THE ROYAL SOCIETY OF CHEMISTRY

ENVIRONMENTAL CHEMISTRY GROUP

Newsletter

Issue No.15 - February 2002

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ECG Newsletter No. 15 - February 2002

The contents page of this ECG Newsletter may be seen on the Internet at http://www.rsc.org/lap/rsccom/dab/scaf003.htm

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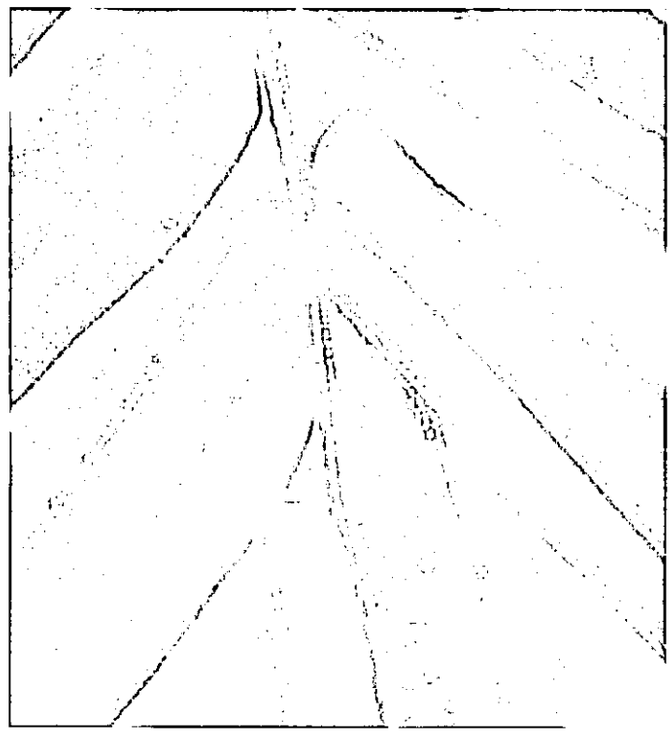
Pteris vittata L. (Adiantaceae)

Chinese Brake Fern (Ladder Brake Fern)



Brake fern is becoming increasingly common. The once-divided fronds are dark green. The pinnae are lightly serrated along the edge. The pinna at the tip of the frond is usually longer than the other pinnae, and its base is clearly unevenly divided. Plants growing on open rock are usually much smaller than plants growing in rich soil. Spores form lines along the edges of each pinna. In 2001, it was discovered that *Pteris vittata* can hyperaccumulate arsenic - offering a possible cheap way of remediating arsenic-contaminated soils: see page 20 for details.

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Chairman's report for 2001

Several changes in legislation are planned or have been enacted in 2001 that have importance for the environmental community. Continuing tightening up of the UK's National Air Quality Objectives suggest that the need for the provision of high quality data to local authorities will continue to increase. The links between traffic planning and air quality are more frequently being used to argue for the implementation of schemes for pedestrianisation and traffic-free zones and hence it may be expected that cheap, reliable real-time monitoring of VOCs, PAHs, PM_{10}s and NO_x will be in demand.

The extension of SSSI regulations implicit in the Countryside and Rights of Way Act 2000 (CROW) also has implications for those involved in environmental monitoring. Effectively the Act requires all Government Departments, local authorities and privatised utilities to take account of advice from English Nature concerning work that may affect a SSSI (this does not have to be on a SSSI). There will be implications of this legislation for impacts of distant sources of air and water pollution on SSSIs.

During 2001 the RSC has been closely involved in the guidance being developed for the UK government in relation to the Royal Commission's Study on the Long-term Effects of Chemicals in the Environment ('the Chemicals Study'). The task of classifying the products of the UK chemicals industry will be long and complicated and profound economic and social implications may result from it. However, there is no doubt that there will also be opportunities for a closer examination of toxicological methods for assessing the long-term effects of the products of the industry on human and environmental health. Legislative processes may take some time to be effective but the eventual outcomes must provide a clear set of procedures that will assist in allaying the fears of an increasingly suspicious public end-user community.

Finally, in this Chairman's report I need to address moves within the RSC to consider the interests of the several groups that have identified environmental matters as a salient feature of their raison d'être. Some of the considerations behind the discussions currently under way are explained in two articles by Rodney Townsend and by Bob Hazell and Derek Lohmann, respectively, in this issue of the ECG Newsletter. The ECG Committee awaits these developments with some interest. In particular we note the need for a coherent annual programme of environmentally themed conferences.

This will be the last edition of the ECG Newsletter in its present form. The excellent editor (Rupert Purchase) has decided to relinquish this role after some 10 years of editorship and the committee thanks him profusely for this large contribution to the ECG. The ECG will try to ensure that some form of a Newsletter/Bulletin is continued and we hope this will retain the high standard that Rupert has set as a precedent. In the past the Newsletter has used a substantial fraction of the ECG's income and for the immediate future, it is the Committee's intention to look at the funds available for 2002-2003 with the idea of organising a major conference. For this Newsletter, as with past issues, we are grateful to other parts of the RSC for their help and for providing information for publication. In particular, we thank the *Journal of Environmental Monitoring* for permission to reproduce the article on teaching environmental and human toxicology at McMaster University.

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Forthcoming symposium

Organic Contaminants in Soil, Water and Sediment: The Cutting Edge

A one day meeting focusing on new research on organic contaminants

VENUE: University of Reading, Thursday 2nd May 2002

INVITATION FOR PRESENTATIONS AND REGISTRATION

Oral presentations and posters of recent (and particularly in-progress) research are welcomed from both established researchers and research students for "Cutting Edge 2002". The meeting offers the opportunity to present new work in the field of organic contaminants in soil, water and sediment in an informal atmosphere. Previous years have seen presentations and posters covering a range of issues such as pesticide transport in sediments and soils, organic contaminant fate in marine systems, degradation of organic contaminants in aquifers and groundwater, steroids in environmental waters and the application of mathematical/computational modelling to organic contaminants in the environment.

The registration fee is £15, which includes lunch, refreshments and a book of abstracts.

For further information please contact: Dr Nicky Warren, Post-graduate Research Institute for Sedimentology (PRIS), University of Reading, Whiteknights, Reading. RG6 6AB UK. tel: +44 (0)118 987 5123 ext 7981 fax: +44 (0)118 931 0279 e-mail: n.warren@reading.ac.uk

or visit the Web site: http://www.rdg.ac.uk/~ass99nw/homepage.html

The Royal Society of Chemistry and the environmental sciences: new directions

Discussions are taking place as to how the Royal Society of Chemistry can best represent its members' interests in the environmental sciences. **Professor Rodney Townsend**, General Manager of Scientific Affairs and Conferences at the RSC, describes the background to these discussions.

A few months ago *Nature* published a feature article entitled "Chemists buried by its interdisciplinary successes" (*Nature*, 2001, **411**, 399). How true this is! We have been outstandingly successful across a range of endeavour; there is scarcely any area of manufacture and technology that has not leant on the chemical sciences to help solve its problems and innovate. Similarly, the academic community is startlingly successful at obtaining money for the chemical sciences from areas in addition to the Chemistry Programme within EPSRC such as chemical biology, materials chemistry and of course environmental sciences.

Yet despite this, the image of chemistry has remained depressingly poor. The RSC has a role in helping to improve our image and profile, but until recently it lacked the science support base that could enable it to respond to new scientific advances, initiatives and activities within the broader field of chemical sciences as a whole. This is why we have been expanding rapidly over the last eighteen months our activities in chemical biology and materials chemistry.

But what about the environmental sciences? We have several large interest groups active in this broad area, as well as the Environmental, Health and Safety Committee, the Green Chemistry Network and, very recently, Project Crystal. It seemed the right time to see if we could organise ourselves more coherently in order to operate more effectively overall. For this reason, David Taylor and I wrote a short paper to act as a "cockshy" and to elicit views from the "environmental community" within the RSC. You may have seen this paper – in essence we suggested that we should perhaps cluster our activities around a new body, which could be called the "environmental forum", and which would represent our interests as a whole without prejudicing the interests and activities of individual interest groups.

The general response to these our initial thoughts was positive, although several common themes of concern emerged. Amongst these were that:

- We must be very clear what added value such a body brought to our current activities. The last thing we wanted to do was just to add another committee to our already Byzantine structure within the RSC!
- As corollary to this first point, we should beware of duplicating activities already covered better by current interest groups (e.g. your own Environmental Chemistry Group!)
- With such a strong emphasis on new science, there was a danger that we would neglect in the future key areas such as health and safety.

Nearly all the comments received were most helpful, and they prompted David and I to meet up together recently to work out how to respond. We realised that maybe we had not been thinking big enough! The reality is that in addition to environmental considerations, we should explicitly include other areas such as energy utilisation, health, safety, well-being and social responsibility. Consequently, Bob Hazell and I are suggesting that representatives of all interest groups meet together to discuss a larger and bolder initiative, one that will assist the RSC to operate more effectively than it does now in the provision of advice to governmental bodies, new initiatives and the public understanding of science. We hope to be able to do this in late April, and will come back to you all after that.

One other, more parochial issue – we all know that Rupert will not be producing this Newsletter in the future. He, Leo Salter and other members of the ECG Committee are anxious that this should not be the last edition. It may be that we should support directly from our central resources this or a similar publication in the future. I hasten to say that we are not clear yet as to whether this is practicable, but the issue should and indeed must remain on the agenda, for resolution in the near future.

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February 2002

Brief biographical note: *Rodney Townsend joined the RSC just over two years ago, as General Manager, Scientific Affairs. His initial remit was to develop new chemical science initiatives within the RSC, beginning with the life sciences. Recently, he became General Manager of Scientific Affairs and Conferences. This enlarged department covers all scientific and industrial divisional, subject group and forum activity within the RSC as well as Awards and the old Conferences Department.*

Before joining the RSC, Rodney was an academic for 12 years, researching on zeolites. He then joined Unilever Research for a further 12 years, to manage parts of their corporate research programmes in the physical and material sciences within Europe, the USA and India.

Environmental methylation and the global chemical merry-go-round

Royal Society of Chemistry, Environmental Chemistry Group Distinguished Guest Lecture for 2002

Professor Peter Liss from the School of Environmental Sciences, University of East Anglia, gave this year's ECG Distinguished Guest Lecture in which he described the role of biomethylation in the transport of elements and the subsequent environmental chemistry of the methylated derivatives.

Introduction

Many of the elements in groups 5, 6 and 7 of the Periodic Table can be easily methylated, or otherwise made volatile, by biological and/or photochemical processes in marine waters. Since this generally happens near the sea surface, the volatile forms are free to cross the sea-air interface and enter the atmosphere. There they undergo a variety of photo-chemical and radical reactions to form products, which can substantially affect the redox chemistry and climatology of the atmosphere. In addition, this transfer of material from the sea to the marine atmosphere and subsequently to land is an important process in the global cycling of the elements, some of which are vital for human health.

Processes by which volatile species are formed in the oceans, and their subsequent impact on the atmosphere and land have been described for, *inter alia*, nitrogen, sulphur, selenium, chlorine, bromine and iodine. The formation processes and environmental impacts of volatile forms of Group 6B elements are representative of how marine methylation leads to the cycling of elements throughout the globe.

Group 6B Elements

Dimethyl Sulphide in the Environment

The most studied of the Group 6B elements, which can be converted into methylated derivatives is sulphur. The product, dimethyl sulphide (DMS), a gas, was first detected in a marine red seaweed by Haas in the mid 1930s. Challenger at the University of Leeds was the first to show some fifteen years later that DMS is formed from the precursor compound dimethyl sulphoniopropionate (DMSP) ($Me_2S^+CH_2CH_2CO_2^-$) (Challenger, F. and Simpson, M. I., *J. Chem. Soc.*, 1948, 1591).

Subsequently, DMSP has been shown to be present in virtually all seaweeds and marine phytoplankton, although the amount is highly variable. Its function in the organisms is thought to be as an osmolyte, and possibly also as a cryoprotectant.

Jim Lovelock made the first substantial measurements of DMS dissolved in the oceans in the early 1970s. Since then considerable effort has gone into the study of DMS, its production by algae, flux across the sea surface, oxidation in the atmosphere to sulphate and other particulate products and their deposition to land. Although many parts of this cycle are of considerable academic interest in their own right, it is the formation of atmospheric particles which has been a major driving force for the work. This is because the particulates formed by atmospheric oxidation of DMS are acidic, and in regions of the globe remote from land and industrial sources they constitute the main source of acid for both aerosols and rain/snow. In areas close to and over land, particularly where fossil fuels are burnt, this natural acidity can be largely swamped by sulphate from oxidation of man-made SO_2.

In addition to their role in atmospheric acidity, the particles formed by oxidation of DMS can also act as cloud condensation nuclei (CCN) and so have an influence on climate, since cloud formation is strongly dependent on CCN number density. The effect is highly non-linear, being far more effective in regions where the CCN number density is low. This is the situation over oceanic areas away from land, a situation particularly prevalent in the southern hemisphere with its high ratio of ocean to ice-free land areas (which are the source of many of the CCN in the northern hemisphere). The production of DMS in the oceans and its reactivity on release to the atmosphere are illustrated in **Figure 1**.

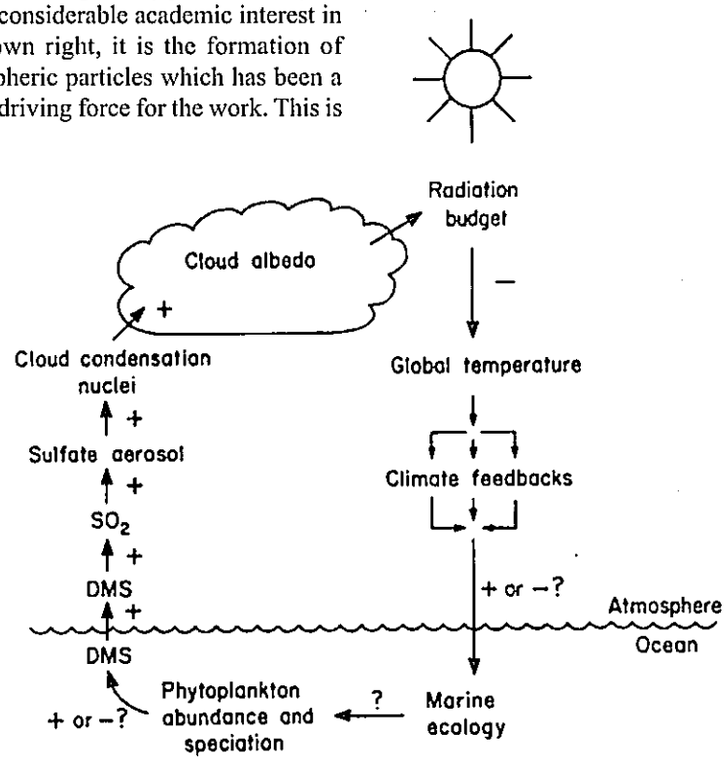

Figure 1 Proposed feedback cycle between climate and marine DMS production. Signs indicate whether an increase in the value of the preceding parameter in the cycle is expected to lead to an increase (+) or a decrease (-) in the value of the subsequent parameter (from Andreae, 1990)

The figure also indicates that a feedback mechanism has been proposed by Charlson, Lovelock, Andreae and Warren (the 'CLAW' authors) in which production of DMS in the oceans is hypothesised to play a role in stabilising the climate of the Earth through the DMS-CCN-cloudiness linkage. Although tantalising, the CLAW hypothesis has proved extremely difficult to prove, or disprove, since it was first proposed about fifteen years ago. For example, evidence from ice cores from Greenland and Antarctica is both positive and negative with respect to the idea, and it may be a long time (if ever) before a definitive answer is forthcoming. Notwithstanding this uncertainty over the validity of the CLAW hypothesis, the role of marine biogenetically-produced DMS in atmospheric acidity and CCN production, particularly in remote marine areas, appears well established.

A further role that DMS plays globally is in transferring sulphur from the oceans to the atmosphere, with some of it ultimately being deposited onto land via precipitation. In regions where the soils are naturally sulphur deficient this transfer from marine to terrestrial realms can be important for plant growth. Without this sea to land flux of DMS it is not possible to achieve balance in the global cycle of sulphur.

