on http://www.geocities.com/capecanaveral/lab/8007/fecs2000.htm or by emailing: fecs-conf@fc.up.pt.

The Eighth FECS International Conference will be a broad based environmental conference held in Athens in early September 2002. Details will appear in due course on the Division Web site (new address http:www.scientificjournals.com/espr/fecs). Extended abstracts for the 7th conference will also be published there. A bulletin board has been established for rapid information exchange on forthcoming conferences etc. Ecomed, publisher of *Environmental Science and Pollution Research*, and host of the Web site has introduced a new electronic journal 'Environmental and Health Science' and 'Online-First' a service to allow immediate publication of accepted articles.

The Division has established sub-groups on Education (Chair - Uri Zoller, Israel) and Atmospheric Chemistry and Air Pollution (Chair - Hartmut Frank, Germany).

Membership of the Division Committee has now increased to thirty-two members from twenty-nine countries (Spain, Switzerland and Gemany having two members each representing separate chemical societies). Allan Astrup Jensen was re-elected unanimously to serve for a second three-year term as Chairman.

The next meeting of the Committee will take place in Burlington House, London on 4th March 2000. FECS members will be invited to attend the RSC's Environmental Chemistry Group Distinguished Guest Lecture on 1st March.

Copies of the full minutes are available on request from j.v.holder@uclan.ac.uk.

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University of Central Lancashire
December 1999

* The Symposium on Polycyclic Aromatic Compounds was held in the Palais des Congres, Bordeaux Lac. It was organised under the auspices of the International Society for Polyaromatic Compounds (ISPAC) and CNRS by the University of Bordeaux, Laboratoire de Physico-toxico Chemie des Systemes Naturels. Proceedings will be published in a special edition of the journal Polyaromatic Compounds (PAC). More information can be found at: www.scientificjournals.com/espr/fecs under conferences. The ISPAC URL is: http://ispac.tor.ec.gc.ca/

Environmental Information from the RSC

The Royal Society of Chemistry (RSC) is the UK's largest and most influential body serving the needs of professional chemists and chemistry in general. The RSC's Library and Information Centre (LIC) can trace its lineage back to the inauguration of the Chemical Society and its library in 1841. The Library and latterly the LIC have a long history of providing information to chemists in the UK and world-wide. The LIC possesses the largest collection of publications and resources specifically devoted to chemistry related matters in the UK.

The LIC's Chemical Industry Enquiry Service (CIES) regularly answers over 150 technical and commercial enquiries a month, and the majority of these are from members of the RSC. Recent queries related to environmental chemistry have included:

- the toxicity of PCMX (p-chloro-m-xylenol), which is used as a preservative;
- handling chemicals in an industrial environment;
- environmental information on ammonium nitrate fertiliser;
- health and safety data for chlorofluorocarbons.

Environmental chemistry is well served by the range of journals, books and CD-ROMs available at the LIC. Journal titles pertaining to the environment and environmental chemistry include:

- Bulletin of Environmental Contamination and Toxicology
- Chemical Hazards in Industry
- The Ends Report
- Environmental Toxicology and Chemistry
- Journal of Environmental Monitoring
- Journal of Hazardous Materials
- Journal of Toxicology and Environmental Health

The LIC holds over 20,000 monographs, many of which are relevant to environmental chemistry. Some of the more important of these are:

- IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans
- ECETOC Technical Reports

  Patty's Industrial Hygiene and Toxicology, 3rd edition
- Environmental Health Criteria Series (published by the World Health Organisation)

The RSC produces a number of journals and books on the environment, for example Green Chemistry, the Journal of Environmental Monitoring, and Issues in Environmental Science and Technology. These journals are available both in hard copy and in an electronic format.

Of the LIC's twenty-three CD-ROMs currently networked, a number are particularly useful for obtaining environmental data and information:

- CHEM-BANK
  This CD-ROM contains databanks of potentially hazardous chemicals including HSDB (Hazardous Substances Databank); RTECS (Registry of Toxic Effects of Chemical Substances); Chemical Hazard Response Information System (CHRIS); and Integrated Risk Information System (IRIS).
- Croner's Environmental Management & Environmental Case Law and Substances Hazardous to the Environment
- DOSE (Dictionary of Substances and their Effects)
  The 2nd edition of DOSE was recently published by the RSC, and an online version is now available.
- Environmental Chemistry, Health and Safety (published by the RSC)
- OSH-ROM
  This collection of databases includes HSELINE and NIOSHTIC

LIC staff are currently evaluating a CD-ROM – EINECS Plus – which contains the complete EINECS (European inventory of existing commercial chemical substances), and the most up to date version of ELINCS (European list of notified chemical substances).

As well as its enquiry service, the LIC offers a document delivery service (photocopies and loans) from over 2000 journal titles (of which 700 are for current subscriptions).

The services of the LIC are available to corporate members as well as individual members of the Royal Society of Chemistry. If you would like further information, then please contact:

Mr. Ron Hudson, Library and Information Centre, Royal Society of Chemistry, Burlington House, Piccadilly, London W1V 0BN UK
Tel: +44 (0)20 7437 8656
Fax: +44 (0)20 7287 9798
Email: library@rsc.org

UK Green Chemistry Awards

UK Green Chemistry Awards for both industrial and academic research projects have recently been announced. These awards, sponsored by the Royal Society of Chemistry, the Salters Company, the Jerwood Charitable foundation, and two government departments, the DTI and the DETR, will be administered by the Green Chemistry Network at the University of York.

There will be three annual awards for Green Chemistry Technology. These will be offered for 'significant improvements in chemical processes, products and services through research and commercial exploitation of novel chemistry, so to achieve a more sustainable, cleaner and healthier environment, as well as creating competitive advantage.' The three awards are:

- the Jerwood-Salters Environment Award, an academic award of £10,000 to a young academic who is also preferably working with industry;
- two awards to UK companies (at least one of which should be an SME) for technology, products or services.

Nominations and applications for these awards must be sent to the Green Chemistry Network no later than 31 March 2000. For further details contact **Mike Lancaster** ml13@york.ac.uk or tel 01904 434549

News of the RSC's Environment, Health and Safety Committee

BOB HAZELL, Secretary of the Society's Environment, Health and Safety Committee (EHSC), reports on the EHSC's activities over the past few months.

Health and Safety Legislation Review

The EHSC responded on the Society's behalf to a major consultation by the Health and Safety Commission (HSC) entitled 'Revitalising Health and Safety'. This consultation reviewed health and safety law and its implementation after 25 years of the Health and Safety at Work Act (HSWA). The Society agreed that the review was sensible and suggested the HSC might consider introducing similar but more regular reviews, perhaps every 10 years. The HSWA remains a good framework for the control of occupational health and safety. Although in some cases it may seem difficult to determine where responsibility for workplace health and safety lies, the guiding principle should be 'control = responsibility' and this should be spelt out more clearly. In their reply, the EHSC felt that the emphasis should move away from further legislation towards more and better enforcement and that the Health and Safety Executive (HSE) should extend its role in providing advice. The EHSC's submissions drew attention to the potential conflicts between health and safety, and environmental risks and suggested that they were likely to be an area of increasing concern. Better methodologies for integrated environment, health and safety risk assessment are needed and there is undoubtedly scope for the HSE to work with professional bodies in this area. The EHSC is currently working on its response to a related consultation entitled 'Reducing Risks, Protecting People.'

EHSC Note on Working in a Laboratory Alone

The EHSC has issued an 'EHSC Note' on lone working in laboratory and allied work areas. The Note pointed out that although there is no specific legislation on lone working, it is covered by the general requirements of the Health and Safety at Work etc. Act 1974 and the 'Management Regulations' made under the Act. After offering useful practical advice on minimising the risks involved, the Note concluded that lone working should only be carried out when there are no reasonably practicable alternatives. Even then it should be kept to a minimum and should only be carried out by fully trained and competent personnel working to clearly defined procedures, and that these procedures must be audited periodically to ensure that they are used and remain effective.

Dealing with Waste

The EHSC responded on the Society's behalf to the DETR consultation 'A Way with Waste.' The EHSC felt this was a considerable improvement on previous consultation papers in this area and welcomed the fact that many of the problems now seemed to be recognised. However, although the document represented a move in the right direction, its logic had been distorted by political considerations and that cost implications were largely ignored. Many of the proposed solutions appeared simplistic and based on unscientific appraisals. Overall the document was good at setting targets (indeed it was liberally sprinkled with them). However, the submission pointed out that targets do not themselves constitute a strategy. The 'action plan' put forward in the document to achieve the visionary targets seemed less a plan of action than a reiteration of what had already been done, often with relatively little effect. The document exhorted other participants to 'do something', but without realistic action plans or detailed description of policies to be implemented. Overall the EHSC concluded that the consultation looked like an exercise in which a rudimentary analysis that 'something must be done' had led to the establishment of arbitrary targets with little or no rational basis and with little thinking as to how these targets might be achieved. The only method that might deliver the targets – and even then the proposed time scales were probably unrealistic – was by waste reduction. However, the consultation appeared to dismiss this for end of life products and to miss the most important point. This is that products may need to be completely re-thought to avoid end of life waste production, not just in terms of design for disassembly and recycling, but more fundamentally in terms of full cost accounting procedures, life cycle assessments, and service versus sales activities. Overall it was felt that DETR must accept that fundamental changes in resource use are likely to be required to reach the targets thought to be desirable. Mere tinkering around the edges of the waste hierarchy will be insufficient.