Biomethylation of Selenium

A similar situation exists for the next element in Group 6B, selenium. Thus, it has been known for several years that in order to balance the global budget for Se it is necessary to invoke a flux of some volatile form of the element from sea to land, although it is only recently that we have been able to demonstrate that such a flux actually occurs. Measurements made by us in collaboration with David Amouroux from the University of Pau in France on samples from the north Atlantic show that the transfer occurs through the formation of dimethyl selenide (DMSe), as well as dimethyl diselenide and dimethyl selenyl sulphide.

As with DMS, it seems likely that the formation of DMSe and the other methyl selenides, is by algal activity. This contention is supported, but not proved, by the moderate correlation between the measured values for DMS and DMSe for the north Atlantic samples shown in **Figure 2.** Calculation of the sea-to-air flux of these selenium gases indicates that, if the measurements are representative of the situation generally, then there it is sufficient to balance the global budget of Se, with the oceans then being a significant provider of the element to the terrestrial zone.

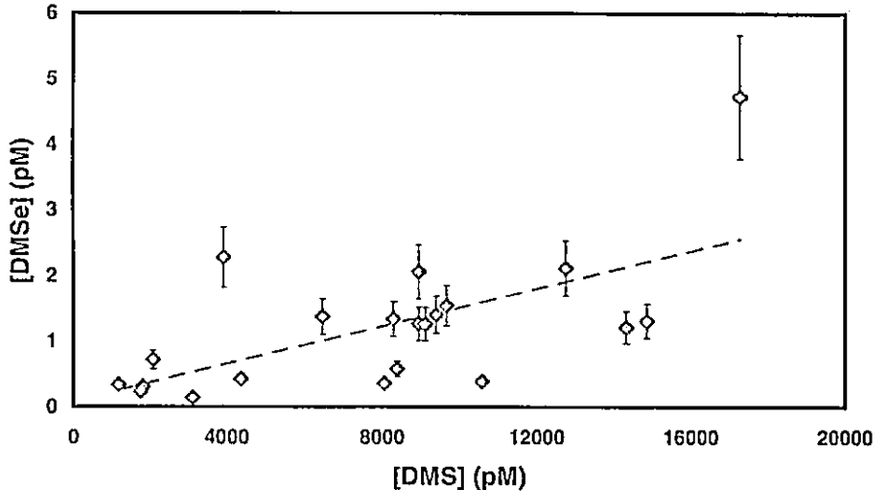

Figure 2 Relationship between DMSe and DMS concentrations in surface waters of the North Atlantic Ocean in June 1998 (Lat. 60°N, Long. 20°W). [DMSe] = 0.0001 (DMS) + 0.0794 (R^2 = 0.4055)

This is important since selenium is a vital element for plants and mammals, including humans. In fact there is evidence that even in Europe, where we like to think that we have a nutritionally satisfactory diet, many people typically receive only half of the selenium needed for good health. The situation in poorer parts of the world is likely to be even less satisfactory, and there is evidence for human disease arising from serious selenium deficiency in parts of China. In contrast, selenium in excess can be injurious to health, for example to aquatic birds in parts of California. Because the fluxes of volatile selenium from the oceans are four orders of magnitude less than those of sulphur, it is unlikely that DMSe etc. play any substantial role in terms of atmospheric acidity or particle formation.

Biomethylation of Tellurium and Polonium

So what is the situation for the remaining elements in Group 6B? For tellurium, although volatile forms are probably formed in extreme situations such as in sewage sludge digesters, no measurements appear to exist for marine waters. This is hardly surprising given the analytical difficulties of measuring this element when its seawater concentration is of order 1 p mol kg^{-1}, i.e. 2000-fold less than Se whose volatile forms are currently at the limit of our detection capabilities. However, given the chemical behaviour arising from its position in the Periodic Table, there is a strong possibility that methylated tellurium is formed and that ultimately it will be detected and measured in the oceans.

For the final member of Group 6B, polonium, the analytical difficulties of detecting it chemically are even more severe. However, because of the existence of natural radioactive forms it is possible to measure it in seawater and atmospheric samples. Indeed, measurements made recently by Tom Church and colleagues at the University of Delaware of ^{210}Po in atmospheric aerosol samples show that marine, as compared to land, derived samples exhibit greater Po enrichment, which is best explained by the existence of a flux of volatile polonium from the sea to the atmosphere.

Several aspects of the research described in this brief overview are conducted in my research group, which is part of the Laboratory for Global Marine and Atmospheric Chemistry (LGMAC) at UEA, as described in more detail in a recent issue of this Newsletter (Issue No. 14, July 2001) and at http://www.uea.ac.uk/env/lgmac/. In the international context the work falls

centrally in the new IGBP project called SOLAS (Surface Ocean-Lower Atmosphere Study), of which further information can be found at http://www.uea.ac.uk/env/solas/.

Further Reading

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Organometallic compounds in the environment: general considerations

In the first of two talks, which accompanied this year's Distinguished Guest Lecture, **Professor Peter Craig** from De Montfort University, an ECG committee member, outlined some of the developments that have influenced our understanding of the behaviour of organometallic compounds in the environment

Introduction

The environmental chemistry of organometallic compounds predominantly centres on compounds with metal sigma carbon bonds and, in particular those with metal alkyl bonds. A few metal pi-bonded systems have environmental implications, e.g. $Mo(CO)_6$; $W(CO)_6$ and cyclopentadienylmanganesetricarbonyl. But most attention has been directed towards compounds with methyl substituents and to a lesser extent on compounds with other alkyl/aryl substituents (e.g. ethyl- or phenylmercury, ethyllead derivatives and butyltin compounds).

The stability, transport, and toxicity of organometallic compounds depend on the number and type of metal alkyl and metal aryl groups present in the compound. Different compounds of the same or dissimilar metals can co-exist in the same location in the environment. Moreover, environmental and toxic effects can be exerted by organometallic compounds at very low concentrations.

Analysis of Organometallic Compounds

Unravelling these subtle distinctions in the identity, speciation and concentration of organometallic compounds has depended crucially on advances in analytical chemistry over the last fifty years. Interfaced or hyphenated analytical systems, which combine **separation** and **detection** methodologies, have been a pivotal development in the analysis of organometallics in the environment.

The main methods of **separation** are:

1. Gas chromatography (conventional or capillary)
2. Thermal desorption methods (these depend on boiling points)
3. High performance liquid chromatography
4. Flow injection methods
5. Ion exchange chromatography
6. Ion chromatography.

The main methods of **detection** are:

1. Atomic absorption spectroscopy (flame, graphite furnace, zeeman, hydride generation/quartz furnace)
2. Atomic fluorescence spectroscopy (alone or via hydride generation)
3. Atomic emission spectroscopy (usually inductively coupled plasma)
4. Voltammetry
5. Mass spectrometry (conventional or chemical ionisation, electrospray, tandem, isotope dilution)
6. X-ray and neutron methods

Many organometallic compounds and especially cationic derivatives are insufficiently volatile for gas chromatographic (gc) analysis unless they are first derivatised. This is usually achieved by transfer of a hydride ion (using $NaBH_4$), an ethyl carbanion (using $NaBEt_4$), or an alkyl group (using a Grignard reagent), in a formal S_N2 stage. Derivatisation has been widely used, even in the case of mercury, where it had previously been thought that mercury

hydrides would be too unstable for gc analysis.

The successful development of coupled **separation-detection** analytical techniques has lead to a better understanding of organometallic compounds in the environment. For example:

- The origin of organometallics – natural, or anthropogenic as a result of deliberate use and release into the environment;
- How and where organometallic compounds are formed in the environment – in sediment, water, or the atmosphere;
- The properties and behaviour of organometallic compounds in the environment;
- The transport, degradation, metabolism, and ultimate fate of organometallics in the environment.

Global biogeochemical cycles, and in particular the environmental methylation of inorganic compounds, are important routes for the formation of organometallic compounds in the environment.

Speciation and Toxicity

A better understanding of the speciation of individual elements (arsenic, mercury etc), has also lead to an appreciation in differences in toxicity of different species of the same metal, e.g. the very toxic As_2O_3 and the relatively non-toxic arsenobetaine, $(CH_3)_3As^+CH_2CO_2^-$. Toxicity also depends on the degree of alkyl substitution of a metal and the identity and chain-length of an alkyl group. There may also be species-species differences in toxicity towards the same organometallic compound.

Speciation can alter the transport parameters of an element, thus influencing its partition properties in air or water. Organometallic cations (e.g. $SnBu_3^+$) tend to be water soluble and non-volatile, but neutral species (e.g. $PbMe_4$) are hydrophobic and volatile.

Speciation and Quantitation

Detection limits for elements in biological and environmental matrices have dramatically decreased over the last twenty-five years. The standard, which is now commonly achieved, is parts per billion (10^{-9}) (ppb; ng g^{-1}). But parts per 10^{-12} (ppt) and parts per 10^{-15} (femtograms per gram; fg g^{-1}) are also frequently reported. The relevance in practical terms of such extremes of dilution should always be borne in mind. Analytical and environmental chemists should pause to consider what chemical species may **not** be present in a matrix at fg g^{-1}, or more dilute, levels. Chemical analysis is usually targeted towards the species of interest and much else that is present may be missed or ignored. As the greater sensitivities of chemical analyses become evermore attainable, there exists a responsibility on chemists to comment on the practical importance or significance of his or her results. The question arises, if the level of a certain species is of the order of 10^{-12} parts per gram, does it **matter** and if so **to whom**? If it does matter, then part of that responsibility is to point out the reasons for the importance of the result.

From an environmental aspect, organometallic derivatives of mercury, lead, tin and arsenic are perhaps of most concern. Organoantimony compounds have also received prominence in the last few years. In the remainder of Professor Craig's talk, the environmental chemistry of these Group II, IV and V compounds was reviewed.

Professor Craig is currently editing a second edition of his book Organometallic Compounds in the Environment, *which was first published in 1986.*

In the second talk, which accompanied this year's Distinguished Guest lecture, Professor Nick Owens from the Plymouth Marine Laboratory discussed the Global Nitrogen Cycle.

New databases on air quality research

The Institute for Environment and Health (IEH), Leicester, has compiled two databases on air pollution research. These have been designed to provide government departments and funding bodies with an up-to-date source of information which they may use to:

- Identify individuals and groups with expertise in particular aspects of air pollution research;
- Provide information on current topics of air pollution research;
- Identify gaps in research on air pollution;
- Identify new advances in the air pollution field; and
- Assist in the prioritisation of future research on air pollution.

The IEH are encouraging all researchers in the field to submit information on their work for inclusion in either or both of these databases.

The Air Pollution Research Database (APRED). This holds information on research into indoor and outdoor air pollution within the UK. Its particular focus is the individual researchers, their expertise and areas of interest. It has been prepared on behalf of the Department of Health and the Department of the Environment, Transport and Regions. The email contact address for this database is apred@le.ac.uk

The Inventory of European Research on the Indoor Environment (IERIE) Database. This holds data on research into indoor air pollution in Europe, including the UK. Its primary intention is to identify all current research projects in this field. It has been prepared on behalf of the European Chemical Industry Council (CEFIC). The email contact address for this database is ierie@le.ac.uk

Researchers working on indoor air pollution in the UK need only submit their details once, using the APRED questionnaire form. Questionnaires for these databases can be downloaded from their respective sites. For further information about these projects or to enquire about submitting data please contact Charles Aylward on +44 (0)116 223 1612 or ca28@le.ac.uk

Environmental analytical chemistry at Imperial College

Dr Susan Parry describes the wide-ranging analytical challenges posed by research into environmental chemistry at the Silwood Park campus of Imperial College.

Introduction

The newly formed Department of Environmental Science and Technology is part of the Faculty of Life Sciences at Imperial College. The Environmental Measurement, Modelling & Assessment Group contains the department's main experimental facilities, based at the Silwood Park campus. My group is concerned with environmental analytical research – the development of novel methodologies to solve environmental problems. Silwood Park is the site of the only UK nuclear research reactor, and my neutron activation analysis (NAA) facility is used in addition to inductively coupled plasma-mass spectrometry (ICP-MS) to address a range of topics through PhD research and industrially funded projects. In addition, my team of experts in NAA carry out analytical service work for industry and the regulators.

Analysis of Platinum Group Metals

A key research topic concerns the platinum group elements (PGE), in particular Pt, Pd and Rh, which are used in catalysts to reduce automobile emissions and have an increasing impact on the environment [1]. This work, carried out in collaboration with Dr Kym Jarvis of the NERC ICP-MS Facility, continues to monitor the presence of the PGE in the roadside environment using a fire assay technique developed in the laboratory to digest and pre-concentrate up to 25 g of road dust. The PGE are collected in a small button of nickel sulfide, which is dissolved in acid and the PGE extracted for ICP-MS analysis. Typical concentrations of PGE measured in road dust in 1995 were 191 ng/g Pt, 25 ng/g Pd and 21 ng/g Rh; a recent study at the same site has shown that Pd concentrations have risen significantly. We have found that Pd is much more soluble than Pt and Rh in these samples, and further work will concentrate on the processes influencing the behaviour of Pd in the environment. The determination of the PGE in the atmosphere creates a greater challenge since the total Pt concentration in an urban environment is only 10 pg/m^3. This requires careful preparation of very small samples and the use of sophisticated sample introduction techniques to enhance the sensitivity of the analysis.

Copper and Manganese Analysis

Fruitful collaborations have also continued with the Water Research Centre (WRc) through the EPSRC Partnership Initiative, where PhD students are funded at Imperial College to work on topics of mutual interest. One area is the development of an environmental quality standard for copper, which may to used to assess the bioavailability of copper in the aquatic environment [2]. The second is related to the health effects of manganese in the environment. My student aims to establish the bioavailability of manganese in the diet and, since the single main source of manganese in the diet is from the consumption of tea, tea drinkers and non-tea drinkers are being studied, in collaboration with St Thomas' Hospital. Blood from the two groups is currently being analysed, and in addition the bioavailability of the Mn in tea is being measured experimentally.

Migration of Packaging Components

Packaging is a potential source of contamination in food and, in the past, I have used NAA to study the migration of elements from plastic packaging into liquids [3]. The Food Standards Agency (FSA) recently funded a project to use the same technique to assess the impact of recycling paper on food safety. It has been noted that the process of recycling can concentrate some elements in the packaging and the purpose of this work was to measure the extent to which this occurred and to determine whether any of these elements migrate into food in contact with the packaging. Using NAA my student has shown that the recycling process concentrates a number of elements, so she applied a radiotracer technique to measure their migration into food [4,5]. The technique is to irradiate a sample of paper & board packaging, to place the food in contact with the paper and board for up to 90 days, and then to look for any evidence of radioactivity in the food. This method is much more sensitive than other analytical procedures, where background levels of the element already present in the food would have to taken into account. Happily, no signs of significant migration have been observed.

Radionuclide Analysis

Although it is usually the case that NAA is used to determine stable elements, it is also possible to activate a radionuclide. My research on the behaviour of ^{129}I is dependent on the ability to improve on the sensitivity of the radiometric determination by activating ^{129}I to produce ^{130}I, and measuring gamma decay, providing a detection limit for ^{129}I as low as 10^8 atoms /g [6]. ^{129}I is a fission product emitted during nuclear waste reprocessing at Sellafield, UK, and La Hague, France. It has a half-life of 15 million years and therefore its behaviour and ultimate fate in the environment is extremely important. Much of the research carried out by my student at Imperial College and Westlakes Scientific Consulting, funded by BNFL and the FSA, has been concerned with elucidating the speciation of ^{129}I as it is dispersed across Sellafield from atmospheric emissions. This is an important research area which is used to validate modelling of the movement of ^{129}I through the food chain. Studies include the speciation of ^{129}I in the atmosphere, deposition onto soil and grass and the uptake from soil into crops and grass, from grass into cows, the concentration of 129I in cows' milk and its behaviour on storage [7]. A project just reaching completion is designed to determine the relative importance of aerial deposition compared to the uptake of ^{129}I from soil into fruit. Future work will look at the speciation of ^{129}I in the

atmosphere and marine environment, since the majority of the radionuclide is discharged to sea. This work will add to the limited knowledge available on the global cycling of ^{129}I and will contribute to the understanding of its behaviour, which will become increasingly important as the Sintra Objectives drive down discharges of other important radionuclides, such as ^{99}Tc.

New Methodologies

My interest in new methodologies extends to the development of specialist nuclear instrumentation, such as a device to measure multiphase flow. A dual energy gamma metering device has been developed for the oil industry to provide rapid metering of oil flow rates from subsea wells, in the presence of water and gas. Gamma density metering is a non-intrusive method, based on photon attenuation, for interrogation of the contents of a pipe or chemical reactor, and therefore can be applied to difficult, remote or aggressive environments. I was responsible for the nuclear instrumentation of the device, which is now manufactured under licence for the oil industry [8]. A research study has since shown that the same technology can be used to detect trace concentrations of heavy metals in a complex solution containing a variety of lighter elements, using a dual X-ray system [9]. Future work is planned to take the work into the measurement of particulates in gaseous emissions, funded by a consortium of members of the minerals industries.

Environmental Diagnosis Course

Finally, in 1998 I initiated the MSc in Environmental Diagnosis, a course designed to provide science graduates with the tools to make an accurate and thorough assessment of environmental problems. The course is 50% practical with a high component of transferable skills. Industry and the regulators have provided enthusiastic support for the course and most of our students find placements where they carry out relevant research projects for five months of their year, and even receive job offers at the end of their stay. For example, students have worked with AWE, WRc, Shell, the British Antarctic Survey, AEA Technology and Knight Piesold, and their projects have taken them as far afield as Hawaii, Mauritius, Gibraltar, Hong Kong, the Bahamas and Greece. The experience gained by our students results in them being quickly employed in the environmental sector, and it is satisfying for me to note that every year one or two students carry out work on radioactivity in the environment. There is a desperate lack of training at undergraduate and postgraduate level for radiochemists in the UK and it is my view that a very positive way of encouraging a continuing interest in radiochemistry is through study in the area of environmental measurement, modelling and assessment.

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Waste management at the University of Central Lancashire

Since the publication of the Government's Waste Strategy 2000 for England and Wales, the waste management sector has attracted increasing attention. The Strategy focused upon the need to reduce the volumes of waste we produce from industrial, commercial and domestic sources in order to reduce environmental impacts and enable us to better manage our valuable, but ever-shrinking, resources. The Department of Environmental Management at the **University of Central Lancashire** has provided post-graduate waste management courses since 1991 and has over 130 graduates, most of whom are employed in the waste management sector. This short article attempts to provide an overview of these activities; for more information the reader is directed to the appropriate searchable web pages to be found at the University (www.uclan.ac.uk).

Introduction

Waste Management is currently taught at Masters Level at the University of Central Lancashire, although lower-level vocational courses have also been provided in the past, The Department of Environmental Management (EM) has worked closely with the industry and its main professional body (the Institute of Wastes Management) in the development of the MSc course curriculum, and consequently, there is a strong emphasis on the development of a combination of academic and professional knowledge and skills. The MSc aims takes an inter-disciplinary approach to the challenges of sustainable waste management, with students being encouraged to link their academic understanding firmly to industrial policy and practice, and there is an emphasis throughout on the development of skills relevant to problem-solving in industry, statutory and voluntary agencies. The course draws on an established network of professional and industrial links that provide regular visiting speakers, site visits, "live" projects and placements.

The taught Masters provision is available full-time (48 weeks) and part-time (normally over 3 years) and has been designed to provide a rigorous post-graduate scheme of education and training for graduates (or equivalent) seeking to enter the waste management and "environmental" sectors, and to offer those working in industry with opportunities to enhance their qualifications and career advancement prospects. In particular, our post-graduate waste management course is well known within the industry and has recently received considerable funding for staffing and student bursaries from the Landfill Tax Credit Scheme.

Practical support for the course is provided by the Faculty of Science's Analytical Unit, which has extensive facilities for chemical analysis. This is a central facility that houses all the basic instrumentation and expertise required for analytical science. The Unit is housed within three newly refurbished laboratories, which comprise the chromatographic suite, the spectrometry suite and the sample preparation and pre-treatment suite. In addition, a wide range of resources are available for use by students and staff, including a Resources Centre that houses the Department's literature, journal, video and CD-Rom collections; a range of monitoring and field equipment; computing facilities; and a number of modern laboratories that may be used for both teaching and research. EM also has a base at the University's Cumbria campus, including newly established laboratories.

Staff within EM have well-developed links with the waste, water and chemical industries, governmental agencies and environmental bodies as well as links with key international organisations.

Course Content

The course is divided into two main components, as indicated below.

Foundation Programme

This part of the course is shared with students following other awards within the Environmental Masters programme, and provides a common foundation of knowledge and skills in a wide range of key subject areas relevant to waste management. The following half modules are taken in Semester 1:

- Earth Science
- Ecology
- Environmental Regulation
- Environmental Chemistry
- Basic Toxicology
- Basic Chemical Analysis

In addition, all students on the Waste Management route follow two more specialized full modules during Semester 2:

- Research Methods
- Environmental Monitoring and Pollution Control

Specialist Programme

The second part of the course allows students to develop their understanding of waste management in depth through the study of two detailed full modules on key aspects of the waste hierarchy, and through completion of a major dissertation. Students are encouraged to complete an industrial placement during their dissertation.

- Waste Disposal
- Waste Minimisation, Reclamation and Recycling
- Dissertation

Course Delivery and Assessment

The full-time course commences in September and operates through a full calendar year, with the final three months allocated to the dissertation project, and where appropriate, project placement, components. Part-time students will normally complete the course at the end of three years of study, and teaching is arranged in blocks to facilitate attendance by professional waste managers who wish to follow the course as part of their continuing professional development.

The taught sections of the course are delivered by a combination of lectures, seminars, tutorials, laboratory and field practicals, industrial and field visits and workshops. We also make use of creative,

student-centred approaches to learning, such as case studies, role-playing and teamwork exercises and "one-minute lecture" presentations. There is a firm emphasis on the development of the core knowledge and skills required for successful career progression within the waste industry, and contact with practitioners on field visits and as contributors to the taught sessions is a feature of the course.

The course is assessed using a wide variety of methods, and the Department's view is that assessment is very much part of the learning process. Students are likely to encounter forms of assessment that range from traditional essays, laboratory/field reports (individual or group-based) and examinations, through to presentations (individual or group-based), critiques of research papers and the preparation of articles suitable for publication. Many modules rely entirely on coursework for their assessment, and where examinations form part of the assessment pattern for any module, they contribute no more than 50% to the final grade.

Research

A number of EM staff are involved in research activities relating to waste management and the effects of waste materials on human health and the environment. These include:

Dr Kevin Butt: Soil ecology / restoration; organic waste utilization.
Dr Mike Clark: Waste and environmental management, planning and auditing.
Dr Alexis Holden: Environmental chemistry and analysis of pollutants arising from waste products; organic waste utilization.
Nigel Mair: Waste management legislation, policy and regulation; attitudes of the business community and public to waste management issues.
Dr Nigel Simons: Environmental Reviews and Environmental Management Systems.
Dr Ian Williams: Environmental chemistry and analysis of pollutants arising from waste products; public perceptions of environmental issues and their implications for environmental protection, public policy and society; wastes minimisation and management.

Current research projects within EM include the use of earthworms in soil restoration; organo-chlorine pesticide residues in human milk from Indonesian women; photocatalytic remediation of polycyclic aromatic hydrocarbons; and green waste collection and disposal in the North-west of England.

Career Opportunities

This MSc course has produced over 130 successful students since its introduction, and they have an excellent record of gaining employment within the industry and securing career progression. Previous students are now working both in the UK and overseas in senior positions in waste operation and regulation within the private, statutory and voluntary sectors. Others are developing successful careers in related fields of environmental management and industry. As the waste industry continues to deal with tightening environmental standards, there will be a continuing need for trained specialists to contribute to the development of more sustainable practices.

For further detailed information about our activities, please contact:

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Web link: Waste Strategy 2000 for England and Wales, Part 1 & 2
http://www.defra.gov.uk/environment/waste/strategy/cm4693/index.htm

Forthcoming symposium

Environment and Health: Regional Decisions – Global Impact

The Institute for Environment and Health in Leicester, UK, is holding a one-day Open Seminar to debate how public, special interest groups, scientific and policy concerns and decisions made in developed countries can influence decision-making and subsequent impacts on environment and health in developing countries.

Confirmed speakers include:

- Dr Maged Younes (WHO, Switzerland)
- Prof. Sandy Cairncross (London School of Hygiene and Tropical Medicine, UK)
- Dr Andy Smith (MRC Toxicology Unit, UK)
- Prof. Paul Hunter (University of East Anglia, UK)
- Prof. David Chambers (University of Greenwich, UK)
- Dr David Blane (Imperial College of Science, Technology and Medicine, UK)
- Prof. Jacqueline McGlade (University College London, UK)
- Prof. Marco Maroni (International Centre for Pesticide Safety, Italy)
- Prof. Dennis Paustenbach (Exponent Inc, USA)
- Prof. Iain Purchase (Consultant in Toxicology and Risk Assessment, UK)
- Dr Harry Kuiper (Wageningen University, The Netherlands)
- Mr John Fawell (Warren Associates Ltd, UK)
- Dr Tippawan Prapamontal (Chiang Mai University, Thailand)
- Dr Philip Rushbrook (WHO, Italy)

DATE: 17th April 2002, 9.00am - 5.00pm

VENUE: University of Leicester, UK

COST: £100.00 (includes refreshments and lunch)

For more information and/or a registration form and programme, please contact Mrs Gail Marvin, Tel: + 44 (0)116 2231611, Email: gm59@le.ac.uk, or visit our website: http://www.le.ac.uk/ieh/update/update.html#opensem

Environmental education and research in Greece

In the second in a series of reviews of environmental chemistry in European countries, **Miltiades I. Karayannis** and colleagues describe environmental education and research in Greece. This article is based on a paper originally published in *Environmental Science and Pollution Research.*

Introduction

Following an invitation of *ESPR - Environmental Science and Pollution Research* to the members of the FECS Division for Chemistry and the Environment to give an account for the development of the field of chemistry and environment in the FECS member countries, this report presents the status and ongoing development of environmental science and education in Greece. Similar reports have already been published from several FECS member countries such as Spain [1], Italy [2] and Hungary [3] while other related issues have also been addressed [4,5]. Within this framework, this report presents the most important issues related to environmental education and research in Greece. The discussion is focused on the post-graduate level environmental education and on issues related to the research activity as currently applied and practised by Greek scientists.

In 1986, Greece adopted its first integrated institutional law for the protection of the environment. According to this law, the protection and preservation of the natural environment is an obligation of the state. Its initial objectives were the protection of the environment to ensure human health and development.

Since then, and in accordance with the EU directives, additional rules and edicts have been added to reinforce the initial law. The law for environment as applied today can be classified in seven parts [6]:

1. Environmental protection (including environmental impact assessments).
2. Management and protection of aquatic resources (water quality, domestic and industrial liquid wastes disposal, limits of pollutants).
3. Management of solid wastes.
4. Atmospheric pollution (including allowed limits and permitted forms of fuels for industries).
5. Toxic and hazardous wastes (including allowed limits).
6. Noise pollution (and potential hazards).
7. Protection of natural environment (preservation of wild life and biodiversity-including international contracts as The RAMSAR contract).

The establishment of environmental protection within Greece's institutional obligations, and following the worldwide growing concern for environmental protection, stimulated a continuously growing research activity in environmental science. In this framework, educational structures for the training of scientists, able to deal with the major environmental issues of our times, have been established.

1 Education

1.1 Graduate Studies

In almost all Greek universities there are departments directly or indirectly related to environmental science. Traditional departments as chemistry, physics, biology, geology and engineering departments all contain curricula concerning environmental science, technology, engineering and ecology. The emphasis of education in these departments is usually given to environmental science in the framework of optional and compulsory selective courses while less obligatory courses are usually offered to deal with the issue of environmental-scientific education [7].

Due to the fact that environmental science is a combination of many traditional scientific courses, these courses are adjusted to the basic curricula of each department so as to exhibit their application in the field of environment. Curriculum requirements and teaching resources for these courses differ from one university to another. In the University of Athens for example, there are two courses on environmental chemistry. In the first, *General Environmental Chemistry,* issues like the basic principles of environmental science, soil chemistry, sources of pollutants, water chemistry, atmospheric chemistry and the effects of pollutants are addressed. In the second course, entitled *Special Environmental Chemistry* issues like photochemical pollution, cleaning technologies, solid wastes, recovery and recycling, toxic wastes, liquid wastes, the chemistry of burning fossil fuels and advanced analytical chemistry, are covered [8]. Moreover, the possibility of specialization in the field of environmental science (and with respect to the department's orientation) is also offered in most cases.

Additionally, in the last few years special attention has been given to establish departments, which will directly deal with environmental science [9]. As a result a variety of departments have been established: The Department of Environmental Studies at the University of Aegean; the Department of Environmental Management and Natural Resources at the University of Ioannina; the Department of Forestry and Natural Environment in the University of Thessaloniki; the Department of Environmental Engineering at the Dimokritio University of Thrace and at the University of Crete. Following this trend, 4-year university levels courses named 'Extended Education Courses' are offered in specified areas as Agro-Ecology at the University of Ioannina and Environmental Cartography at the University of the Aegean.

1.2 Post-graduate Studies

The need for scientists, properly trained to deal with the environmental problems and issues arising from the development of Greece and the international perspective for environmental protection, stimulates a great number of post-graduate studies at all universities from M.Sc. to Ph.D levels. As a result post-graduate courses related to all fields of environmental science have been established. **Table 1** presents the Post-Graduate studies offered by Greek Universities.

Table 1: Post-graduate courses on environmental sciences offered in Greek universities

University	Department	Post-Graduate Course Title (M.Sc. and/or Ph.D level)
University of Athens	Dept. of Plant Production	Plant Protection
	Dept. of Biology	Plant Physiology
		Ecophysiology of Mediterranean Plants
		Biological Oceanography
		Oceanography (a)
	Dept. of Natural Resources Exploitation & Agricultural Engineering	Agricultural Engineering
	Dept. of Mathematics	Biostatistics
	Dept. of Chemistry	Environmental Chemistry & Technology
Aristotelian University of Thessaloniki	Dept. of Geology	Chemical Oceanography
		Hydrogeology
		Mineral Resources and Environment
		Climatology and Meteorology
		Applied and Environmental Geology
		Geochemical Pollution of the Environment
		Geological Oceanography
		Geosciences and the Environment
		Geography and the Environment
	Department of Chemistry	Environmental Chemistry
	Department of Biology	Hydrobiology and Aquaculture
		Environmental Biology
		Environmental Sciences
		Ecological Management and Environmental Technology
		Marine Biology - Fishery and Aquaculture
		Basic Biology: Ecology
	Dept. of Agronomy and Topographical Engineering	Aquatic Resources
	Dept. of Civil Engineering	Environmental Protection and Sustainable Development
		Science and Technology for Aquatic Resources
	Dept. Mineral Resources Engineering	Environmental Geotechnology
	Dept. of Agronomy (Geoponics)	Ecology - Management of Agroecosystems
	Dept. of Ship Mechanics and Engineering	Navy and Marine Technology and Science (a)
	Dept. of Chemical Engineering	Energy and the Environment
		Bioecology - Technical Development
	Dept. of Forestry and Natural Environment	
	General Department	Analytical and Environmental Chemistry
	Dept. of Physics	Environmental Physics
National Technical University of Athens (Ethniko Metsovio Politechnio)	Dept. of Architecture	Monument Protection (a)
	Dept. of Agronomy and Topographical Engineering	Environment and Development
	Dept. of Civil Engineering	Science and Technology of Aquatic Resources (a)
Agronomic University of Athens	Dept. of Natural Resources Exploitation & Agricultural Engineering	Natural Resources Exploitation & Agricultural Engineering
University of Ioannina	Dept. of Mathematics	Biostatistics
	Dept. of Physics	Meteorology and Climatology
University of Crete	Dept. of Biology	Management of Marine and Terrestrial Resources
Technical University of Crete	Dept. of Mineral Resources Engineering	Environmental Geotechnology
	Dept. of Environmental Engineering	Quality Control and Environmental Management (b)
	Dept. of Electronics and Computer Engineering	Renewable Sources of Energy
Xarokopio University of Athens	Dept. of Home Economics and Ecology	Sustainable Development
University of Thesalia	Dept. Industrial Mechanics & Engineering	Contemporary Methods in Energy Systems and Remediation Technologies
	Dept. of Spatial Engineering and Regional Development	Spatial & Urban Planning, and Regional Development
		Environmental Planning and Sustainable Development
	Dept. of Agronomy (Geoponics), Plant and Animal Production	Contemporary Systems in Agricultural Production in The Mediterranean
University of Aegean	Dept. of Environmental Studies	Environmental Science
		Politics and Planning in Environmental Sciences
		Environmental Politics and Management (b)

(a) Courses offered in co-operation between different departments (inter-departmental courses)
(b) Courses offered in co-operation between different Universities (inter-university courses)

Many Departments not included in Table 1 perform post-graduate level Environmental Research. For example, the post-graduate course of Chemistry in the Department of Chemistry at the University of Ioannina, offers the possibility of M.Sc. or Ph.D. degree in Environmental Chemistry or Environmental Chemical Technology.