Proposed Changes to the CHIP Regulations - CHIP 99

The EHSC responded on the Society's behalf to an HSC consultation on 'CHIP 99.' CHIP is an important component in making many risk assessments and the committee was particularly interested by the invitation to submit views on 'CHIP' in general. The response made the point that while some aspects of 'CHIP' are rather arcane, overall it is reasonably clear, understandable and applicable, and perhaps just as important, it is familiar to users. The EHSC is not aware of any great demand for change. CHIP has become an integral part of assessment processes and major changes would now be costly and confusing. Nonetheless the committee anticipated a continuing series of amendments from the EU as more chemicals were classified. It seemed unfortunate that it was necessary to carry out full legal consultations for all these, especially as the scope for change was very limited. The EHSC felt that it should be possible to establish a legal mechanism for periodic, perhaps, re-issue of the relevant approved lists much in the same way that EH40 is updated. In this way we should be able to accommodate EU changes within the time-scale for transposition into UK law and it might even be possible to show changes on the Internet on a continuous basis or to produce periodic updates on CD-ROM.

Scale-up of Chemical reactions

The EHSC has issued an 'EHSC Note' on safety issues in the scale-up of chemical reactions. The committee identified the need to provide some basic guidance on safety issues raised by the scale-up of chemical reactions from laboratory scale to full sized commercial plant. Chemists should be fully aware of the safety problems associated with the scale-up of chemical processes and should contribute to the scale-up procedure in order to ensure the health and safety of all persons involved. The Note made the point that it is essential that suitable and sufficient risk assessments are undertaken of all new and modified reactions during the scale-up of laboratory processes to full sized commercial plant. Appropriate process controls and protective measures are needed to reduce the risk both of a runaway exothermic reaction and the generation or release of toxic materials. The latter should be kept to a level which is as low as reasonably practicable. These controls not only ensure that legal requirements are complied with but also avoid the disruption, cost, potential damage and injuries that can be caused by the loss of control of chemical reactions.

Laboratory Waste Management

The EHSC has issued an 'EHSC Note' on laboratory waste management. This Note outlines best practice in managing wastes from chemical laboratories in the context of relevant statutory controls. It stresses both the need to assess the risks to health or safety in handling wastes, and the need to protect the wider environment. There are good reasons to reduce both the volume and the hazards of laboratory waste as far as possible. Not only does this have environmental benefits but it can also save money. In the past the majority of waste, including much laboratory waste, was discharged to landfill. Increasing pressures of environmental acceptability, possible consequential land contamination and spreading urbanisation have forced not only the development of alternative waste treatment and disposal methods but, more significantly, the re-evaluation of ways in which materials once thought of as waste can be used or re-used to conserve natural resources. The Note discussed how European Directives, which have been implemented in UK legislation, set objectives and targets for waste management in a manner that contributes to sustainability. The hierarchy of options for dealing with waste act as a guide to planning laboratory programmes and waste control measures and can often lead to significant cost savings in the long term, since waste treatment and landfill costs, which are already high, are likely to continue to rise.

The committee is currently working in several areas that may be of interest to ECG members. For example 'EHSC Notes' are being prepared on the following topics: HAZOP; Risk; Controlling Chemical Risk in School Science; Inherently Safer Chemical Processes; and Material Safety Data Sheets (MSDSs). The EHSC is also investigating whether there is scope to improve MSDSs for use in schools (and also possibly for SMEs, small to medium sized enterprises). A number of consultation documents are currently under consideration by the committee and some responses are likely to have been made by the time this article is published (for example the current DETR consultation on contaminated land). The committee has produced a number of 'Policy Statements' on pivotal issues on the Society's behalf. These are currently with the Society's Steering and Co-ordinating Committee (to which EHSC reports) for approval. They include statements on Life-cycle Assessment and an overarching policy statement on health, safety and the environment. The latter would replace and update the two separate statements (one on health and safety, and the other on the environment) published in *Chemistry in Britain* some years ago, and in particular take into account the concept of sustainable development. Such statements are important in demonstrating to the outside world (e.g. government) that the Society has a position on key issues. They also help to set a framework for the Society's views on more detailed policy. Building on such statements, the committee is considering two new series of papers. The first would be like policy statements but would set out the Society's views on major issues (e.g. risk assessment and the precautionary principle) with the aim of taking the debate to decision makers in a more pro-active way. The second series would set out the Society's position on issues of long-term public concern (one example might be air pollution) with the aim of countering the misinformation and misinterpretation that often surrounds such issues. Finally the EHSC together with the Society's Education Department is involved in a major initiative on professional practice for sustainable development. The aim of this project is to help give professionals, and particularly those over thirty, the confidence and competence to deal with sustainable development issues in their daily practice. The project involves several major professional bodies and is facilitated by a partnership between the Environment Agency, WWF-UK, the Council for Environmental Education, The Natural Step (part of the Forum for the Future), and the Institution of Environmental Sciences. It includes but is not limited to, issues relating to CPD. Finally in collaboration with other RSC units (including the Environmental Chemistry Group) the EHSC is attempting to develop a more coherent environmental strategy to help better prioritise and focus RSC environmental activities.

Copies of all the published 'EHSC Notes' and responses to consultation documents may be obtained free of charge from Christine Algate on 0171 440 3304 or e-mail algatec@rsc.org, or from the Society's Web site (under Chemical Communities/EHSC).

The EHSC always welcomes suggestions for new activities (such as topics for EHSC Notes) and feedback on its existing products. The Committee also welcomes volunteers to assist with its work. All suggestions should be sent to the Committee Secretary: **Mr. R. W. Hazell,** Royal Society of Chemistry, Burlington House, Piccadilly, London W1V 0BN Phone: 0171 440 3337; Fax: 0171 437 8883; E-mail: hazellr@rsc.org

New Publications on the Environment from the Royal Society of Chemistry

The **Issues in Environmental Science and Technology** series continues to provide concise, authoritative and up to date reviews of current environmental issues. Subscribers to the series in 2000 will benefit from:

- free sitewide access to all volumes in the series (90 articles at the end of 1999)
- lower prices for each individual issue, with delivery of the print copy on publication
- titles for 2000 are *Chemistry and the Marine Environment* and *Causes and Environmental Implications of Increased UVB Radiation*. A pay-per-view option is also available for individual articles: visit www.rsc.org/issues

For industries wishing to develop environmentally friendly products and processes, the **RSC Clean Technology Monographs** is a new series which addresses major issues relevant to the chemistry of waste minimisation. The first two titles are *Feedstock Recycling of Plastic Wastes* and *Applications of Hydrogen Peroxide and Derivatives*. Further details are available from sales@rsc.org or via the web site at www.rsc.org/is/books/clean.htm

Green Chemistry is a journal and information resource covering all chemical aspects of clean technology. Launched in Spring 1999, this exciting new journal is written in a way that makes it accessible to a wide audience, from students and policy-makers to researchers and industrialists. Already making its mark in the Green Chemistry Community, so visit www.rsc.org/greenchem to judge for yourself!

Journal of Environmental Monitoring is a must-have journal for environmental and health professionals in industry, officials in government and regulatory agencies, and research scientists interested in the environment. Very well received since its launch in February 1999, JEM is dedicated to the measurement of contaminants in our environment, with a view to assessing exposure and the associated health risks. Visit www.rsc.org/jem for further details.

The Dictionary of Substances and their Effects (DOSE) 2nd edition was published in October 1999. Purchasers benefit from free site-wide access to the DOSE searchable web database, which is located at www.rsc.org/dosesearch. If you would like a free 30-day trial of the database please contact sales@rsc.org.

More than 20 years of information on analytical applications and methods is easily accessible via a new web database. The database, which is located at www.rsc.org/aasearch, is based on the RSC's **Analytical Abstracts** and contains more than 265,000 items, dating back to 1980. Searching and display of titles is free. Display of full items incurs a charge. For a free 30-day trial contact sales@rsc.org.