1.3 General Education

The Greek Chemical Society has established short courses related to environmental problems. Such courses given so far include *Environmental Microbiology*, *Toxic Industrial Waste*, *Domestic Waste* and *Treatment Technologies of Liquid Waste*. Furthermore, other organizations and scientific societies are also involved in training young scientists and technologists on different topics of the environmental science and technology [7].

Moreover, the Institute of Continuing Training, under the shield of the National Center of Public Administration, trains on a continues basis public employees and administrators in new concepts, technologies and legislation related to environmental topics important for the implementation of the European Environmental Policy. In 1994-95 for example, the following topics, through intensive courses in different cities in Greece (lasting two weeks-100 hours), have been covered [7]: *Management of Water Resources*, *Pollution and Technologies for the Protection of the Environment*, *Natural Environment and Natural Risks*, *Environmental Management*, *Assessment of Environmental Impacts*.

2 Research

In general terms, research on the field of Environmental Science is carried out at in three types of location [10]:

2.1 Research Institutes - Centres

Some of the research institutes active in research in Greece are:

- **The NCMR (National Center for Marine Research).** The NCMR is a governmental research institution whose aim is the scientific research of the hydrosphere with the living and non-living organisms. It performs studies on the atmosphere, coastal areas, oceanography, benthic studies and environmental analysis.

- **The MARTEDEC (Marine Technology Development Company).** The main scope of MARTEDEC is to contract research and development projects and to provide services in the marine technologies (i.e. maritime transport, ocean and environmental engineering) as well as the field of port and coastal engineering.

- **The IMBC (Institute of Marine Biology of Crete).** The IMBC is a semi-independent research and technology organization in marine biology. It performs research on issues of aquaculture, fisheries, marine ecology, management of coastal resources, biological oceanography, remote sensing, and molecular biotechnology.

- **The IGME (Institute of Geology and Mineral Exploration).** The basic objectives of IGME are the research and study of the country's geological structure, the location and evaluation of the mineral raw materials (except hydrocarbons) and geothermal fields and the exploration and exploitation of the water resources with special emphasis to the environmental protection. The work field of IGME includes almost the whole range of geosciences and specifically it carries out geological, hydro-geological, engineering geological, geophysical, geochemical, mineralogical studies, mineral and mining explorations as well as projects aiming at the location of ore deposits, aggregates and industrial minerals.

- **The National Centre for Scientific Research Demokritos (NCSRD).** The Centre is the largest in Greece and commits itself to serving industrial, environmental and social needs providing advanced R&D services. The R&D group of Environmental Research Laboratory (**EREL**) has been at the forefront of environmental computational fluid dynamics while developing experimental infrastructure for the measurement and analysis of a variety of pollutants. In particular, **EREL** has gathered advanced expertise in the field of atmospheric dispersion modelling, air-ground interaction and air quality measurements over the last 15 years.

Other research centres and institutes, active in research in Greece, are the **Aquaculture Centre of Acheloos**, the **National Research Institute (NRC)**, the **Nestor Institute (Institute for Deep Sea Research and Neutrino Astroparticle Physics)**, and the **Fisheries Research Institute**.

2.2 Universities

Many research groups in university laboratories, which are usually funded from EU or national programs in the field of the environment, also perform environmental research in Greece. Traditional research in Greek universities includes monitoring of pollutants in the ecosystems, development of new environmental analytical techniques and engineering, while some toxicological issues have also been addressed. Quite recently other areas of research have been developed as environmental technology, biotechnology, biomechanics, biodiversity, environmental management and economics etc. Some examples of the research activity on environmental chemistry in Greek Universities are presented in **Table 2.**

2.3 Private, Semi-private or Associated Public-private Institutes

Although the environmental research activity in the private sector is not much developed in Greece there are some organizations or institutes, which are working on subjects related to Environmental Science and Research. These include the municipal enterprises of water supply and sewage and a few laboratories or institutes, which are usually incorporated in Industries. Their research is basically focused on technical or more likely on technological activities.

Table 2: Research activities on environmental chemistry in Greek universities

University	Department	Subject
University of Athens	Chemistry	Air Pollution (indoor and outdoor) • Volatile Organic Compounds (VOC's) • PAH's • PCB's • Carbonyl Compounds • Acid Rain • Heavy Metals Water Pollution • Heavy Metals • PAH's
University of Thessaloniki	Chemistry	Air Pollution • PAH's • Acid Rain • Heavy Metals Water Pollution • PAH's • Heavy Metals • Surfactants
University of Ioannina	Chemistry	Air Pollution (indoor and outdoor) • PAH's • Heavy Metals Water Pollution • Pesticides • Heavy Metals
University of Crete	Chemistry	Air Pollution • PAH's • Heavy Metals Water Pollution
University of Patras	Chemistry	Air Pollution • VOC's • Secondary Photochemical Pollutants • Acid Rain
University of Aegean	Environmental Studies	Air Pollution • Heavy Metals Water Pollution • Heavy Metals • Pesticides • PAH's
University of Thessaly	General Department	Water Pollution • Pesticides

3 Funds

Funds for environmental research are granted from the General Secretariat of Research and Technology (GSRT) of the Ministry of Development and from European Union projects. NATO-GSRT grants have also been supplied while funds from Industries are obtained occasionally. A few ongoing or recently concluded research projects financed or co-financed by the GSRT are:

1. NATO/CCMS Pilot Study 'Industrial and toxic wastes management and substances research';
2. Migration of anthropogenic impurities of toxic elements, halogen-organic substances, oil products and phenols in surface and drinking waters;
3. Solidification-stabilization of wastes from metal industries;
4. Survey of the wastewater management in Bulgaria;
5. Actions in the treatment and reuse of treated wastewater and sludge in South Mediterranean and Middle East Countries.

EU projects performed by Greek University laboratories or institutes are MEDPOL, EUROPEROX, ENVIREG, ENVIRONMENT, etc.

4 Publications

Some journals where original papers on Environmental Science have been recently published from Greek authors are presented here.

Analytical Chemistry Journals
Analytica Chimica Acta; The Analyst; Journal of Analytical Atomic Spectrometry; Journal of Chromatography A.

Environmental Science Journals
Environmental Science & Technology; Chemosphere; ESPR – Environmental Science and Pollution Research-International; Environmental and Health Science – Online (EHS-Online); Marine Chemistry; The Science of the Total Environment; Fresenius Environmental Bulletin; Atmospheric Environment; Journal of Environmental Chemistry and Toxicology; Journal of Degradation and Biodegradation; Water Research; Water Science and Technology; Environmental Technology; Toxicological and Environmental Chemistry; International Journal of Environmental Analytical Chemistry;

Environment International; Journal of Environmental Science and Health, Part A – Toxic/Hazardous Substances & Environmental Engineering.

A search of four publishing companies revealed a great number of recent publications from Greek authors, in the field of environmental science research. An indicative evaluation with respect to each sector of environmental research is presented in **Figure 1.**

5 Scientific Meetings

Following the above-mentioned increasing interest and research activity in Greece on issues related to environmental science, there is an increasing trend for the organization of Conferences and Workshops in this field of research. Some examples are:

- The Conference on 'Environmental Science and Technology' held every two years since 1989 by courtesy of The Department of Environmental Sciences, University of Aegean;
- The Scientific Yearbook of the Department of Forestry and Natural Environment held in Thessaloniki 1995;
- International Conference on 'Environment and Society: Education and Public Awareness for Sustainability', Thessaloniki, Greece, 8-12 December 1997;
- The 1st Conference on 'Pesticides and Relative Organic Compounds in the Environment', Ioannina, 5-8 October 2000;
- 8th FECS Conference on 'Chemistry and the Environment', to be held in Athens (Greece) from 1st to 4th September 2002.

Many conferences on Chemistry, Physics Biology, Ecology etc, organized by Greek institutions (universities, research institutes, governmental organizations etc), include sessions on environmental issues.

6 Organizations

Recently, environmental organizations with international and transboundary character have been established:

• **The Global Nest** An association for scientists, technologists, engineers and others concerned with the study of environmental science and technology and of the environment generally, and of the application of such knowledge to the development of sustainable solutions. The network has wide-ranging aims and objectives, which cover:

- advancing the study of environmental science, technology and policy;
- the widest-possible dissemination of knowledge in the fields of environmental science, technology and policy;
- exchanging information between academics and between academia, business, industry, policy makers and the general public;
- bringing together scientists, technologists, engineers and others for discussion on areas of concern;
- influencing policy makers, business leaders and the general public
- liaising with and cooperating with other organisations worldwide with similar aims and objectives.

As part of the network's efforts for environmental protection a scientific journal has been established. *The Global Nest International Journal* published its first issue in 1999.

• **The Balkan Environmental Association (B.EN.A.)** A non-profit organization, in accordance with European Union law regulations for non-profit organizations. The objective of B.EN.A. is to bring together its members and other interested persons from scientific political or economical domains, in order to examine the current problems of environmental protection in the Balkan region and investigate solutions to these problems on regional, national and international basis. Its objective is also to give suggestions and recommendations concerning environmental quality and safety so as to enable the regulatory bodies of the various Balkan Countries to take proper decisions regarding the evaluation of the risk of chemicals and physical agents. The aims of B.EN.A. are:

- development of international co-operation on reducing of the

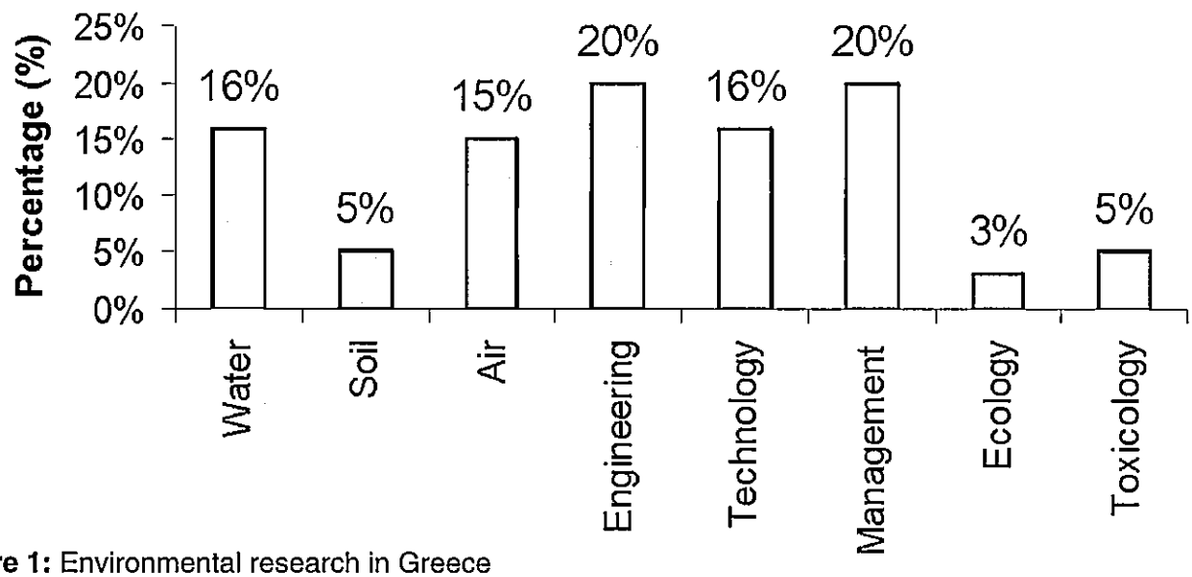

Figure 1: Environmental research in Greece

transboundary pollution (air and water);
- development of air and water quality assessment and improvement through collaboration among affected countries;
- development of strategies and options for environmental protection of Balkan rivers and lakes;
- wetland quality monitoring;
- development of the environmental quality management system for the region;
- international research projects for neighbouring countries regarding the cross-border pollution;
- development of international programmes for restoration and sustainable improvement of ecological safety of cross-border regions;
- establishment of, an integrating framework for the support of local and international environmental issues.

B.EN.A. has recently moved forward with the establishment of a scientific journal entitled *Environmental Protection and Ecology*. The journal published its first issue in 2000.

7 Conclusions

The particular characteristics of Greece's natural environment (extended coastal areas, unique and protected species) and the indissoluble linkages between economic activities and natural resources, in combination with the worldwide growing concern for environmental protection, initiated a wide activity on issues related to environmental protection in Greece.

Following the establishment of legislation for environmental protection and preservation, Greece has undertaken significant steps in research areas related to environmental chemistry, technology, engineering, biotechnology, management and ecology. This continuously growing research activity is closely followed by an expanding educational framework, which aids to the training of experts and scientists able to deal with the major (national and transboundary) environmental issues of our times.

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Chronic arsenic toxicity in Bangladesh and West Bengal, India - an update

Fifty districts of Bangladesh and nine districts in West Bengal, India have arsenic levels in groundwater above the World Health Organisation's maximum permissible limit of 50 micrograms/L. The area and population of 50 districts of Bangladesh and 9 districts in West Bengal are 118,849 km^2 and 104.9 million and 38,865 km^2 and 42.7 million, respectively.

Our current data show arsenic levels above 50 micrograms/ L in 2000 villages, 178 police stations of 50 affected districts in Bangladesh and 2600 villages, 74 police stations/blocks of 9 affected districts in West Bengal. We have so far analysed 34,000 and 101,934 hand tube-well water samples from Bangladesh and West Bengal respectively by FI-HG-AAS of which 56% and 52%, respectively, contained arsenic above 10 micrograms/L and 37% and 25% arsenic above 50 micrograms/L.

In our preliminary study, 18,000 persons in Bangladesh and 86,000 persons in West Bengal were clinically examined in arsenic-affected districts. Of those, 3695 (20.6% including 6.11% children) in Bangladesh and 8500 (9.8% including 1.7% children) in West Bengal had arsenical dermatological features. Symptoms of chronic arsenic toxicity developed insidiously after 6 months to 2 years or more of exposure. The time of onset depends on the concentration of arsenic in the drinking water, volume of intake, and the health and nutritional status of individuals. Major dermatological signs are diffuse or spotted melanosis, leucomelanosis, and keratosis. Chronic arsenicosis is a multi-system disorder. Apart from generalized weakness, appetite and weight loss, and anaemia, our patients had symptoms relating to involvement of the lungs, gastrointestinal system, liver, spleen, genitourinary system, haemopoietic system, eyes, nervous system, and cardiovascular system.

We found evidence of arsenic neuropathy in 37.3% (154 of 413 cases) in one group and 86.8% (33 of 38 cases) in another. Most of these cases had mild and predominantly sensory neuropathy. Central nervous system involvement was evident with and without neuropathy. Electro-diagnostic studies proved helpful for the diagnosis of neurological involvement. Advanced neglected cases with many years of exposure presented with cancer of skin and of the lung, liver, kidney, and bladder. The diagnosis of sub-clinical arsenicosis was made in 83%, 93%, and 95% of hair, nail and urine samples, respectively, in Bangladesh; and 57%, 83%, and 89% of hair, nail, and urine samples, respectively in West Bengal. Approximately 90% of children below 11 years of age living in the affected areas show hair and nail arsenic above the normal level. Children appear to have a higher body burden than adults despite fewer dermatological manifestations.

Limited trials of four arsenic chelators in the treatment of chronic arsenic toxicity in West Bengal over the last two decades do not provide any clinical, biochemical, or histopathological benefit except for a preliminary report of clinical benefit with dimercaptopropanesulfonate therapy. Extensive efforts are needed in both countries to combat the arsenic crisis including control of tube-wells, watershed management with effective use of the prodigious supplies of surface water, traditional water management, public awareness programmes, and education concerning the apparent benefits of optimal nutrition.

Chronic arsenic toxicity in Bangladesh and West Bengal, India: a review and commentary. Rahman, M. M. *et al, J. Toxicol. Clin. Toxicol.*, 2001, 39(7):683-700.

Web links for the arsenic crisis in Bangladesh:

West Bengal & Bangladesh Arsenic Crisis Information Centre http://bicn.com/acic/ (includes a link to the 'arsenic crisis news' discussion group).

Bangladesh Centre for Advanced Studies http://www.bcas.net/arsenic/ (includes links to the latest news from Bangladesh http://www.bcas.net/arsenic/news/2002/January.htm)

UNDP Sustainable Development Programme, Bangladesh http://www.sdnbd.org/sdi/issues/arsenic/

UNICEF http://www.unicef.org/arsenic/

British Geological Survey http://www.bgs.ac.uk/arsenic/Bangladesh.html

Harvard University Arsenic Project http://phys4.harvard.edu/~wilson/arsenic_frames.html (includes details of a January 2002 Workshop in Dhaka).

Arsenic contaminated groundwater found in northern Vietnam

Following the headlines of massive arsenic contamination of drinking water supplies in Bangladesh in the mid-1990s, researchers have been on the lookout for other regions heavily reliant on groundwaters that might be similarly contaminated.

Now, it seems, Bangladesh may have been just the tip of the iceberg, and arsenic is poised to become the key environmental health problem of the 21st century in developing countries. The latest region to fall victim is Vietnam, where researchers from the Swiss Federal Institute for Environmental Science and Technology and Vietnam National University have discovered arsenic levels in the groundwater around Hanoi on a scale comparable to those found in Bangladesh, where some 85 million people are at risk of developing cancer.

Although the affected area seems to be much smaller in Vietnam than in Bangladesh, approximately 11 million people living in the Red River delta of northern Vietnam are currently at risk of chronic arsenic exposure. This delta is one of the most agriculturally productive regions of Southeast Asia, and over the past 5–7 years people have moved away from using surface water sources such as rivers for drinking water in favour of tubewells tapping into groundwater aquifers. This water is free of the

microbial contamination found in surface waters, but researchers speculate that oxidation of buried organic matter may be helping to release naturally occurring arsenic into the groundwater aquifers.

A research paper and feature article appearing in the July 1st 2001 Issue of *Environmental Science & Technology* detail the latest findings in Vietnam and what's being done to avoid the chaos and panic that occurred in Bangladesh following the discovery of the arsenic problem. Curiously, no signs of the devastating and debilitating skin afflictions associated with arsenic poisoning so commonly observed in Bangladesh have cropped up in Vietnam as of yet, but it may be only a matter of time.

Arsenic Contamination of Groundwater and Drinking Water in Vietnam: A Human Health Threat. M. Berg *et al.*, *Environmental Science & Technology*, 2001, **35** 2621.

Web link

Mekong Forum Essays http://www.mekongforum.org/long4e.html

Lower standard set for arsenic in drinking water in the USA

After some dithering, the USA's Bush administration will set a 10 part-per-billion (ppb) standard for arsenic in drinking water – down from the current level of 50 ppb. USA EPA Administrator Christine Whitman made the announcement in October 2001. The standard mirrors the one set by the Clinton administration in January 2001, which was initially rejected by the Bush administration until a review of the science could be completed. Whitman's announcement follows studies by EPA's science advisory board and the National Research Council, showing that even arsenic concentrations as low as 10 ppb are associated with higher cancer risks. Nearly 97% of the water systems affected by the rule are small drinking water systems that serve less than 10,000 people each, according to EPA. The 50 ppb standard was set in 1942.

Web links: EPA's science advisory board review http://www.epa.gov/sab under "Reports"; National Drinking Water Advisory Council cost analysis http://www.epa.gov/safewater under "What's New"; National Research Council report *Arsenic in Drinking Water: 2001 Update* http://www.nap.edu/books/0309076293/html/

A mechanism for arsenic's carcinogenicity

Researchers have discovered a mechanism that may explain the link between long-term exposure to arsenic in drinking water and cancer of the bladder, lungs, skin, kidney, nasal passages, liver, and prostate. Paradoxically, the mechanism that empowers arsenic as a tumour promoter also seems to be closely linked to arsenic's effectiveness in the treatment of some forms of leukaemia.

The findings could have implications for the USA EPA's new 10 parts-per-billion (ppb) rule for arsenic in drinking water. Although the lowest concentration of arsenic trioxide used in this latest experiment by Wen-Chien Chou of Johns Hopkins University and colleagues was 20 ppb, the researchers say this same mechanism could play a role in chronic exposure to arsenic at very low levels.

Studying arsenic trioxide's exposure on various cell lines, including leukaemia, cervical cancer, and breast cancer, Chou and colleagues observed a marked decrease in telomerase activity. Telomerase is an enzyme that maintains the length of chromosomal ends, or telomeres, which otherwise would become progressively shorter after each cell division. For most advanced tumours, telomere maintenance is essential for continued proliferation. In healthy, noncancerous cells, however, the loss of telomeres could lead to genomic instabilities and the formation of cancerous cells. These phenomena may explain the seemingly paradoxical carcinogenic and antitumour effects of arsenic.

The researchers found that arsenic inhibits the transcription of the human gene, *hTERT*, which in turn inhibits telomerase expression. The inhibition was dose-related and occurred with arsenic concentrations at or lower than those measured in plasma taken from human subjects exposed to the metal in pharmacokinetic studies.

The authors believe that the inhibition of *hTERT* is the result of decreased activity of *c-Myc* and *Sp1* transcription factors - proteins that promote the conversion of DNA sequences into corresponding RNA - in the exposed cultures. However, this explanation leaves open the questions of why other processes in which *Sp1* plays a role are less affected by arsenic and whether the inhibitory effect of arsenic on other genes may also contribute to the decrease in *hTERT* expression and telomere maintenance.

Arsenic inhibition of telomerase transcription leads to genetic instability. Chou, W. C. *et al*, *J. Clin. Invest.*, 2001, **108**, 1541-7.

A fern that hyperaccumulates arsenic

A hardy, versatile, fast-growing plant that extracts arsenic from contaminated soils has been found in Florida. First reported in *Nature* (2001, **409**, 579), this discovery attracted much media interest both in the USA and the UK for its potential in remediating arsenic-contaminated soils. **Dr Lena Ma**, from the University of Florida and one of the co-authors of the *Nature* communication, was awarded the Royal Geographical Society's Discovery of the Year prize in 2001 for this work.

Contamination of soils with arsenic, which is both toxic and carcinogenic, is widespread [1]. It has now been found that the fern *Pteris vittata* (brake fern) is extremely efficient in extracting arsenic from soils and translocating it into its above-ground biomass. This plant – which is thought to be the first known arsenic hyperaccumulator as well as the first fern found to function as a hyper-accumulator [2] – has many attributes that recommend it for use in the re-mediation of arsenic-contaminated soils.

The brake fern was found growing on a site in Central Florida contaminated with chromated copper arsenate. The fronds of plants growing at the site were analysed for total arsenic by graphite furnace atomic absorption spectroscopy. Of 14 plant species studied, only brake fern contained large amounts of arsenic (As; 3,280-4,980 ppm). Additional samples of the plant and soil from the contaminated site revealed 18.8-1,603 ppm As. Analysis of samples from an uncontaminated site showed 0.47-7.56 ppm As. Brake fern extracted arsenic efficiently from these soils into its fronds: plants growing in the contaminated site contained 1,442-7,526 ppm arsenic and those from the uncontaminated site contained 11.8-64.0 ppm These values are much higher than those typical for plants growing in normal soil, which contain less than 3.6 ppm of arsenic [3].

As well as being tolerant of soils containing as much as 1,500 ppm arsenic, brake fern can take up large amounts of arsenic into its fronds in a short time. Arsenic concentration in fern fronds growing in soil spiked with 1,500 ppm arsenic increased from 29.4 to 15,861 ppm in two weeks. Furthermore, in the same period, ferns growing in soil containing just 6 ppm arsenic accumulated 755 ppm of arsenic in their fronds, a 126-fold enrichment. Arsenic concentrations in brake fern roots were less than 303 ppm, whereas those in the fronds reached 7,234 ppm.

Addition of 100 ppm arsenic significantly stimulated fern growth, resulting in a 40% increase in biomass compared with the control. After 20 weeks of growth, the plant was extracted using a solution of 1:1 methanol:water to speciate arsenic with high-performance liquid chromatography–inductively coupled plasma mass spectrometry. Almost all arsenic was present as relatively toxic inorganic forms, with little detectable organo-arsenic species [4]. The concentration of As(III) was greater in the fronds (47–80%) than in the roots (8.3%), indicating that As(V) was converted into As(III) during trans-location from roots to fronds. As well as removing arsenic from soils containing different concentrations of arsenic, brake fern also removed arsenic from soils containing different arsenic species. Again, up to 93% of the arsenic was concentrated in the fronds. Although both $FeAsO_4$ and $AlAsO_4$ are relatively insoluble in soils [1], brake fern hyper-accumulated arsenic derived from these compounds into its fronds (136–315 ppm) at levels 3–6 times greater than soil arsenic.

Brake fern is mesophytic and is widely cultivated and naturalized in many areas with a mild climate. In the United States, it grows in the southeast and in southern California [5]. The fern is versatile and hardy, and prefers sunny (unusual for a fern) and alkaline environments (where arsenic is more available). It has considerable biomass, and is fast growing, easy to propagate, and perennial.

This is thought to be the first report of significant arsenic hyperaccumulation by an un-manipulated plant. Brake fern has great potential to remediate arsenic-contaminated soils cheaply and could also aid studies of arsenic uptake, translocation, speciation, distribution and detoxification in plants.

At the moment, researchers are unsure as to why the fern has such a strong affinity for arsenic because it's not an essential element. "The only thing we can think of is self-defence," said Dr Lena Ma. "This plant is so poisonous that no insects or bugs can touch it." Indeed, the arsenic levels observed easily surpass the U.S. EPA's 5-ppm threshold for classification as an industrial-level hazardous waste. Another possibility is that the fern accumulates arsenic as a way of coping with its environment, detoxifying a toxic element present in the root surface.

Because the fern also grows well in water, researchers speculate that the plant's roots could extract arsenic from water. Jianwei Huang, a plant biologist working as a consultant for Edenspace Systems Corp., which has licensed the fern for commercial development, is growing the plant in a hydroponic system. Results so far indicate arsenic removal rates five times higher than EPA's current maximum limit of 50 parts-per-billion within 24 hours. Huang warns, however, that much research remains in optimising the system, such as determining the number of roots necessary, their lengths, and the surface of root per unit of water. "Theoretically it works," Huang said, "but to determine whether it actually works, we'll have to wait for the field demonstrations."

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[Scientists and environmental decision-makers concerned with arsenic contamination will meet in Gainesville on March 4th-5th, 2002 for a symposium on the principles of arsenic behavior in Florida's soils. The symposium is sponsored by the University of Florida's Institute of Food and Agricultural Sciences and other units of the university].

An environmental threat from the thermolysis of fluoropolymers?

The possible environmental threat of degraded fluoropolymers featured in the BBC Radio 4's *Today* programme in 2001. The item was based on a communication in *Nature* by Canadian investigators.

Following the introduction of hydrochlorofluorocarbon (HCFCs) and hydrofluorocarbon (HFCs) gases as replacements for the ozone-destroying chlorofluorocarbons (CFCs), it has been discovered that HCFCs/HFCs can degrade in the atmosphere to produce trifluoroacetic acid.

Trifluoroacetic acid has no known loss mechanisms in the environment, and higher concentrations in natural waters have been shown to be mildly phytotoxic. Present environmental levels of trifluoroacetic acid are not accounted by HCFC/HFC degradation alone.

It has now been found that thermolysis of fluorinated polymers, such as the commercial polymers Teflon and Kel-F, can also produce trifluoroacetate and the similar compound chlorodifluoroacetate. This can occur either directly, or indirectly *via* products that are known to degrade to these haloacetates in the atmosphere. The environmental significance of these findings is confirmed by modelling, which indicates that the thermolysis of fluoropolymers in industrial and consumer high-temperature applications (ovens, non-stick cooking utensils and combustion engines) are likely to be a significant source of trifluoroacetate in urban rain water.

Thermolysis also leads to longer chain polyfluoro- and/or polychlorofluoro-(C3–C14) carboxylic acids, which may be equally persistent. Some of these products have recently been linked with possible adverse health and environmental impacts and are being phased out of the USA market. Furthermore, FCs and fluorocarbons – groups that can destroy ozone and act as greenhouse gases, respectively – were detected among the other thermal degradation products, suggesting that continued use of fluoropolymers might also exacerbate stratospheric ozone-depletion and global warming.

Thermolysis of fluoropolymers as a potential source of halogenated organic acids in the environment. David A. Ellis *et al*, *Nature*, 2001, **412**, 321-324.

Further Reading:

Concentrations and mass fluxes of chloroacetic acid in rain and natural waters in Switzerland. Berg, M., *et al. Environmental Science & Technology*, 2000, **34**:2675.

Accumulation of trifluoroacetate in seasonal wetlands in California. Cahill, T.M. *Environmental Science & Technology*, 2001, **35**:820.

Regional distribution of trifluoroacetate in surface waters downwind of urban areas in Northern California, U.S.A. Cahill, T.M., and J.N. Sieber., *Environmental Science & Technology*, 2000, **34**:2909.

Trifluoroacetate in the environment. Evidence for sources other than HFC/HCFCs. Jordan, A., and H. Frank. *Environmental Science & Technology*, 1999, **33**:522.

Determination of trifluoroacetic acid in 1996-1997 precipitation and surface waters in California and Nevada. Wujcik, C.E., T.M. Cahill, and J.N. Seiber, *Environmental Science & Technology*, 1999, **33**:1747.

Greenpeace and PVC

As postscript to last year's Distinguished Guest Lecture by Dr John Emsley on the adverse publicity surrounding the environmental effects of PVC, two Web sites from Greenpeace are of interest. The first, which outlines Greenpeace's case against PVC, may be found at http://www.greenpeace.org/~toxics/pvcdatabase/bad.html

To quote from the Web site:

"**WHY PVC IS BAD NEWS**

Globally, over 50% of PVC manufactured is used in construction, in products such as pipelines, wiring, siding, flooring and wallpaper. As a building material PVC is cheap, easy to install and easy to replace. PVC is replacing 'traditional' building materials such as wood, concrete and clay in many areas. Although it appears to be the ideal building material, PVC has high environmental and human health costs that its manufacturers fail to tell consumers.

From its manufacture to its disposal, PVC emits toxic compounds. During the manufacture of the building block ingredients of PVC (such as vinyl chloride monomer) dioxin and other persistent pollutants are emitted into the air, water and land, which present both acute and chronic health hazards. During use, PVC products can leach toxic additives, for example flooring can release softeners called phthalates. When PVC reaches the end of its useful life, it can be either landfilled, where it leaches toxic additives or incinerated, again emitting dioxin and heavy metals. When PVC burns in accidental fires, hydrogen chloride gas and dioxin are formed."