Managing Risks of Nitrates to Humans and The Environment

Edited by W. S. Wilson and A. S. Ball, University of Essex, UK, and R. H. Hinton, University of Surrey, UK

Nitrate levels in the environment have been the subject of intense discussion for some time. There is now a growing awareness of the need to balance the benefits and risks involved, not only in respect of nitrogenous fertilizers but also in respect of nitrate as a dietary component.

Managing Risks of Nitrates to Humans and the Environment offers the latest research information on the beneficial effects of nitrates and their fate in the environment. Covering in an integrated way the agricultural, environmental and medical aspects of this emotive topic, the book confirms the sources, interactions and fate of nitrate in soils, water and the atmosphere. There is also an extensive description of the biochemistry of nitrates in plants, animals and humans, indicating the positive aspects as well as the hazards.

This unique book will be applicable to a wide research audience at graduate and postgraduate level.

Hardcover x + 348 pages
ISBN 0 85404 768 9
£69.50 (£45.00 to members of the RSC)

You might like to know that all the above information, and details of all other RSC products, are available from our searchable online catalogue, located at www.rsc.org/pubcat

Geochemical Transactions

THE Royal Society of Chemistry and The Division of Geochemistry of the American Chemical Society are jointly launching a new, fully electronic journal, *Geochemical Transactions*, covering all areas of Geochemistry.

As a service and benefit to members of the Division of Geochemistry, the Publishers are offering a free three month trial subscription to *Geochemical Transactions*. To take advantage of this offer, members and affiliates of the Division of Geochemistry should go to the following Web site, and sign up to receive a logon password etc. which will allow them access to the journal. Other information about the journal is also available at this site:

http://www.rsc.org/is/journals/current/geochem/geopub.htm

Individuals who are not currently members or affiliates of the Division, and who would like to take advantage of this offer, can join the division online via the Division's Web site:
http://membership.acs.org/g/geoc/

Membership is (US)$10.00 for ACS National Members, and (US)$12.00 for non-members. New members signing up now will receive all Division membership benefits for 2000, and will be able to sign up for the *Geochemical Transactions* free introductory period.

Endocrine Disruptors and Children's Health

A SYMPOSIUM on endocrine disrupting chemicals in the environment is being organized for the 219th American Chemical Society (ACS) Meeting in San Francisco, CA in March 2000. For further details see the ACS's Division of Environmental Chemistry Web site at http://www.acs-envchem.duq.edu/

In August 1999 at the ACS in New Orleans, LA the Division of Environmental Chemistry held a symposium on "Analytical Challenges for Assessing Environmental Exposures to Children." Endocrine disrupting chemicals were some of the topics of concern at this symposium. Information from abstracts and notes taken at the symposium are linked at http://www.acs-envchem.duq.edu/eeds.htm

Links are also provided from this latter ACS Division of Environmental Chemistry site to a new Web site with a free PowerPoint slide show summary on 'Preventing Children's Exposure to Endocrine Disruptors – A Teaching Aid.' A larger, comprehensive slide show is also commercially available at this site http://www.instantref.com/children.htm

These slide shows provide an overview of what is known and what is not yet known about these chemical pollutants at a level that everyone can understand. The slides may be used with Microsoft's PowerPoint Viewer for presentations or printed for handouts. Teachers will be able to use these slides for materials that can be used to discuss this topic at PTA meetings, other community and public outreach forums, and in the classroom.

Other Publications on Endocrine Disruptors

The US EPA has a useful Web site on endocrine disruptors with links to other sites – see http://www.epa.gov/endocrine/

A Web site with links to recent media stories on environmental estrogens is located at http://www.carnell.com/environment_health/estrogens/

A review on 'Endocrine Disrupting Chemicals' was published in the RSC's *Issues in Environmental Science and Technology* series in 1999.

Keith, L.H. *et al.* (eds.), *Analysis of Environmental Endocrine Disruptors,* ACS Symposium Series No. 747, American Chemical Society, Washington DC.

Keith, L.H., *Environmental Endocrine Disruptors: A Handbook of Property Data*, J. Wiley, New York, 1997.

Forthcoming Symposium

Climate Change and its Impact

RSC Environmental Chemistry Group Distinguished Guest Lecture and Accompanying Symposium

The Environmental Chemistry Group will be holding a half-day symposium on "Climate Change and its Impact" at the Royal Society, 6 Carlton House Terrace, London on Wednesday 1 March 2000.

At this meeting the ECG 2000 Distinguished Guest Lecture will be given by **Sir John Houghton** CBE, FRS the co-chairman of the Science Assessment Working Group of the Intergovernmental Panel on Climate Change. The title of Sir John Houghton's lecture is "*Global Warming and Climate Change: the Latest Science and the Likely Impacts*"

The Distinguished Guest Lecture is part of a half-day symposium which starts at 13.30. Two supporting lectures will be given at the symposium: "*The Implications of Climate Change for Ecosystems*" (**Dr. Terry Parr**, Co-ordinator of the UK Environmental Change Network) and "*The Implications of Climate Change for Human Health*" (**Professor Tony McMichael**, London School of Hygiene and Tropical Medicine). The 27th AGM of the Environmental Chemistry Group will be held during an interval of this meeting.

We are fortunate to have three such eminent speakers for a symposium that should provide an 'up to the minute' assessment of the possible impacts of global warming.

Sir John Houghton

Sir John Houghton, CBE, FRS is co-chairman of the Science Assessment Working Group of the Intergovernmental Panel on Climate Change and a member of the British Government's Panel on Sustainable Development. He was Professor of Atmospheric Physics at the University of Oxford form 1976-1983, Chief Executive of the Meteorological Office from 1983 to his retirement in 1991 and Chairman of the Royal Commission on Environmental Pollution from 1992-1998. He has received Gold medals from the Royal Meteorological Society and the Royal Astronomical Society and the prestigious International Meteorological Organisation Prize. Sir John is the author of a number of books including two textbooks, *The Physics of Atmospheres* (Cambridge University Press, 2nd edition, 1986) and *Global Warming - The Complete Briefing*, Lion Publishing, 1994; 2nd edition, Cambridge University Press, 1997.

Professor Tony McMichael

Tony McMichael, a medical graduate from Adelaide, South Australia, is currently Professor of Epidemiology at the London School of Hygiene and Tropical Medicine, UK. His research interests, over 25 years, have encompassed the causes of occupational diseases, diet and cancer, and environmental epidemiology (including environmental/dietary causes of cancer, effects of environmental lead (Pb) upon childhood intellectual development, aetiology of cataracts, and methods of

quantitative environmental health-risk assessment). He has been an advisor to WHO, the World Meteorological Organisation and the World Bank (Environment Division). In 1990-92 he chaired the Scientific Council of the International Agency for Research on Cancer (WHO).

He has major interest in the assessment of population health risks from global environmental change (see also his: *Planetary Overload: Global Environmental Change and the Health of the Human Species*. Cambridge University Press, 1993). During 1994-98 he convened the Intergovernmental Panel on Climate Change (Second Assessment Report) review of potential health impacts of climate change. He will be doing likewise for the IPCC Third Assessment Report (1999-2001). He has written extensively on the methodology and recent findings in environmental health research.

Dr. Terry Parr

After completing a D.Phil at the University of York in 1978, Terry Parr worked as a plant ecologist at the Institute of Terrestrial Ecology (ITE) where he undertook research on woodland change, wetland dynamics, vegetation management and modelling. From 1990 to 1993 he was seconded to the Department of the Environment's Directorate of Rural Affairs where, amongst other things, he provided scientific advice to policy sections and managed a wide range of research projects including 'Countryside Survey 1990', the first major survey of the British Countryside. On returning to ITE in 1993, he joined the Environmental Information Centre and worked on the development of Geographical Information Systems and environmental indicators for the investigation of the impacts of land use and climate change.

Since 1995 he has been the Co-ordinator of the UK Environmental Change Network, which is a long-term multidisciplinary integrated monitoring network. He is currently co-ordinating an EC project on integrated monitoring requirements in Europe and, through ECN, has direct links with initiatives such as the Global Terrestrial Observing System, the International Long-term Ecological Research Network and the European Biosphere Reserves Network. The detection, interpretation and forecasting of climate change impacts on terrestrial systems is one of the key issues in the monitoring and research programmes associated with all these initiatives.

Registration

There are no registration formalities associated with this meeting and guests are welcome, but in order to assist the organisers it would be appreciated if those intending to be present would notify the Hon. Secretary of the ECG using a photocopy of the slip below. There will be a charge of £10 for non-members of the Environmental Chemistry Group (cheques made payable to RSC Environmental Chemistry Group), which should be returned with the slip. Attendance is free for ECG members.