The second Greenpeace Web site is a **PVC ALTERNATIVES DATABASE** http://www.greenpeace.org/~toxics/pvcdatabase/, which aims to list alternative materials to PVC and the names and addresses of suppliers where these products may be obtained.

Teaching environmental and human toxicology at McMaster University

1 Background

McMaster University's pioneering contributions to problem-based, self-directed instruction is recognized in medicine,[1,2] occupational health,[3] pharmacology[4] and engineering[5]. This approach to learning shifts the attention from the teacher or instructor to the learner. It places more emphasis on a process that facilitates acquisition by the students of information and motivational skills, thereby encouraging them to take greater responsibility for their own learning.

In problem-based learning (PBL), real situations (case studies) or paper problems provide the vehicle for learning. The students identify issues, knowledge concepts and the data needed to understand and/or solve or manage a problem; learning objectives are set and pursued by the learners and therefore the process is self-directed. Small-group learning (maximum of 8-10 students per tutorial group) fits PBL as it caters to the individual, encourages cooperation and generates critical thinking. There are no formal lectures. The tutor is a facilitator, while the tutor and learners themselves constitute important resources. The problem, peers, tutor and resources assist "guided discovery". Student assessment involves summative evaluation (to facilitate decisions about performance in a course; i.e., assign academic grades) and formative evaluation (feedback to enhance student learning by optimising the learning dynamics).[6]

The course described in this article ('Pharmacology: Principles of Toxicology') is offered within the Honours Biology and Pharmacology Programme in the Biology Department at McMaster University[4]. It is a five-year co-op programme, three four-month terms of which are spent in work related to pharmacology, toxicology or pharmaceutics. In their first year students take year-I science, while in the second year the focus is on chemistry, biology, biochemistry and statistics courses with some room for electives. A co-op work term occurs during each of the last 3 years, and are interspersed with academic terms featuring courses in biology and pharmacology, as well a laboratory course, a senior thesis and electives. All the pharmacology courses are taught in a small group setting using the PBL format; others taken are not.

2 'Pharmacology: Principles of Toxicology'

2.1 Course objectives

One objective of this course is to provide information about the mechanisms whereby chemicals given as therapeutic agents, encountered naturally in foods, in the work place or the general environment produce toxic effects. Both chemical and biological determinants of toxicity are examined, as well as the fundamental principles of toxicology (absorption, distribution and excretion; exposures and pathways to man; dose-response relationships; antagonism and synergism; and analytical aspects).

2.2 Format

Student contact consists of one 3-hour tutorial per week for one term (13 weeks). Case studies constitute the vehicles for learning and the knowledge and information needed to understand, resolve and/or manage a problem described is the basis for the study objectives.

In a typical tutorial, the students begin by agreeing upon and agenda based on the previous week's study objectives. Usually, one or two students take the lead voluntarily and others generate discussion by asking questions or by requesting more details. After a suitable break, the discussion is resumed. Handouts or overheads are frequently employed by the students to support their participation. Before the end of the tutorial, new study objectives are set. In these deliberations, the problem scenario is likely to be consulted again. The workload is then divided and assigned. The students, alone or in small teams, consult suitable sources in preparation for the next tutorial. Most often original research articles or subject-specific critical reviews are selected.

Before the session is adjourned, the students engage in a brief period of formative evaluation. It involves personal and peer assessment of preparedness and participation, the communication and interpersonal skills exhibited, and it is determined if group dynamics can be improved, or whether the group objectives were achieved. The appropriateness of the case scenario is also addressed.

2.3 Evaluation

Student evaluation is based upon: class participation (20%); class presentation (10%); written assignment (20%); mid-term Evaluation Exercise (15%); and end-of-term Evaluation Exercise (35%).

The assignment and Evaluation Exercises constitute the summative student evaluation component of the course. Learner competencies assessed include: knowledge; application of knowledge; reasoning ability; judgment; decision-making; problem-solving, technical, information retrieval and critical appraisal skills. Assessment of class participation and class presentations (including one formal talk) are more subjective evaluation aspects and student participation in this is invited.

2.4 Course schedule

WEEK	*PROBLEM OR ACTIVITY*[a]
1	Introduction to Course and to Self-directed, Problem-Based Learning
2 & 3	Aflatoxin: A Food Contaminant
4 & 5	Toxic Encephalopathy from a Seafood Toxin
6	Case Study on Lead Exposure: How Clean is Clean?
7	Mid-Term Evaluation Exercise
8[a]	Case Study on Lead Exposure: How Clean is Clean?
9[a] & 10[a]	Reproductive Impact of Endocrine-Disruptive Chemicals
11[a] & 12[a]	Particulates, Acid Aerosols and Oxidant Pollutants
13	Final Evaluation Exercise

[a] Time is allotted for formal student presentations based on the assignment.

2.5 Scope of coverage

With each case study, selected references are provided to introduce the student to the literature. The coverage for each problem usually includes the following aspects, if applicable: epidemiology, exposure, pathways to man, metabolism (including biotransformation), toxicokinetics, pathogenesis, target organ, structure-function relationships, risk assessment and regulation, analytical chemistry aspects, and preventive measures. Critical appraisal of the evidence is emphasized throughout the course.

2.6 A typical case scenario

Reproductive Impact of Endocrine-Disruptive Contaminants

Fish of the carp family (cyprinids), living downstream from where effluent from a sewage-treatment work (STW) entered a river, were bisexual (hermaphrodites). Hermaphrodites occur very rarely among healthy cyprinids. When caged trout were placed in the STW effluent channel, the results summarized in the **Figure** below were obtained. Vitellogenesis may be taken as a biomarker of estrogenic contamination of the aquatic environment. It illustrates the widespread concern about developmental effects in wildlife and humans of estrogen-like substances and other endocrine-disruptive chemicals.

2.7 Example of an Evaluation Exercise Component

The evaluation exercises are conducted in the context of case scenarios and thus reflect the approach taken in the tutorial. Below a typical scenario and questions are reproduced, which are used in the evaluation of students' knowledge and other summative attributes pertaining to the tutorial problem highlighted above. By mutual agreement, study guidelines for the evaluation exercise were drawn up and toxicological outcomes were limited to reproductive and develop-mental effects since cancer, bio-transformation and neurotoxicity had been included in the previous evaluation exercise.

Case Scenario: *Detailed environmental surveys completed in 1998 showed, based on soil and plant analyses, that some of the First Nation Cree communities in the James Bay region of Ontario were contaminated with PCBs reaching as high as 21,000 ppm in soil and 550 ppm in vegetation (the corresponding acceptable criteria levels in Ontario are 5.0 ppm and <1 ppb, respectively). Others were contaminated with pesticides (especially p,p'-DDE and p,p'-DDT) or PAHs (polycyclic aromatic hydrocarbons). Elevation of organochlorine contaminants have also been shown to occur in bottom-feeding fish caught in nearby river channels and in the blood of adults living in the contaminated communities.*

The following questions were used in a recent examination.

1a) Investigators studying endocrine disruption frequently use the Vitellogenin Assay. What is vitellogenin? Describe the vitellogenin assay and illustrate how this might be used to test for the presence of estrogens and estrogen-like compounds in the waters surrounding the contaminated communities in the scenario.

b) PCBs, DDT/DDE and some PAHs are representative of compounds known to be endocrine disrupters. Based on available evidence for detrimental effects of contaminants with estrogenic/anti-estrogenic or androgenic/anti-androgenic activities among wildlife, succinctly summarize your concerns for the sexual development and reproductive health of bird (e.g. eagles), mammals (e.g., black and polar bear; caribou and moose; marine mammals such as whale and seal), fish and invertebrates of the Hudson-Bay/James Bay lowlands of Ontario.

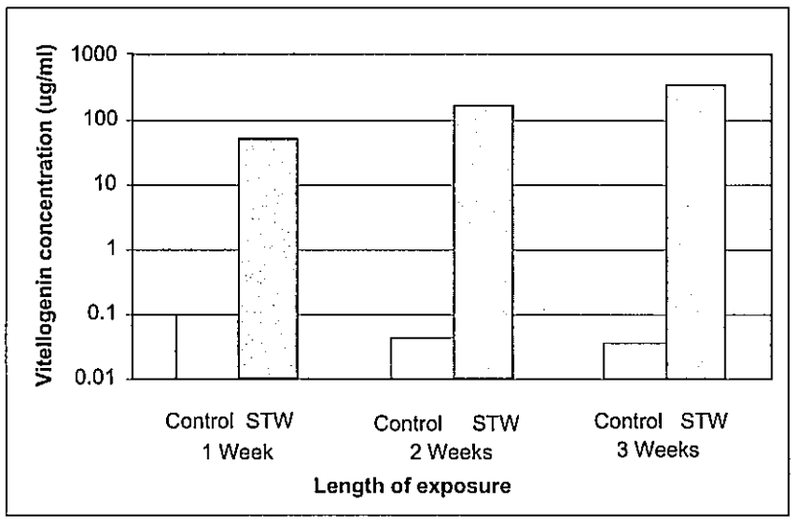
OR

Based on available human evidence and any supporting animal (experimental and/or wildlife) evidence, state/describe your concerns for possible detrimental effects on the reproductive and developmental health of people living in native communities contaminated with endocrine disrupting organochlorines and polycyclic aromatic hydrocarbons.

c) Describe the underlying (fundamental) mechanism(s) of action corresponding to the endocrine-disrupting effects of two outcomes described in your answer to 1(b).

3 Concluding Remarks

During the tutorials of the 2 weeks allotted, the topics covered in some depth in relation to endocrine-disrupting



The effect of effluent from a sewage-treatment works on the plasma vitellogenin concentration of male rainbow trout. One cage containing 20 male trout was placed directly in the effluent channel of a sewage-treatment works (STW), and another (control) was maintained in a laboratory supplied with high-quality spring water. Plasma samples were collected after 1, 2, and 3 weeks and assayed for vitellogenin. Exposure to effluent caused a pronounced increase in the plasma vitellogenin concentration ($p<0.001$ at all observation times). Results are mean ± SEM (n=20). The SEMs shown in the original figure are omitted from the histogram because they were of small magnitude. (Adapted with permission from Sumpter and Jobling.[7])

chemicals typically include: roles of estrogens and androgens in sexual development; sources and types of estrogens (i.e., endogenous, phytoestrogens, synthetic); biotransformation; bio-accumulation and bioconcentration; toxicokinetics; mechanisms of action of hormones; biomarkers of exposure; effects of specific hormones or endocrine-disrupting chemicals documented in wildlife and humans and the strength of the evidence; bioassays available to assess potencies; and analytical methods for quantitative measurements. The estrogen-related risks established for breast cancer constitute a major focus.

Students enjoy the broad scope of the course and the opportunity to learn basic concepts in the context of real, holistic situations. Motivation remains high throughout the course, and each year new developments in the published literature are identified and consulted. Clearly, the educational rewards are not limited to the students.

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Forthcoming symposium

The Third Informal Conference on Reaction Kinetics and Atmospheric Chemistry

DATE: June 7th – June 9th, 2002
VENUE: Helsingør, Denmark

Organised by The Nordic Network for Chemical Kinetics, The Copenhagen Global Change Initiative and
The Federation of European Chemical Societies

List of Invited Speakers:

Prof. Marcus Alden, Department of Combustion Physics, University of Lund, Sweden
Prof. Urs Baltensperger, Laboratory of Atmospheric Chemistry, Paul Scherrer Institute, Switzerland
Prof. David W. T. Griffith, Department of Chemistry, University of Wollongong, Australia
Prof. C. A. de Lange, Laboratory for Physical Chemistry, University of Amsterdam, The Netherlands
Dr. Stanley P. Sander, Jet Propulsion Laboratory, Pasadena, California, USA
Dr. Tom Slanger, SRI International, Menlo Park, California, USA
Dr. Tim Wallington, Ford Research Laboratories, Dearborn Michigan, USA
Prof. Paul Wine, School of Chemistry and Biochemistry, Georgia Institute of Technology, Atlanta Georgia, USA.

The conference program includes the areas of atmospheric chemistry, theoretical and experimental reaction kinetics, gas-phase, heterogeneous and aqueous reactions, spectroscopy and combustion. The goal of the Informal Conference is to promote the study of chemical kinetics in the geographical region including Scandinavia, the Baltic States and Northwest Russia. We encourage student participation - prizes will be awarded for the best student poster and oral presentations. The conference centre is well known for its fine art, superb view of the Øresund and Swedish coast, and recreational facilities.

Abstracts of oral and poster presentations will be published as a book of proceedings available at the conference. The registration fee is 2500 Danish Crowns and covers food, lodging and conference proceedings, and will be collected during check-in at the conference site. To cover unavoidable expenses, a 500 crown fee will be charged for cancellations after May 15.

Financial assistance for travel and conference registration fees is available for those who are travelling from a network partner laboratory. With rare exceptions, we are not able to provide assistance to applicants from outside the network.
To pre-register, please send your name, address, affiliation, phone, fax and e-mail information to noneck@kiku.dk by January 31, 2002.

Conference website: http://kl5.ki.ku.dk/noneck/

Organising Committee: Matthew S. Johnson, Department of Chemistry, University of Copenhagen,
Denmark Mats Jonsson, Royal Institute of Technology, Stockholm, Sweden Sarka Langer, Swedish National Testing and Research Institute (SP), Department of Chemistry and Materials Technology Claus J. Nielsen, Department of Chemistry, University of Oslo, Norway Ole John Nielsen, Department of Chemistry, University of Copenhagen, Denmark

Co-Sponsors: The Nordic Network for Chemical Kinetics (NoNeCK) program of the Nordic Academy for Advanced Study, The Copenhagen Global Change Initiative, The Danish Society for Environmental Chemistry, The Federation of European Chemical Societies (FECS).

For further assistance you may contact: Matthew S. Johnson, msj@kiku.dk, Department of Chemistry (KLV), University of Copenhagen, Universitetsparken 5, DK-2100 Copenhagen Oe, Denmark, Office +45 3532 0303 Lab +45 3532 0316 Fax +45 3535 0609.
http://kl5.ki.ku.dk/laser/_http://kl5.ki.ku.dk/noneck/
http://kl5alfa.ki.ku.dk/laser/seminar.html

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

Bob Hazell, Secretary of the Society's Environment, Health and Safety Committee (EHSC) and **Derek Lohmann**, an ECG committee member, report on the EHSC's activities in 2001.

During 2001 the EHSC continued to pursue its principal objectives:

- to provide health, safety and environmental services to RSC members to help them fulfil their responsibilities as professional chemists;
- to influence health, safety and environmental legislation and its implementation to ensure they are in the public interest and based on sound science; and
- to promote sustainable development by advising RSC and its members on relevant policy issues.

EHSC Notes

The committee's Working Party on EHSC Notes was particularly active and issued three Notes on the LD_{50} acute toxicity test, HAZOP, and Contaminated Land respectively, which are intended to provide RSC members with authoritative guidance on these topics. All EHSC Notes are available free of charge on request from Bob Hazell at Burlington House (hazellr@rsc.org) or from the www.rsc.org Web site.

In addition the Working Party is currently finalising Notes on:

- Practical Chemistry in Schools
- Fire Safety in Laboratories
- Green Chemistry
- Acceptable Risk, Precaution and Uncertainty.

EHSC Notes aim to 'add value' by providing a consensus view or advice from a group of experts, who give their time voluntarily to the Society. The Working Party welcomes constructive feedback on its publications and suggestions for new topics. These should be sent to Bob Hazell.

The Working Party selects topics using several criteria. However, it is significant that the decision to consider a Note on 'Acceptable Risk, Precaution and Uncertainty' arose from a meeting that the EHSC organised with senior HSE staff. Concern was expressed on both sides that the public is increasingly 'risk averse', and like EHSC the HSE are keen to promote a 'risk-based' approach to controlling chemicals, in line with the EHSC 'Position Statement' on this subject. However, within the EU, and elsewhere, hazard-based approaches are considered to be more appropriate. It was felt that in order to promote risk-based approaches, it was important to get to grips with issues like *acceptable risk*, *uncertainty* and *best practice*, hence the Note, which should be available later this year.