ROYAL SOCIETY OF CHEMISTRY ENVIRONMENTAL CHEMISTRY GROUP

Distinguished Guest Lecture & Symposium and Twenty-seventh Annual General Meeting

CLIMATE CHANGE AND ITS IMPACT

Venue: The Royal Society, 6 Carlton House Terrace, London (*note the venue* - nearest tube stations: Green Park, Charing Cross, or Piccadilly)

Wednesday, 1st March 2000

Please tick the item(s) below as appropriate and return to:

Dr. Andrea Stroh
Environment Centre
University of Leeds
Leeds LS2 9JT
Tel: 0113 233 6728
e-mail: andrea@lec.leeds.ac.uk

Name: .....

I would like to attend: ❑

The AGM ❑

The Symposium ❑

The Distinguished Guest Lecture ❑

I enclose a cheque for £10.00 (non-members of the ECG only) ❑

Forthcoming Symposium

Whistler 2000 Speciation Symposium

Fourth International Symposium on Speciation of Elements in Biological, Environmental and Toxicological Sciences

http://sciserv.mcmaster.ca/biochem/speciation/

June 25 - July 1, 2000, Whistler Conference Centre, Whistler Resort, British Columbia, Canada

Goals and Scope

The aim of the speciation symposia is to facilitate interdisciplinary and intersector discussion about all aspects of elements requiring an understanding of speciation, including: analytical science, geochemistry, biochemistry, clinical chemistry, environmental science, toxicology, essentiality and nutrition, medical uses, environmental and occupational health, and regulatory aspects. The scope of the scientific programme is defined by the working definition of speciation endorsed in 1994 by participants of the Second Speciation Symposium in this series: Speciation is the occurrence of an element in separate identifiable forms (i.e. chemical, physical, or morphological state).

Scientific Programme

The programme will comprise 4 days of oral presentations, posters, and discussion. All contributors are asked to focus on recent research results. Oral presentations (invited or submitted) will be 20 or 30 minutes duration. The tradition, established at previous symposia in this series, of assigning a prominent and central role to poster presentations is to be maintained. Consequently, concurrent sessions organised by themes will be held after the formal viewing period to encourage in-depth feedback and discussion. In these special discussion groups, each author will be allotted 5 minutes for an oral presentation of the salient features of her or his poster.

The aim of the meeting is to link the various fields of activity mentioned above under Goals and Scope through topics pertaining to natural or contaminant species of the elements: new developments in methods/techniques of species determination; source characterisation and multi-media transport; bioavailability, uptake, bioaccumulation and metabolic fate; environmental and biological monitoring; essentiality, toxicity & resistance and associated mechanisms of action.

Abstracts

Instructions for the preparation and submission of abstracts are available from the web page at http://sciserv.mcmaster.ca/biochem/speciation.

Conference Proceedings

As for previous Speciation Symposia (see *The Analyst* **117**: 549-691, 1992; **120**: 29-30N, 583-763, 1995; **123**: 765-937, 1998), papers presented as posters or lectures may be submitted as full papers for publication in a special issue of the *Journal of Environmental Monitoring* (JEM), subject to the normal review procedures. Authors of strict analytical papers outside of the scope of JEM are invited to submit them to *The Analyst*.

Secretariats

Registration and Accommodation
Venue West Conference Services;
email: congress@venuewest.com

Local Organisation

Dr Michael W Blades;
email: blades@chem.ubc.ca

Programme

Dr Evert Nieboer ;
email: nieboere@fhs.mcmaster.ca

Forthcoming Symposium

Teaching the Environmental Sciences in the New Millennium

Organised by the RSC's Environmental Chemistry Group, the RSC's Green Chemistry Network and the Education Department of the Royal Society of Chemistry

Saturday, 25th March 2000 at the Scientific Societies' Lecture Theatre, New Burlington Place, London

This one-day meeting for lecturers and teachers will focus on current developments in the environmental sciences and their impact on the teaching of this subject in schools and colleges. Topics for discussion include "green chemistry", which can be considered as the practice of chemistry with an awareness of the environment, and the "greening" of bulk chemical production, highlighting the reduced environmental impact of these processes.

PROGRAMME

Education for Sustainable Development: a Whole School Perspective

Mr John Westaway (QCA)

John Westaway is the Principal Subject Officer for Geography at the QCA, with responsibility for education for sustainable development. He has previously been Professional Officer for Geography at SCAA and Professional Officer in Science at SEAC. During the 1980s John was warden of the ILEA Geography and Environmental Studies Teachers' Centre.

The Relevance of Environmental Chemistry to the Science Curriculum

Dr. Colin Osborne (Royal Society of Chemistry)

Colin Osborne taught in comprehensive schools in London and Brighton for 24 years and became Head of Science. For the last 3 years he has been Education Officer (Schools and Colleges) for the RSC. He has also been a reviser for

GCSE Chemistry and an A-level examiner.

The Stratospheric Chemistry of Ozone Depletion and Climate Change

Dr. Rob MacKenzie (Lancaster University)

Rob MacKenzie is an environmental chemist who graduated from Edinburgh and then Essex. He worked at the University of Cambridge, latterly as the Scientific Co-ordinator of the Centre for Atmospheric Science there. He is currently a lecturer in the Environmental Science Department at Lancaster University and is UK Project Leader of the Airborne Platform for Earth Observation.

Why Ecotoxicology is Important

Dr. Tony Stebbing (Plymouth Marine Laboratory)

Tony Stebbing has worked at Plymouth Marine Laboratory for nearly thirty years – latterly as head of the ecotoxicology group. He is currently Scientific Co-ordinator for the NERC's Land-Ocean Interaction Study (LOIS).

The Greening of Chemistry

Professor James Clark (University of York)

Green chemistry can be considered as the practice of chemistry with an awareness of the environment. Professor Clark will talk about the motivation behind the green chemistry revolution, its principles, the implications for the chemistry communities, and the challenges and opportunities it brings.

James Clark is Professor of Chemistry at York University and a Royal Academy of Engineering Clean Technology Fellow. He carries out research on green chemistry topics with companies all over the world and has lectured in America, Asia, Europe and the Middle East. He is the Scientific Editor for the RSC journal "Green Chemistry."

Green Developments in Industrial Processes

Dr. Mike Lancaster (Green Chemistry Centre, University of York)

Greening of large bulk chemical processes has been quietly going on for many years, largely for economic reasons. Dr Lancaster will discuss some of the technical advances made in processes commonly covered in the chemistry curriculum, highlighting the reduced environmental impact they have.

Mike Lancaster is manager of the RSC's Green Chemistry Network. He has spent most of his career in industry in a range of research and business management roles. He moved to York in 1998 to establish the GCN, which aims to promote environmentally friendly chemistry in schools.

The registration fee for this meeting is £25 for RSC members or £40 (non-members) and includes a buffet lunch and refreshments. The presentations will start at 10.30 am and the day will finish at approximately 16.00.

To register for this meeting, please use a photocopy of the application form printed below, and return to: **Ms Lorraine Hart,** Royal Society of Chemistry, Burlington House, Piccadilly, London W1V 0BN; Tel. 020 7440 3350; Fax. 020 7287 9825.

ROYAL SOCIETY OF CHEMISTRY

TEACHING THE ENVIRONMENTAL SCIENCES IN THE NEW MILLENNIUM

Saturday, 25th March 2000 at the Scientific Societies' Lecture Theatre.

The Scientific Societies' Lecture Theatre is situated in New Burlington Place, off Savile Row and behind Regent Street (opposite side to Hamleys). The nearest tube stations are Oxford Circus and Green Park.

I wish to register for the Symposium on Saturday, 25th March 2000

I enclose a cheque made payable to the "Royal Society of Chemistry"

RSC Members	£25.00
Non-RSC Members	£40.00

BLOCK CAPITALS PLEASE

Name ..... Title .....

Address .....

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Tel ..... Fax .....

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Special dietary requirements. .....

Society for Environmental Geochemistry and Health (SEGH)

Forthcoming Symposia

5th International Symposium on Environmental Geochemistry (ISEG)

The broad theme is the understanding of chemical processes, both natural and induced by human activities, and the quantitative evaluation of their impact on landscapes, human communities and the environment.

Location: Cape Town, South Africa
Dates: 24-28th April 2000
Contact: Miss Deborah McTeer
Postgraduate Conference Division
UCT Medical School
Observatory,
7925, RSA
Tel: +27 21 4066348
Fax: +27 21 4486263
Email: deborah@medicine.uct.ac.za
Website: http://www.uct.ac.za/depts/pgc

Suggestions for special symposia and possible pre-conference workshops should be addressed to Martin Fey (fey@geology.uct.ac.za).

Fourth International Conference on Arsenic Exposure and Health

This conference will focus on recent US EPA legislation on As, health effects of As, As exposure, patient treatment, and water treatment.

Location: San Diego, USA
Dates: 18-22 June 2000
Contact: Rosemary Wormington
Campus Box 136,
University of Colorado at Denver
PO Box 173364
Denver, CO, USA 80217-3364
E-mail: rwormington@castle.cudenver.edu.
Fax: +1 303-556-4292
Phone: +1 303-556-4520.

SEGH Conference on Environmental Chromium Contamination and Remediation.

This two-day conference will focus primarily on solutions to the problems created by the historical dumping of chromium ore processing residue.

Location: Glasgow, Scotland.
Dates: 11-12 September 2000
Contact: Dr. John Farmer
Department of Chemistry
The University of Edinburgh
West Mains Road
Edinburgh, Scotland EH9 3JJ
E-mail: J.G.Farmer@ed.ac.uk

5th International Symposium on Environmental Geochemistry (ISEG)

Edinburgh, Scotland. September 2003

For further information about SEGH, see our website, **www.segh.org**

Forthcoming Symposia

Details of many meetings related to the environmental sciences to be held in the first half of 2000 are given in the leaflet *Environmental Science and Technology Meetings* (No. 33, December 1999) which accompanies this issue of the ECG Newsletter. Future ECG-sponsored meetings are publicised elsewhere in this Newsletter.

Other symposia on environmental and related topics, which have come to our attention, are as follows:

'Chemical Control Regulations in Europe – From Chaos to Harmony'

Organised by the SCI Environment & Water Group, Tuesday 8th February 2000, SCI, 14/15 Belgrave Square, London. E-mail deborahn@chemind.demon.co.uk for details.

HAZARDS XV – The Process, Its Safety, and the Environment – 'Getting it Right'

Organised by the SCI Health & Safety Group and by the IChemE, 4th to 6th April 2000, UMIST, Manchester. Contact M.J. Adams, 01539 732845, e-mail mikeadams@valrichardson.com for details.

Towards Sustainability

Organised by the RSC's Industrial Affairs Division as part the RSC Annual Congress, 16th to 20th April 2000, UMIST, Manchester. Contact Stanley Langer, 020 7440 3388, e-mail langers@rsc.org for details.

Groundwater Quality Conference 2001

GQ2001 will be a research-based conference to discuss the newest understanding of natural and enhanced restoration of pollutants in groundwater and soils. For further details visit the Groundwater Quality 2001 Web sitehttp://www.shef.ac.uk/~gq2001/ or contact:

GQ2001 Conference Secretariat
(David Lerner)
Groundwater Protection and Restoration Group,
Department of Civil and Structural Engineering,
University of Sheffield,
Mappin Street,
Sheffield S1 3JD UK
Email: gq2001@sheffield.ac.uk
tel +44/0 114 222 5743 fax +44/0 114 222 5701 or 5700
email d.n.lerner@sheffield.ac.uk
http://www.shef.ac.uk/~gprg/

Meeting Report

Chemical Contaminants in Estuaries and Coastal Waters: Practical Applications of Models

THIS SYMPOSIUM organised by the Environmental Chemistry Group was held on 19th November 1999 in London. A range of modelling techniques and a variety of approaches to this topic were discussed. The attendance was not as large as we would have liked, especially considering most of the attendees were not members of the Environmental Chemistry Group. However, the participants felt that it was a worthwhile day and a number of new contacts were made, which may lead to some beneficial developments.

The speakers provided a good mix of the theoretical and practical aspects of modelling. The ability to use projections of computer-driven simulations meant that the outputs from some of the models were easily displayed. This led to some lively discussion about data validity and practical applicability of the models.

It was unfortunate that Professor Alan Elliott had to withdraw at the last minute because of illness, but the abstract of his paper is included, for information, along with the abstracts of the other five papers.

Abstracts from the Meeting

Use of Models in the Environment Agency

Dr. Neil Murdoch and Dr. Peter Jonas, Environment Agency, Manley House, Kestrel Way, Sowton, Exeter EX2 7LQ

Contaminant levels in the marine environment are regulated by the Environment Agency primarily through consents to discharge. European Union Directives, such as the Bathing Waters, Shellfish Waters, Dangerous Substances, Habitats and Species, Nitrate, and Integrated Pollution Prevention and Control, are the basis for Environment Quality Standards (EQSs). The discharge consent is then set so as to ensure compliance with the EQSs in the receiving marine waters.

Models are used to determine whether or not a proposed discharge will result in EQS compliance. EQSs are often expressed as a statistic. For example the Bathing Waters Directive states that 95 percent of samples must be less than 2000 faecal coliforms/100ml. The model calculations must then be such to allow comparison between predictions and these statistically based EQSs, which are expressed as percentile standards. In the freshwater environment this problem of matching model outputs to standards has been solved through the use of combined distribution/Monte-Carlo methods.

An impediment to the Monte-Carlo approach in the marine environment is computational execution time. Specifically 2D and 3D models may not run sufficiently fast to allow full simulation of the environmental and discharge variability. In practice a number of scenarios are run. A way to relate these limited model outputs to the EQS percentile standard in a more rigorous and less ad hoc manner is needed.

A method called JUDE (Justified Design Evaluation) has been developed to achieve this. The method assumes, initially, that the environmental response (i.e. concentration) is monotonic for the various forcing variables (e.g. flows and concentrations for environment and discharge) and that the forcing variables are independent. It is demonstrated the method works in the simple freshwater case and a more complex estuary situation. The method may be refined for non-monotonic and non-independent circumstances.

The power of the method is that it reduces the computational requirement from, say 1000 shots or simulations, to a small member and that 1 or 2 simulations will give an estimate of the environmental response at the EQS percentile.

The implication for model developers is that the use of models is enhanced because they can now be formally coupled to the regulatory process.

Disclaimer: the views expressed here are not necessarily those of the Environment Agency

Applied Modelling of Oil Spills and Complex Effluents

Dr. Andrew Tyler, BMT Marine Information Systems Ltd.

Increasing computer power and software have enabled marine modelling applications, previously the exclusive domain of the research scientist, to be used by end-users for management, planning and emergency response applications. These new generation modelling applications focus on ease and relevance of user input data, speed of model run-times, and a high degree of data processing and visualisation so that users can directly apply results to their decision-making processes.

Over recent years advances in this technology have resulted in the development of a Visual Marine Information Systems (VMIS) framework. This framework provides hosted modelling applications with access to primary datasets (maps, bathymetry, hydrodynamics, meteorology) through data servers which isolate the application from the databases thus greatly increasing flexibility and use of multiple databases. The framework also provides a wide range of generic data processing and visualisation facilities including model output mapping, contouring, graphing, status panels, reporting, data export etc. The framework is explicitly configured to operate at a range of scales from global to local.

Applications hosted within the VMIS framework include marine oil and chemical spills, search and rescue, coastal effluents and offshore oil & gas industry drilling and production discharges. An oil spill modelling application was demonstrated, capable of predicting the three-dimensional transport of both surface slicks and sub-sea dispersed oil. The weathering of the oil spill is simulated to predict flash point, viscosity, water content and consequent spill volume changes. The shoreline impact is mapped and can be interactively coupled with mapping layers describing coastal sensitivities.

Recent developments in the applied modelling of complex effluents were

described including laboratory experiments to determine the partitioning behaviour of oilfield chemicals using ^{14}C-labelled analogues, and field studies to track plumes discharged from oil platforms. New transport algorithms simulate the dynamic, buoyancy and passive mixing of effluents. Geochemical transformations are represented by solid-phase and dissolved-phase numerical particles controlled by a geochemical sub-model controlling dynamic loss and partitioning behaviour. Experimental data describing partitioning kinetics has been assimilated. The model is able to predict the dispersion of particulate and effluent plumes and concentration of associated contaminants. It can also apply various ecotoxicological risk assessment methods to quantify environmental risk.

Flexible Modelling Using EcoS

Dr. John Harris, Centre for Coastal and Marine Sciences, Plymouth Marine Laboratory, Citadel Hill
Plymouth PL1 2PB

Equipped with available cut and paste components of physical and biogeochemical dynamics, the ECoS shell gives a versatile way to assemble complex models of estuarine biogeochemisty.

Complex, multi-parameter models may be validated against independent data from the system modelled, but rigorous statistical testing is normally not possible. Strictly (Oreskes et al., *Science* **263**: 641-646), this is only valid with the complete knowledge, which, in science, we can never have. The alternative is to develop deliberately simple models that can be rigorously calibrated.

A Levenberg-Marquardt minimisation procedure has been used to fit ECoS models to observations. A two-parameter model gives a good fit with salinity profiles from three years of monthly axial surveys in the Humber and tidal Ouse undertaken in the LOIS programme, but its residuals show a significant seasonal cycle and long-term trend. The unexplained long-term trend immediately vitiates any prediction. Fitting the same model to Environment Agency monitoring data suggests that the trend is confined to the LOIS period (1994-96).

Qualitative fits to the LOIS data have been obtained for a simple SPM model, which is suitable for the same least squares approach. The intention is to proceed stepwise to develop a fully calibrated model of estuarine nitrogen cycling.