The Working Party also reviewed its existing papers on reproductive effects of chemicals and related issues with the help of the Society's Women Chemists Network and Occupational and Environmental Toxicology Group. Finally the Working Party took over responsibility for revising the EHSC booklet *COSHH in Laboratories*. Meetings were held with HSE to consider how the booklet could be brought into line with HSE's *COSHH Essentials* package. This is a major project for an expert group composed entirely of volunteers and work is currently at an early stage.

EHSC Liaisons with UK Government

UK Chemical Stakeholder Forum

The EHSC continued to lead the Society's involvement with the UK Chemical Stakeholder Forum which is operated by DEFRA (www.defra.gov.uk). A sub-group of the EHSC with representatives of ECG, OETG, WCF and IAD meets shortly before meetings of the Forum itself to advise the RSC representative on the Forum (Dr Tom Inch). All the members of the sub-group are volunteers, and the Society is indebted to them for their diligence in coping with voluminous papers that are usually received from DEFRA only a few days before the meetings. An especially great burden inevitably falls on the EHSC Chairman, Professor David Taylor, who also chairs the sub-group.

EU Chemicals White Paper

During 2001 the Forum was particularly involved in tracking and advising DEFRA on the EU Chemicals White Paper, which represents one of the most significant pieces of EU legislation to have an impact on the practice of chemistry for the last 25 years. The Forum established four sub-groups to track different aspects of the EU Chemicals White Paper, and expert volunteers represent the Society on each of these sub-groups.

In addition four volunteer experts from the RSC, Professor Taylor, Dr Norman King, Mr. Paul Whitehead and Dr Tom Inch gave oral evidence to a House of Lords sub-committee* on the White Paper, and EHSC made additional written submissions on it to DETR (as it was then named) and to the House of Lords. A supplementary submission on 'Persistence in Environmental Risk Assessment' was also made to the House of Lords Sub-committee. [* Sub-committee D (Environment, Public Health and Consumer Protection) of the House of Lords European Union Committee].

Royal Commission on Environmental Pollution

At the same time that the EU White Paper was being scrutinised, the UK Royal Commission on Environmental Pollution (RCEP) continued its study on long-term effects of chemicals in the environment. This is a long-term look at the issue. The EHSC prepared the RSC submission on the initial phase of the study (**scope**) in early 2001 and work is currently in progress to prepare the Society's submission on the second phase (**evidence**).

The RSC submission on the first phase (**scope**) suggested the need to identify 'most-at-risk eco-systems' for priority monitoring, and as a result of this an RSC group met the NERC to discuss a possible joint RSC/BES workshop on the issue. This is currently being pursued by

the OETG, which is taking the lead on behalf of RSC.

Review of the RSC's Health, Safety and Environmental Activities

It will be clear from the above account that EHSC depends heavily on the voluntary input of expert RSC members. The Scientific Affairs Board, to which EHSC reports, has initiated a review of the Society's health, safety and environmental operation to see how it might be improved. During the course of 2001 an internal 'discussion paper' was produced by Professor Taylor and Professor Townsend, the RSC's General Manager Scientific Affairs. The discussion paper made certain proposals for reorganisation and was circulated in the first instance to EHSC and to the other units represented on the committee, including the ECG.

The responses expressed a very wide range of opinions. Very few people showed any significant dissatisfaction with existing structures (ECG, EHSC, WCF, OETG). However, there was some dissatisfaction with the Society's overall environmental operation and its arguable that the underlying issues may be more to do with resources than with the way that the RSC is structured.

Views were quite divided about the priorities that the RSC should have in the health, safety and environmental area. Taken together the responses clearly confirmed that RSC 'environmental interests' are very broad indeed, involving almost every part of the Society – cleaner synthesis, understanding environmental processes, analysis of food & water, environmental monitoring, toxicology, regulation, professional standards, liaising with Government, dealing with the media, informing the public, etc. The comments are now being considered in detail. The ECG will of course be fully involved in developments.

Other Activities

In addition to the above the EHSC has undertaken numerous other activities. For example the committee has continued to oversee the Society's involvement with the **Hazards Forum** [www.hazardsforum.co.uk] and with the **Science Council** group on the environment.

The Hazards Forum has emerged from a period of review with a broader focus than its origins in engineering. It has organized several high level 'invitation only' meetings which aim to bring together opinion formers from industry, government and academia, as well as professional institutions, on topics of current interest (such as 'the Board and Corporate Risk Culture'), and has initiated discussions with EHSC amongst others on proposals to set up a Risk Assessment and Information Centre. The Science Council group is relatively new but hopes to set up a multidisciplinary project on environmental indicators.

Normal EHSC business has continued. For example, various enquiries from RSC members (and others) have been dealt with, and submissions on Consultative Documents have been made on several issues including:

- Identification of CFC/HCFC Foam Insulation in Refrigeration Equipment
- New NERC Science and Innovation Strategy
- Cabinet Office Performance and Innovation Unit [PIU]: Review Of Energy Policy.

A high level meeting with representatives of the **Environment Agency** will be held in early February and it is hoped that this will be as fruitful as the analogous meetings that were set up and have continued with HSE.

Finally the EHSC continued to oversee the RSC input to the 'Professional Practice for Sustainable Development' [PP4SD]* project [www.ies-uk.org]. An introductory course on sustainable development for professionals was finalised and 'train the trainers' meetings held and RSC Education Dept and the Green Chemistry Network have been considering how to make use of the course. PP4SD plan further projects in due course. [*PP4SD was set up by the Environment Agency, WWF, IES, Natural Step and others to develop 'bottom up' approaches to sustainable development for professionals. 13 Professional Bodies including RSC participate in its work.]

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January 2002

Forthcoming symposium

Chemistry for a Sustaining World

8th FECS Conference on Chemistry and the Environment

VENUE: Athens, Greece, 31 August to 4 September 2002

Conference website:
http://www.scientificjournals.com/espr/fecs/8thConf.2002

Under the auspices of: FECS-DCE; The Association of Greek Chemists; ecomed publishers

Organized by the University of Athens, Department of Chemistry

Conference Aims

To fulfill its part in sustainable World development, chemistry is changing. This 'greening' of chemistry involves two main thrusts. First, production, use and disposal of hazardous chemicals are being reduced and where possible eliminated. This must, however, be achieved whilst maintaining or improving the quality of human life, the natural environment and industrial competitiveness. Secondly, the environmental impact of anthropogenic chemicals is being studied so that it may be better understood, monitored and controlled.

Research is continuing to support these goals. New synthetic pathways are being developed using renewable feedstocks,

alternative solvents, catalysts and reaction conditions to increase energy and atom efficiency and reduce waste. Simultaneously the toxicology, metabolism and biogeochemical cycling of environmental contaminants and pollutants are being elucidated.

Although sustainability in chemistry has become established in many parts of the industry, there is still a lack of general awareness amongst academics, industrialists, regulators and the media. The aim of this conference is to bring together scientists from universities, industry and governments to discuss and promulgate the current state of knowledge, latest research findings and likely future developments in all aspects of chemistry in the environment to point the way to an integrated approach to chemistry for a sustainable and sustaining world in the twenty-first century.

The conference will include invited plenary lectures from world authorities, parallel sessions of oral presentations of submitted papers arranged to cater for both specialist and generalist participants, dedicated workshops and exhibitions of commercial laboratory and field equipment. A special session will be devoted to the 2004 Olympic Games and its potential impact on the city of Athens.

Preliminary Program

1. Air Quality and Exposure (Chairs: Hartmut Frank, Herman van Langenhove)
2. Water and Sediment Quality and Treatment (Chairs: Fritz Frimmel, Maria Teresa Vasconcelos)
3. Soil Quality and Remediation (Chairs: Toomas Tenno, Costas Michael)
4. Anthropogenic Chemistry (Chairs: Valery S. Petrosyan, John Holder)
5. Environmental Management (Chairs: Allan Astrup Jensen, Sergio Facchetti)
6. Education in Environmental Chemistry (Chairs: Uri Zoller, Miltiades I. Karayannis)
7. Olympic Games and the Environment (Chairs: Panayotis Siskos, Ramon Mestres)
8. Conservation of Ancient Monuments (Chairs: Luciano Morselli, Nikos Katsanos)

Call for Abstracts:
Deadline for abstracts is March 2002

Registration fee: Participants: 300 Euro; Graduate students: 100 Euro
Pre-registration: online by the website or by using the pre-registration form

Accommodation: www.eot.gr

Contact Panayotis A. Siskos, Assoc. Professor of Analytical Chemistry and Environmental Analysis
Department of Chemistry, University of Athens, Panepistimiopolis-Zographon, Athens 15771, Greece
T: +301-727-4311; F: +301-727-4750 e-mail: siskos@chem.uoa.gr; info@eex.gr; Websites: http://www.siskos.gr; http://www.eex.gr

Suggestions for further topics and speakers are welcome

The abstracts will appear as a Special Issue of *Environmental Science and Pollution Research*

Forthcoming symposium

Gordon Research Conference on Green Chemistry

DATE: 8th-13th September 2002

VENUE: Queens College, Oxford, UK

Key themes include:

- New Green Synthetic Methods
- Chemical Biology
- Elucidation
- Atom Economy
- Clean Oxidation
- Asymmetric Catalysis
- Heterogeneous Catalysis
- Novel Reaction Media
- Alternative Feedstocks
- Solar Energy

The Co-Chairs are keen to encourage all participants in the above meeting to present a research poster. Also, selected poster presenters will be invited to make oral contributions of their very latest results. Please contact Jim Bashkin or Adrian Kybett with a 100 word (maximum) poster proposal.*

Note that registration numbers are strictly limited and registration is via application; online applications may be made at http://www.grc.uri.edu/attend.htm

FOR FURTHER DETAILS CONTACT: James K Bashkin, Pharmacia Corporation R3A, 800 N. Lindbergh Blvd., St. Louis, MO 63167 USA. Tel +1 (314) 694 3244, Fax +1 (314) 694 3479
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*See http://www.acs.org/education/greenchem/principles.html

A SELECTION OF RECOMMENDED GREEN CHEMISTRY SITES:

http://www.rsc.org/greenchem

http://www.chemsoc.org/gcn/

http://www.lanl.gov/projects/green/index.html

http://www.acs.org/education/greenchem/

http://www.epa.gov/opptintr/greenchemistry/

http://web.chem.monash.edu.au/GreenChem

http://www.grc.uri.edu/programs/2002/green.htm

http://bama.ua.edu/~cgm/

Meeting report: Global atmospheric change

During the last week of August 2001 a NATO Advanced Research Workshop on **Global Atmospheric Change and its Impact on Regional Air Quality** was held in Irkutsk, which is situated in the eastern part of the Russian Federation on the southern edge of Lake Baikal. **Leo Salter** reports

The conference was organised by Professors Karl Becker (University of Wuppertal, FRG) and Igor Mozorow (Russian Academy of Science, Moscow) and drew together some fifty participants from America, Canada, Russia and several European countries.

The papers presented at the conference could be categorised into four broad groups:

Field Measurements (of ozone, atmospheric aerosols, biogenic compounds and sulphur containing compounds (e.g. dimethyl sulfide).

Modelling (e.g. David Simpson, Norwegian Meteorological Institute, *Regional Modelling of Ozone and Aerosols over Europe* and Frank Dentener, Environment Institute, Ispra, Italy, *Global Modelling of Atmospheric Chemistry*).

Laboratory Based Studies (e.g. Claus Neilsen, University of Oslo, Experimental *and Theoretical Studies of the OH Initiated Degradation of Aldehydes*).

General Issues of Global Atmospheric Change (e.g. Igor Mozorov, *Fluorinated Radical Reactions of Atmospheric Importance* and Professor Laritchev, Institute of Chemical Physics, Moscow *Soot Particles from Different Combustion Sources: Composition, Surface Groups, Oxidation under Atmospheric Conditions*).

Attention was focused on a number of problematic areas:

- A continuing and increasing recognition of the importance biogenic organic emissions in understanding local air quality;
- The need for continuing studies of the contribution of dimethyl sulphide emissions to cloud formation and the global sulphur budget;
- The difficulties in categorising reactions which occur on and in atmospheric aerosols;
- The importance of halogen chemistry (particularly bromine) for oxidative processes in the troposphere.

The conference also drew attention to sources of information and data within the Russian Federation and highlighted the possibilities for cooperative programs – particularly in relation to these field measurements of important chemical species that would help refine and extend the capabilities of global models of atmospheric chemistry.

LEO SALTER,
Cornwall College

Meeting report: Monitoring ambient air

A meeting on 'Monitoring Ambient Air - an Update' was held in December 2001 at the Scientific Societies Lecture Theatre in London. **Leo Salter** reports.

The meeting was organised by the Automation and Analytical Management Group of the Royal Society of Chemistry in co-operation with the Health and Safety Executive, the Institute for the Environment and Sustainability (Ispra, Italy), NMI (Nederlands Meetinstitut) and the National Physical Laboratory (DTI VAM programme). There were around 140 attendees from industry, environment agencies and academia; and several European countries were represented in each of these categories.

Lynne Edwards (DG Environment, EC) presented the opening lecture in the first session: *Development and Implementation of the New Ambient Air Directive: an EU Perspective*. She focused chiefly on the European Directives (EDs) - their creation, function and future development - and, in particular, the 4th Daughter Directive (DD) on heavy metals and PAHs; the National Emission Ceilings Directive (which will require annual inventories of selected air pollutants) and CAFE (Clean Air for Europe) - an international trans-European study due to report in 2005 and aimed at improving air quality.

Don Munns (EA, Hatfield) then spoke on *The Role of CEN TC264 in Standardisation within the EU*. He argued for the advantages of CEN (Comité Europeén de Normalisation: European Committee for Standardisation) standards over national, ISO and others and referred especially to the three completed CEN/TC264 documents: EN12341 (PM_{10} monitoring); TR-N422 (uncertainty) and EN 13528 (diffusive sampling).

Peter Bruckmann (Landesumweltamt NRW, Essen, Germany) gave a clear (but unresolved) elucidation of the current status of PM_{10} measurement verification (i.e. gravimetric reference methods in relation to continuous systems such as the Teom and β-attenuation techniques); *Problems with PM_{10} monitoring, Implementation of the PM Directive*. His talk covered much detail concerning the problems relating to the site-to-site variation in agreement between gravimetric and continuous methods, and the dependence of this variation on sample flow-line temperature, humidity, ambient temperature and the nature of the particulate matter collected (especially ammonium nitrate).

The argument was for local correlation of real-time continuous monitoring with gravimetric methods via the use of

experimentally identified site-specific and instrument-specific correlation expressions, which are regularly re-validated. Otherwise a 'fail-safe' 1.3 factor was to be used to multiply continuous measurements and allow for mass loss due to volatilisation of material such as ammonium nitrate. Summertime measurements correlate better than wintertime measurements chiefly because the differences in operating temperature between gravimetric samplers (ambient temperature) and continuous samplers (heated, usually 50 °C) are less than in winter.

In the afternoon session, Martin Lutz (Directorate IX, Environmental Policy, Berlin) in a talk on *Ozone and Photochemical Pollution* emphasised the continuing problem of ozone in terms of its effects on health and vegetation. The southern Mediterranean area in particular may find ozone abatement difficult and, in this context, high spatial resolution (10 km) will be required to locate local ozone hotspots and to identify whether VOC or NO_x abatement would be the most appropriate strategy for achieving reductions in ozone exposure. The importance of national reductions in ozone for the reduction of ozone in neighbouring states was discussed both for intra-European and cross-Atlantic transport – the latter can contribute up to 5 ppb to European ozone concentrations.

Mike Woodfield (AEA Technology) gave a paper entitled *PAH, Occurrence, Epidemiology and Monitoring*. Recent indications from the UK and the EU (4th DD) are that issues surrounding PAHs are receiving more attention. This raises problems relating to the monitoring and assessment of these compounds. Benz[*a*]pyrene is to be used as a marker compound for PAHs – though other marker species may be added in the future. Currently, typical measurement uncertainty is ±50% at the 95% confidence level and detection limits are in the region of 0.02 to 0.05 ng m^{-3}; hence the measurement of PAHs (sampling, analysis and reporting) needs to be harmonised across the EU and CEN is working on a ' . . . robust and cost-effective BaP reference method'.