Modelling Radionuclide Transport in Coastal Waters

Dr. Adrian Punt, Westlakes Scientific Consulting Moor Row, Cumbria, CA24 3LN

Westlakes Scientific Consulting (WSC) are expert users of software packages used for environmental assessment by industry, local authorities and regulatory bodies. Modelling expertise is provided for routine and emergency discharges to both the atmosphere and to marine, estuarine and freshwater systems for a variety of contaminants including radionuclides. Further radiological dose assessment and food chain modelling is also provided.

The talk focuses on three modelling strategies, long term assessment using tidally averaged models of coastal waters, emergency discharge assessment in coastal water using tidally resolved models and a tidal 2D estuarine model currently under development at WSC.

MEAD (Marine Environment Annual Dispersion) and its progenitor CUMBRIA are used for long term predictions (of the order of 10's years) for radionuclide concentrations and other contaminants in coastal waters and are used to assess the effects of historical discharge or long term consequences of new discharges. Both models are set up for the Irish Sea and are driven by a residual flow field generated by averaging a twelve-month tidal simulation. Radionuclide parent-daughter decay chains with advection-dispersion transport of both parent and daughter isotopes in the dissolved phase and suspended sediment are predicted and the partition coefficient is used to describe the transfer between dissolved and particulate phases. Erosion and deposition terms describe the accumulation of bed sediment off the Cumbrian coast and the potential store of radionuclides within this sediment. Desorption from this historical load is becoming more significant as current anthropogenic discharges decline and is an important factor in long term modelling. The development of MEAD and calibration results for ^{137}Cs and ^{241}Am are presented indicating the importance of this bed sediment source.

The use of the Danish Hydraulic Institute designed software MIKE21 by WSC for conservative and non-conservative contaminant dispersal in coastal and estuarine waters is briefly described. Tidally resolving models with a fine grid size (100 m) allow high spatial and temporal resolution in predicting plume or beaching events.

VERSE, a 2D baroclinic estuarine model developed by WSC is designed to describe in detail the vertical and horizontal flux and fate of sediment and contaminants in the Ribble Estuary. The model extends over 23 km and covers the Ribble and Douglas Estuaries with a vertical segment spacing of 250 m and a horizontal spacing of 30 cm and time step of 15 seconds. It uses an upwind scheme to calculate velocity and advection-dispersion of the water, solutes and suspended particles. Partition coefficients are currently being encoded for a range of contaminants, in addition to decay chain transfers for a range of radionuclides. Further estuarine and riverine modelling using the software package ECoS is also due to be introduced by WSC by the end of the year.

The choice of tidal verses tidally average models and some of the assumptions that are made when modelling geochemical partitioning or biological uptake are summarised and suggestions for future work made.

Modelling of Nutrient Behaviour in Estuaries and Coastal Waters

Dr. David Hydes, Southampton Oceanography Centre

Although models of biogeochemical systems in marine environments can produce output which closely parallels the real world, the user of models must be aware of how that match has been achieved within the model. The NERC's North Sea project in 1988-89 systematically collected data in a way that was ideal for quantifying processes in the North Sea and well suited for the calibration and verification of models. At

SOC we have been working with the Proudman Oceanographic Laboratory (Roger Proctor) and Napier University (Paul Tett) to develop models which relate the hydrodynamic processes in the North Sea and Irish Sea, nutrient inputs and biogeochemically related processes to the development and decay of phytoplankton blooms. In the Irish Sea the model clearly reproduces the appearance in the southern Irish Sea in winter of an area of water where nutrient concentration are lower than in both of the source waters in (a) river inflows and (b) the high salinity ocean water which mixes with the fresher waters in the Irish Sea. Comparison of a simple linear mixing model between ocean water and river waters indicates that although the long time series data from the Port Erin Marine Laboratory appears to have convincingly detected an increase in concentrations of nitrate since the 1950s, this simple model shows that concentrations are lower than expected. A process such as denitrification must be responsible for the removal of nitrate from the system. A new model (Boris Kelly-Gerreyn SOC), linked to data from sediments in the Wash, demonstrates the link between the organic carbon content of sediments and both (a) the degree of nitrate removal, and (b) the removal pathway, by dissimulatory bacterial processes, to nitrogen or ammonia.

Computer Simulation of Oil and Chemical Spills in Estuaries and Coastal Waters

Prof. Alan J. Elliott, Unit for Coastal and Estuarine Studies, Marine Science Laboratories, Menai Bridge, Anglesey LL59 5EY

Two examples of pollutant transport studies are presented. The first concerns the simulation of suspended sediment concentrations (SPM) in the Firth of Forth where the dominant particle size is 10 microns with about 70% of the near-bed particles and over 90% of the surface particles being in the size range 0-15 microns. The importance of the time-varying nature of erosion and deposition threshold parameters has been demonstrated using a single grid point model that calculated SPM concentration from in-situ erosion and deposition processes alone.

The second example illustrates the importance of air-sea exchange by considering the movement of a gas cloud following a collision at sea, which occurred in January 1997. A feasible advection path can only be reproduced by assuming that the water/atmosphere exchange of vapours occurred on a time scale of 12 hours. Evidence to support the simulated trajectory has been obtained from the UK National Air Quality Information Archive, which contains hourly data for benzene and NOX concentrations. By regressing the benzene concentration against NOX, which is assumed to be an indicator of traffic density, it is shown that an increase in benzene concentrations on the day following the spillage was consistent with the simulated movement of the vapour cloud.

DR. PETER O'NEILL
University of Plymouth,
December, 1999

Meeting Report
Endocrine Disruptors in the Environment – The Analytical Challenge

This two-day meeting organised by the RSC Water Chemistry Forum; the Analytical Division North East and North West Regions; the Environmental Chemistry Group; and the SCI's Environment & Water Group was held at the North West Conference Suite at Lingley Mere, Warrington on 11th to 12th October 1999. The latest techniques for monitoring endocrine disruptors in environmental matrices were discussed.

The US EPA defines endocrine disruptors as 'exogenous substances interfering with the synthesis, secretion, transport, binding, action or elimination of the hormones in the body that are responsible for the maintenance of homeostasis, reproduction, development and/or behaviour.' Although various chemicals have been discovered whose biological properties fit this description, analytical problems still exist in detecting and measuring these substances in the environment.

The meeting, divided into seven oral sessions spread over the two days, was augmented with a small poster display and an exhibition of analytical equipment. On the first day the analysis of natural and synthetic endocrine disruptors was discussed, while the second day's proceedings were concerned with regulatory aspects.

Twenty-five speakers covered the subject in depth and provoked lively discussion. The analysis protocols varied, depending on the entity been sought, but used a wide range of modern analytical techniques. For example:

Solid Phase Extraction (SPE)
Semi-Permeable Membrane Devices (SPMD)
GC-MS
GC-MS/MS
LC-MS
HPLC
SPE-HPLC-GCMS

Other techniques have also been used for the detection of endocrine disruptors, for example:

Recombinant yeast assays
Immunoassays
Bioassays

No one technique can yet claim to be a generic method for these compounds. The conclusion of this rapporteur is that because of the complex cocktail of chemicals, natural or otherwise, that can produce biological effects on the endocrine system, a multi-disciplined approach is needed to study the levels in the environment rather than a purely 'analytical' approach. If a relatively simple non-specific test could be devised to pinpoint 'hot-spots' of endocrine disruption, it would enable analysts to direct their efforts to produce useful analytical data.

The sixty or so participants at the meeting

left with some questions answered, but with more problems still to be solved.

The proceedings of the two days will be published later this year by the Royal Society of Chemistry in their 'Special Publication' series.

I should like to thank the participants, and everyone who helped with the organisation of the meeting. In particular I should like to mention Elaine Wellingham, Mark Tombs, and North-West Water for their help.

MIC DANIEL
Environment Agency,
Leeds LS12 6DD

Meeting Report
Monitoring for the Millennium

The RSC Analytical Division (Automation and Analytical Management Group) in collaboration with the Health and Safety Executive organised this conference at the Scientific Societies' Lecture Theatre, New Burlington Place, London, on the 15th and 16th of December 1999.

The first day of this two-day meeting had the title 'Implications of the Ambient Air Directive', and began with presentations from Martin Williams of the DETR ('Measurement of pollution levels: a DETR perspective - what the local authorities will have to do') and Dick Derwent of the Meteorological Office ('Atmospheric modelling for regulatory purposes').

Rolaf van Leeuwen from the WHO described how the air quality guidelines for Europe have been updated to take account of new toxicological and epidemiological data for air pollution. Dr Emile De Saeger from the Joint Research Centre/Ispra in Italy spoke on 'Assessment of pollution levels: an EU perspective.'

These latter two talks and other comments from the meeting indicated the complexities of the new air quality guidelines, which are being developed in parallel by national governments, the EU and WHO. Acceptable exposures are being reduced, standards are constantly being revised, political perspectives altered, and commercial monitoring instruments developed to meet the new criteria. This conference and similar meetings, in which many of the participants advise regulatory bodies, provide a useful update on the long -term thinking on air pollution issues and future legislation.

The first day continued with John Tipping from the Environment Agency (EA) who described the EA's Monitoring Certification Scheme (MCERTS). This is currently used for certifying continuous stack-emission monitoring systems (CEMs) and includes categories of ambient-air quality monitoring systems (CAMs). Sira Certification Services will operate the MCERTS accreditation for the EA and testing will be performed by the AEA, Harwell or the NPL, Teddington. A consultation document on MCERTS is available from john.tipping@environment-agency.gov.uk

Mike Woodfield (AEA Technology) then spoke on 'The PAH Problem' and considered the technical problems associated with monitoring polyaromatic hydrocarbons (PAHs). Air quality standards are being considered under the European Unions Air Quality Framework Directive for these pollutants. A degree of urgency in the development of standards seems to be necessary if member states are to have workable analytical methods that they can adopt in time for a major review of air quality in 2003.

Ente Sneek (KEMA Power Generation and Sustainable Energy, Netherlands) concluded the first day's proceedings with a paper on reference methods for measuring SO_2, NO_2, O_3 and CO. The requirements of the Air Quality Framework and Daughter Directive on SO_2 and NO_2 indicate that the existing ISO-standards are inappropriate. New draft standards for SO_2 and NO_2 are to be presented to the CEN Technical Committee 264 "Air Quality" for approval.

The second day commenced with a presentation from Theo Hafkenscheid (Netherlands Meetinstituut) on 'The Magic of Standard Atmospheres.' The technical difficulties in producing standard atmospheres and their vital importance as meteorological 'reference' standards were emphasised.

Bob Large (MScan, Sunninghill, Berkshire) discussed 'Sources of uncertainty in air sampling and analysis.' He illustrated the practical business of providing advice for air sampling - from his company's experience - and gave warning that the documentation and legal basis of the certification process for commercially available gas standards is dubious if there is not clear linkage to a national laboratory standard.

Rod Robinson (NPL) ('Uncertainty in air monitoring measurements') described efforts to harmonise ISO and CEN work on the requirements for air monitoring data to be produced with "uncertainties attached." Differences in the definitions of "uncertainty" and a plethora of ISO standards make this topic a little fearsome. One can only hope that simple, consistent and intelligible guidelines will be produced quickly!

The conference closed with five papers describing experiences of monitoring for volatile organic compounds (VOCs):

- Henrik Slov (Department of Atmospheric Environment, Denmark) 'Reference and indicative methods for benzene'
- Eddy Goelen (Vito, Mol, Belgium) 'VOCs in Antwerp: ambient air exposure versus population exposure'
- Norbert Gonzalez (INERIS, France) 'Diffusive sampling for indicative measurements'
- Jan-Olov Levin (NIWL, Umea, Sweden) 'Measurement of aldehydes and BTX from ethanol fuelled buses'
- Iain Marr (University of Aberdeen) 'Organics in breathing gases.'

LEO SALTER
Cornwall College, Pool, Redruth,
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Book Reviews

The following reviews first appeared on the Web site of *The Analyst.*

Methods of Seawater Analysis, 3rd Edition

Edited by K. Grasshoff, K. Kremling and M. Ehrhardt. Pp. xxxii + 600. Wiley-VCH. 1999. Price £140.00. ISBN 3-527-29589-5.

Investigations of seawater are still a very attractive field, even after many years of research and development. Many problems remain to be tackled that are within the remit of the environmental and analytical sciences. The latter have advanced considerably in the last 15 years since the second edition of this book was written and therefore one can only welcome this update. The monograph contains a wealth of interesting information about the state-of-the-art of detailed procedures and available equipment for seawater analysis. This is reflected by the chapter headings:

Sampling, Filtration and storage,
Determination of salinity,
Determination of oxygen,
Determination of hydrogen sulfide,
Determination of thiosulfate and sulfur,
Determination of pH,
Determination of total alkalinity and total dissolved inorganic carbon,
Determination of carbon dioxide partial pressure,
Determination of nutrients,
Determination of the major constituents,
Determination of trace elements,
Determination of natural radioactive tracers,
In situ determination of pH and oxygen,
Determination of dissolved organic carbon and nitrogen by high temperature combustion,
Automated determination of dissolved organic carbon by ultraviolet photooxidation,
Determination of particulate organic carbon and nitrogen,
Preparation of lipophilic organic seawater concentrates,
Adsorption chromatography of organic seawater concentrates,
Clean-up of organic seawater concentrates,
Determination of petroleum residues dissolved and/or finely dispersed in surface seawater,
Determination of selected organochlorine compounds in seawater,
Determination of volatile halocarbons in seawater,
Determination of dimethyl sulfide in seawater,
Determination of marine humic material,
Determination of amino acids and carbohydrates, and
Determination of photosynthetic pigments.

Obviously this is a multi-author book which reflects also several of the advantages and disadvantages of such an approach. The content of information is broad and impressive and almost all topics are reported in detail. On the other hand a general introduction and an outlook which could guide the reader to the still open problems of the field are missing. In general fundamentals of the methods are very briefly described and the book is written for the experienced analytical chemist.

The monograph starts with very informative chapters on sampling and sample conservation. These are very important issues and I believe that each book on analysis should cover this important step of the total analytical process. Unfortunately, the part on quality control seems to be too short and not up-to-date according to the uncertainty concept and now widely accepted terms (limit of detection and sensitivity are different parameters!). The following chapters are in general also well written and one may only wonder about several inconsistencies and repetitions with respect to the sequence and content of contributions from different authors such as chapters 8 and 15 (both on dissolved carbon, but far apart in the book), chapters 15 and 16 (both on DOC with many repetitions), and the arrangement of the clean-up description (Ch. 20) after the chromatography (Ch. 19).

Overall this monograph is well printed and should be on the bookshelf of all departments for marine research and chemical analysis.

Hendrik Emons
Research Center Juelich
Institute of Applied Physical Chemistry
Juelich, Germany

The Use of Matrix Reference Materials in Environmental Analytical Processes

Edited by A. Fajgelj and M. Parkany. Pp. x + 206. The Royal Society of Chemistry. 1999. Price (Hardcover) £59.50. ISBN 0-85404-739-5.

This book contains fourteen lectures presented at the Workshop on Proper Use of Environmental Reference Materials, which was held in Berlin on 22nd and 23rd April 1999. There are 14 different authors (or group of authors), many of whom are well known in the communities of matrix reference materials (RMs). How to prepare and certify RMs (CRMs), how to use them and how RMs provide measurement assurance are described. Some contributions are even embellished with philosophical thoughts about the role of matrix reference materials in the measurement process.

The chapters are unequal in quality and length, ranging between 7 and 30 pages. The first chapter 'China GBW reference materials' by Pan Xiu Rong and Zhao Min is the longest one. It might have benefited from a more thorough editing. This chapter comes very close to an incomplete textbook course. The authors go also out of their way to impress the reader by the achievements in the domain of RMs in the Republic of China.

Then follows an interesting chapter on 'How to use matrix certified reference material? Examples of materials produced by IRMM's reference materials unit' by J. Pauwels from the European Commission. As examples he cites the Mussel Tissue CRM, butyltins in coastal sediment, cadmium in polyethylene, 238-uranium dioxide for reactor neutron dosimetry, and two sets of curd RMs for the detection of cows' milk case in cheeses from ewes' and goats' milk. These examples illustrate the usefulness of new types of RMs for quality assurance in environmental and industrial issues.

The contribution on 'Proper use of reference materials for elemental speciation studies' (K. Okamoto and J. Yoshinaga, Japanese National Institute for Environmental Sciences) highlights the trend in trace element analyses towards speciation of the trace elements instead of total element measurements. Organotin compounds and alkylmercury species were chosen as examples.

The work of several other national and international organisations is discussed. For example the NIST (the USA National Institute for Standards and Technology), which has a longstanding tradition in RMs, the achievements of the IAEA (International Atomic Energy Agency) in the field of radionuclides, and the contribution of the UK's Laboratory of the Government Chemist in supplying RMs.

P. De Bièvre describes the function of matrix reference materials in the measurement process, and the book closes with an introduction to the ISO Guide 33 in the use of RMs and an overview on the activities at ISO/REMCO (this is the ISO's committee on reference materials).

This is a resourceful book for developing an understanding of the usefulness of reference materials in environmental analytical measurements. It is a valuable addition to the literature. Many of the authors represent the world-leading organisations in this field. The book can be recommended to beginners and experienced workers.

Rita Corneli
Laboratory of Analytical Chemistry, Institute for Nuclear Sciences, University of Gent, Gent, Belgium

These two reviews are reproduced from *The Analyst* by permission of the Royal Society of Chemistry. More reviews of general-interest analytical science books are available at www.rsc.org/analyst

Recent Books on the Environment and on Toxicology at the RSC Library

The following books and monographs on environmental topics have bee acquired by the Royal Society of Chemistry library, Burlington House, during the period July to December 1999. Recent additions on toxicology are also included in this list.

Chemistry, Health and Environment

Sterner, O., Wiley-VCH, Weinheim, 1999,
ISBN:3527300872, 345 pp., Accession No: 990361,
West Gallery 628.5:661

Practical Environmental Analysis

Radojevic, M., Bashkin, V.N.,
Royal Society of Chemistry, Cambridge, 1999,
ISBN:0854045945, 466 pp., Accession No: 990393,
West Gallery 628.54:543

Polymers and the Environment

Scott, G., Royal Society of Chemistry, Cambridge, 1999,
ISBN:0854045783, 132 pp., Accession No: 990405,
West Gallery 628.5:541.64

Environmental Protection: The Environment Act 1995 (Consequential Amendment): Regulations 1999 (SI 1999/1108)

The Stationery Office, London, 1999,
ISBN:0110824679, 1 p., Accession No: 990438,
A 100

Environmental Protection: The United Kingdom Ecolabelling Board (Abolition): Regulations 1999 (SI 1999/931)

The Stationery Office, London, 1999,
ISBN:0110823516, 3 pp., Accession No: 990439,
A 100

Environmental Protection: The Highway Litter Clearance and Cleaning (Transfer of Responsibility) (North West Leicestershire and South Derbyshire) Order 1999 (SI 1999/1007)

The Stationery Office, London, 1999,
ISBN:0110824296, 3 pp., Accession No: 990444,
A 100

Environmental Radiochemical Analysis

Newton, G.W.A. (ed.), Royal Society of Chemistry, Cambridge, 1999,
ISBN:0854047344, 406 pp., Accession No: 990542,
Reading Room 543.53:628.5:061.3

Lysimeter Concept: Environmental Behaviour of Pesticides

Fuhr, F., Hance, R.J., Plimmer, J.R. and Nelson, J.O. (eds.),
American Chemical Society, Washington DC, 1998, ISBN:0841235686, 284 pp., Accession No: 990611, West Gallery 632.95:628.5:061.3

Kyoto Protocol: a Guide and Assessment

Grubb, M., Vrolijk, C. and Brack, D., Earthscan, London, 1999,
ISBN:1853835811, 256 pp., Accession No: 990654, West Gallery
628.5

Register of Environmental Legislation 1999

Engineering Employers' Federation (EEF), London, 1999,
ISBN:0901700894, 120 pp., Accession No: 990655, Reference Shelves
REF 628.5:328.34 R

Managing Risks of Nitrates to Humans and the Environment

Wilson, W.S., Ball, A.S. and Hinton, R.H. (eds.), Royal Society of Chemistry, Cambridge, 1999,
ISBN:0854047689, 347 pp., Accession No: 990669, West Gallery 63:615.9:061.3

Environmental Catalysis

Janssen, F.J.J.G. and van Santen, R.A. (eds.), Imperial College Press, London, 1999,ISBN:1860941257, 369 pp., Accession No: 990711, West Gallery 628.5:541.128

Environmental Labels and Declarations - Self-Declared Environmental Claims (Type II Environmental Labelling) (BS ISO 14021:1999)

British Standards Institution (BSI), London, 1999, ISBN:0580354253, 23 pp., Accession No: 990782, West Gallery 628.5

European Community Environment Legislation: Volume 1 - General Policy, 2nd Edition

European Commission, Brussels 1996, ISBN:928276835X, 260 pp., Accession No: 990801, Reference Shelves REF 628.5:328.34 R

European Community Environment Legislation: Volume 2 - Air, 2nd Edition

European Commission, Brussels, 1996, ISBN:9282768465, 330 pp., Accession No: 990802, Reference Shelves REF 628.5:328.34 R

European Community Environment Legislation: Volume 3 - Chemicals, Industrial Risks and Biotechnology, 2nd Edition

European Commission, Brussels, 1996, ISBN:9282768554, 369 pp., Accession No: 990803, Reference Shelves REF 628.5:328.34 R

European Community Environment Legislation: Volume 4 - Nature, 2nd Edition

European Commission, Brussels, 1996, ISBN:9282768643, 293 pp., Accession No: 990804, Reference Shelves REF 628.5:328.34 R

European Community Environment Legislation: Volume 5 - Noise, 2nd Edition

European Commission, Brussels, European Community, 1996, No: 990805, Reference Shelves REF 628.5:328.34 R

European Community Environment Legislation: Volume 6 - Waste, 2nd Edition

European Commission, Luxembourg, European Communities, 1996, ISBN:9282768821, 238 pp., Accession No: 990806, Reference Shelves REF 628.5:328.34 R

European Community Environment Legislation: Volume 7 - Water, 2nd Edition

European Communities, Luxembourg, European Communities, 1999, ISBN:9282768910, 187 pp., Accession No: 990807, Reference Shelves REF 628.5:328.34 R

Endocrine Disrupting Chemicals (Issues in Environmental Science and Technology)

Hester, R.E. and Harrison, R.M. (eds.), Royal Society of Chemistry, Cambridge, 1999, ISBN:0854042555, 151 pp., Accession No: IEST9912, C 23A

Handbook of Environmental Data on Organic Chemicals [CD-ROM], 3rd Edition

Verschueren, V., John Wiley, Chichester, 1998, ISBN:047128811X, Accession No: 990566, Reference Shelves REF 615.9547 R

Progress in Neuropharmacology and Neurotoxicology of Pesticides and Drugs

Beadle, D.J. (ed.), Royal Society of Chemistry, Cambridge, 1999, ISBN:0854047298, 217 pp., Accession No: 990614, West Gallery 632.95:615.21:061.3

The *ortho* Side of PCBs: Occurrence and Disposition

Hansen, L.G., Kluwer Academic, Massachusetts, 1999, ISBN:0792385411, 269 pp., Accession No: 990627, West Gallery 615.9

Product Safety Evaluation Handbook

Gad, S.C. (ed.), Marcel Dekker, New York, 1999, ISBN:0824719719, 692 pp., Accession No: 990632, West Gallery 615.9:614.8

Skin and Respiratory Sensitisers: Reference Chemicals Data Bank

ECETOC, Brussels, 1999, 89 pp., Accession No: 990684, West Gallery 615.9

IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Printing Processes and Printing Inks, Carbon Black and some Nitro Compounds: Volume 65

International Agency for Research on Cancer (IARC), Lyon, 1996, ISBN:9283212657, 578 pp., Accession No: 990828, West Gallery 616-006.6:061.3

IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Some Pharmaceutical Drugs: Volume 66

International Agency for Research on Cancer (IARC), Lyon, 1996, ISBN:9283212665, 514 pp., Accession No: 990829, West Gallery 616-006.6:061.3

IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Human Immunodeficiency Viruses and Human T-cell Lymphotropic Viruses: Volume 67

International Agency for Research on Cancer (IARC), Lyon, 1996, ISBN:9283212673, 424 pp., Accession No: 990830, West Gallery 616-006.6:061.3

IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Silica, Some Silicates, Coal Dust and para-Aramid Fibrils: Volume 68

International Agency for Research on Cancer (IARC), Lyon, 1997, ISBN:9283212681, 506 pp., Accession No: 990831, West Gallery 616-006.6:061.3

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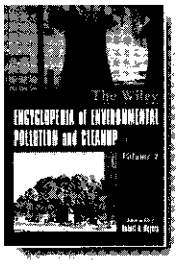

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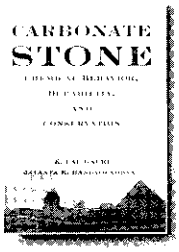

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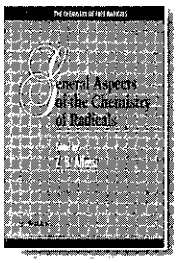

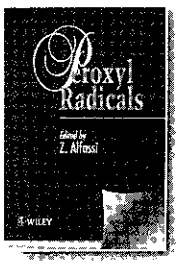

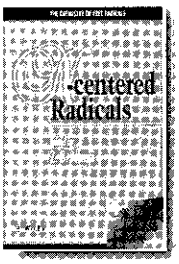

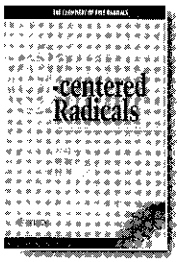

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