Hilde Uggerud (NILU, Norway) in a review of *Heavy Metals, Occurrence and Monitoring* described the EMEP (European Monitoring and Evaluation Programme), which co-ordinates data from European countries on heavy metals in air and precipitation. It was reported that the annual averages of lead and cadmium in precipitation show increasing eastbound (lead) and southbound (cadmium) gradients – the highest values were recorded at the Belgian and Czech stations. The paper also presented information on the use of a carpet-forming moss (*Hylocomium splendens*) to survey the atmospheric deposition of lead. Finn Palmgren (National Environmental Research Institute, Roskilde, Denmark) then spoke on *Fine Particulates, the Sub-$PM_{2.5}$ Debate.*

The following day had presentations on equipment (*Equipment for Thermal Desorption*, Jan Kristensson, Chemik Lab, Sweden) and *Measurement Options for Benzene and Acid Gases – the Role of Diffusive Sampling* (Richard Brown , Health and safety Laboratory, Sheffield). The latter paper described how – in relation to the EU Ambient Air Quality Directive – Working Group 11 (TC264/WG11) is preparing performance requirement documents for diffusive samplers (prEN 13528-1 and 13528-2) and Working Group 13 (TC264/WG13) is preparing documentation referring to five measurement methods for benzene two of which (Reference method for the determination of benzene in air Parts 4 and 5) utilise diffusive samplers. WG11 is also " . . . planning a minimum validation programme of diffusive samplers for nitrogen dioxide (and/or NO_x), sulfur dioxide, ozone and ammonia." which may result in further CEN guidance.

Carl Percival (Nottingham Trent University) argued for the development of techniques for radical detection (Chemical Ionisation Mass Spectrometry (CIMS)) and hydrocarbon detection and speciation (Quartz Crystal Microbalances (QCMS)) in his paper; *Future Needs and Techniques for Ambient Air Monitoring.*

Bill Boyle (BP Amoco, Sunbury UK) described the extensive activities of BP in monitoring and mapping benzene (and other VOC) releases (*Benzene, the Issues*) chiefly around Grangemouth. He also discussed the extensive variation of benzene air quality standards between nations and (in the US) between states.

The final session of the meeting was devoted to a workshop on QA/QC for ambient air monitoring.

The conference had a wide European participation and in the presentations mixed strands of European policy-making, monitoring methodologies and data-reporting. To a certain extent this meant that the conference had a broad focus and that many of the presentations were of a review style rather than closely argued scientific papers. However, the attempts this regular conference is trying to make to link the progress of EU policies and guidance with practitioner activities are noteworthy.

LEO SALTER,
Cornwall College

Meeting report: Association of Chemistry and the Environment

Second European Meeting on Environmental Chemistry of the Association of Chemistry and the Environment (ACE), Dijon, December 2001

Despite the cold weather and with the help of the local mulled wine at an opening "ice-breaking party", 280 participants attended the second European Meeting on Environmental Chemistry, which was held in Dijon in December 2001. Representatives from thirty-one European and other nations were present.

Around 50% of the attendees were Ph.D. students and younger scientists - attracted by the low registration fee for students (149 Euro), by the promotion of many job opportunities in the environmental sciences, and by the presence of one Ph.D. student (Nathalie Grova) and other talented young scientists on the ACE Board.

The meeting and poster sessions covered fundamental and applied aspects of the environment: air, water, soil, sediment and food pollution, green chemistry, ecotoxicology, toxic metals, organic pollutants, stable isotope, and analytical methods for environmental science. In an invited lecture, Prof. Dr. Antonius Kettrup from the Institute of Ecological Chemistry, Munich described environmental sample banking in Germany. He stressed the need to couple trace analysis and ecotoxicological tests in order to give a realistic evaluation of pollutant toxicity.

Springer-Verlag, Berlin, will publish a selection of the proceedings from the meeting in a book, due to be issued in 2002. The meeting's abstracts on CD-ROM can be purchased via the ACE website http://www.u-bourgogne.fr/ACE. The meeting's scientific program can be downloaded for free.

ACE European Young Researcher of the Year Award

The Stable Isotope session was held in the memory of Dr. Gareth Rieley, a bright and committed young British environmental scientist. Gareth died in 1998 aged 28, at the start of a promising and successful research career aimed at understanding the factors which control isotopic fractionation at the molecular level in organic compounds of biological and environmental significance*. Gareth studied at the Organic Geochemistry Unit, University of Bristol, and obtained his Ph.D. in 1993 in "Molecular and Isotopic Studies of Natural Environments: Distributions and Stable Carbon Isotopic Compositions of Individual Lipids".

In memory of Gareth, a new award was announced at the meeting, the "ACE European Young Researcher of the Year Award", which is aimed at recognising the achievements of young researchers who have made an outstanding contribution to the scientific understanding of environmental processes. The first ACE European Young Researcher of the Year Award, consisting of 500 Euros and a free meeting registration, will be presented at the next meeting in Geneva (see ACE website for nominations).

* For example, "Sources of Sedimentary Lipids Deduced from Stable Carbon Isotope Analyses of Individual Compounds", Rieley, G. *et al*, *Nature*, 1991, **352** (August 1st): 425-427.

ACE Environmental Chemistry Award

The second ACE Environmental Chemistry Award, consisting of a Daum artwork, was presented during the meeting to Céline Xrouet, Caroline Nadin and Edwin De Pauw from the University of Liège, Belgium, in recognition of their poster presentation entitled "Prevention of dioxins *de novo* formation on sintering process fly ash by using amines compounds".

Future ACE Meetings

December 2002: 3rd European Meeting on Environmental Chemistry, December 11-14, 2002, Geneva, http://www.u-bourgogne.fr/ACE. Contact: Dr. Monserrat Filella montserrat.filella@cabe.unige.ch

December 2003: Plymouth, United Kingdom. Contact: Dr. Mark Fitzsimmons mfitzsimons@plymouth.ac.uk

December 2004: Bari, Italy. Contact: Dr. Michele Aresta aresta@metea.uniba.it

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Meeting report: The comet assay as a tool for biomonitoring and environmental monitoring

At a recent International Comet Assay Workshop, held in Ulm, Germany, participants discussed the usefulness of the single cell gel electrophoresis technique – otherwise known as the **comet assay** - for evaluating the genotoxicity of drugs and industrial chemicals. **Nick Morley** from the Cornwall Dermatology Research Unit reports.

Ostling and Johanson devised the comet assay in 1984 to detect double stranded DNA breaks in isolated single cells and the technique was later modified by Singh *et al.* (1988) to detect single strand breaks (SSBs). Because SSBs are generated during the process when cells repair DNA damage, and may also be induced directly by drugs or other chemicals in the environment, the modified version of the comet assay is now used by many scientists worldwide in biomonitoring and environmental monitoring.

Although much of the workshop was spent discussing the technical aspects of the comet assay and ways in which the application could be expanded, poster presentations gave an insight into the wide range of applications of the comet assay. For example, Swedish investigators reported on how they have used the comet assay for screening 28 compounds in cultured mammalian cells (mouse lymphoma) from chemical groups as diverse as mutagens and metabolic inhibitors. Similarly, a Swiss team has screened 71 compounds, of various chemical classes, in cultured murine cells and found that 37 compounds cause significant DNA damage and are therefore genotoxic. Interestingly, 80% of these genotoxicants cause only minimal cytotoxicity, which is one of the end-points that are tested for in the development of new drugs.

Other research showed that the use of the comet assay for the genotoxicity testing of drugs is as novel as it is vast, ranging from the genotoxic testing of anabolic steroids in blood cells from Brazilian body building athletes, to an English study of paracetamol genotoxicity in human cells exposed to solar radiation. In China, scientists have used the comet assay to study the genotoxic effects of smoking, passive smoking, alcohol, and occupational exposure to benzene in cells from a number of workers at a lift-manufacturing factory. Perhaps the most surprising results of this study were that alcohol had no effect and passive smoking at home was more genotoxic than in the factory; DNA damage from this insult increased with age and was worse in males.

Workers in Greece have used the comet assay for biomonitoring occupational exposure to agrochemicals in different countries in Europe. A team from Italy has investigated the genotoxic potential of metals in catalytic converters. Initial results suggest that rhodium and platinum can induce significant oxidised DNA damage in cultured human cells. Other work is aimed at standardising the comet assay to ensure global consistency and establish the technique as a leading tool for human biomonitoring.

In addition to human biomonitoring, the application has been employed in a number of animal studies for environmental monitoring of exposure to chemicals and pollutants. An Italian team has used the comet assay in a study with aquatic vertebrates and mussels to monitor the purity of drinking water that may have been contaminated with disinfectant. Likewise, cells collected from the fish of a German river have been used to monitor the genotoxic potential of organic extracts of marine sediment. One study in the USA has found that a photosensitive xenobiotic located in the marine sediment has been identified in grass shrimp embryos, where it has caused damage to DNA after it has become photosensitised by ultraviolet radiation.

In respect of air pollution, the Brazilian city Sao Paulo is one of the most polluted cities on Earth, with the highest levels of pollution occurring in the winter. Studies using the comet assay on the blood cells of Swiss mice exposed to this pollution have revealed that it has the potential to cause DNA damage. Consequently, a larger study is being conducted to investigate seasonal variation and the minimum exposure time required to induce a genotoxic effect.

Possibly the most unusual, yet equally effective environmental monitoring studies conducted using the comet assay, include cell extracts from pig bladders collected from a German slaughterhouse in order to monitor the effects of ochratoxin, a mycotoxin produced by certain species of *Aspergillus* and *Penicillium*, and a widespread contaminant of various foods including corn, wheat, barley and oats.

Another inventive study includes the recruitment of earthworms by a Danish team to monitor soil contamination. In particular, these scientists are interested in polyaromatic compounds and chlorinated aromatics. Earthworms were chosen because they are exposed to the unaltered contaminant in a solid matrix rather than as an organic solvent or aqueous extract which is commonly the case in most genotoxicity assays of polluted soil.

There is however, a modification to the comet assay that enables investigation into SSBs in plant cells, which is being exploited by French workers. Higher plants are also sensitive to soil and water pollutants. So, as part of the International Program on Plant Bioassay, a collaborative study initiated by the United Nations Environmental Program, the French team have been monitoring soil contamination in the cells of roots, leaves and stems of the broad bean and spiderwort in various locations in France.

The poster presentations gave a good insight into the many different uses of the comet assay. And, while most of the workshop time was taken up on how to improve and expand the technique, it is the range and quality of the research over the years that have helped to see the international reputation of the comet assay grow in stature and become accepted as a reliable application for

biomonitoring and environmental monitoring.

References

Ostling, O. and Johanson, K. J., Microelectrophoretic study of radiation-induced DNA damages in individual mammalian cells. *Biochemistry Biophysics Research Communication.* **123:** 291-8. (1984)

Singh, N. P., McCoy, M.T., Tice, R. R., and Schnieder, E. L., A simple technique for quantitation of low levels of DNA damage in individual cells. *Experimental Cell Research.* **175:** 184-191. (1988)

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Web links: http://cometassay.com/ http://cometassay.de/

Book review

Environmental Chemistry: A Modular Approach

Ian Williams

John Wiley and Sons, Chichester, 2001, ISBN 0-471-48942-5 Paperback, 388pp, £19.99

Like me, you may have searched in vain for a single text which assumes only basic chemical knowledge but which covers all the fundamental theoretical and experimental requirements of a first year undergraduate Environmental Chemistry course. Search no more (for a while anyway), Ian Williams book goes a long way to achieving this ideal.

I should say from the outset that Ian is a colleague of mine at the University of Central Lancashire but, nevertheless, I still feel able to praise his valuable contribution to the genre.

The book begins with a general introduction to the subject and the practical skills the student needs, including laboratory techniques and report writing. Subsequent chapters cover: the Structure and Composition of the Earth, Earth's Vital Resources – Minerals, Metals and Fossil Fuels, Natural Cycles, and Water – the Lifeblood of the Earth. Each begins with the theory and then provides a selection of illustrative experiments and graded self-study exercises. Finally, the book provides a comprehensive Glossary and useful 'Links' section.

The book is full of detail for university teachers, providing a course in itself whilst cueing those distinctive little add-ons which we all like to make. It also remains to my mind at least accessible to the student. It is old fashioned in style but modern in content. Well worth a look before you rewrite your lecture notes this summer. You may well be able to save some time for that extra grant proposal!

JOHN HOLDER,
Faculty of Science,
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Book review

The Skeptical Environmentalist: Measuring the Real State of the World

Bjørn Lomborg

Cambridge University Press, 2001, 515 pp. £47.50 (hardback) £17.95 (paperback)

For years to come the simplicity and common sense appeal of the decontextualised statistical evidence in this book will make it essential reading for all anti-environmentalists. Polemical and anthropocentric, the book focuses on global trends to criticise the 'selective' use of data by environmentalists in garnering support for their consciousness-raising activities (pejoratively referred to by Lomborg as 'the Litany') – though it seems as though the author himself indulges in some fairly judicious data selection to support his thesis. It is easy to read – though the style of listing selected data to justify a perverse point of view followed by declamatory exclamations against core environmental values becomes tedious. It is a book to pick up and read in bits.

In the early part of the book, Lomborg examines indicator data such as those related to access to drinking water or the incidence of TB and malaria to deal with aspects of human welfare (life expectancy, food and hunger and the ill-defined 'human prosperity') to demonstrate that things are getting better. This seems not only to ignore 'quality of life' and its links to the perceived environment but also to ignore the evidence of local destruction of habitat and wildlife. A dispassionate understanding of the audited loss of habitat in Africa, the difficulties of escape from anthropogenic influences, the changes in insect populations and land use, the deterioration of watercourses and the loss of hedgerows contrasts with Lomborg's righteous non sequiturs and yah-boo denial. His approach to the scientific literature is often devoid of the objectivity scientists expect and full of aphoristic simplifications; most importantly his approach lacks the detailed knowledge of the research literature to give his point of view mature perspective. A certain amount of fervent religiosity pervades the work, for instance, one might agree that 'Research is basically a question of revealing truths about ourselves and our surroundings . . .' if, like Lomborg, one classified a great deal of environmental science as a 'Litany' and environmentalists as somehow expressing a '. . . Calvinistic sense of guilt'.

The book has had a somewhat scathing review in *Nature* ("No need to worry about the future – Environmentally, we are told, 'things are getting better'." by Stuart Pimm and Jeff Harvey, *Nature*, 414, 149-150, (2001)) pungently encapsulated in its classification of the book as,
'. . . a compilation of term papers from one of those classes from hell where one has to fail all the students.' So, whatever the 'truth' of the book's contents it certainly has irritation appeal!

However, it is a must to buy and no environmentalist should be excused the task of reading it. Partly because its arguments and logic are going to surface again and again in every place where students, business leaders and politicians meet (not least the pub). And partly because the effort required to craft responses to Lomborg will sharpen and crystallise the environmental debate for the benefit of all. For lecturers and students alike the book provides a rich source of material to question, debate and discuss and the many figures throughout the text have value in this respect; for instance, in the section on oil pollution a figure showing the decline in spills since 1970 is a useful demonstration that at least some progress is being made!

And, provided they are read with a critical eye, there are many sections which provide good summary introductions to various topics – the section on airborne particulate matter is brief, concise and largely without flaw. This would be a dangerous book if it were the only book about the environment that a student (or politician or entrepreneur) ever read. But the discipline of environmental science can withstand the assaults of a dissenting voice and should embrace its challenge. The book demands a reply and refutation.

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Web link: http://uk.cambridge.org/economics/lomborg/

Chemistry at the University of Plymouth

Professor Steve Hill, a committee member of the Environmental Chemistry Group, describes the structure of chemistry courses at the University of Plymouth, and some of the analytical techniques and opportunities for research available to students.

Introduction

Many Chemistry Departments have diversified their activities in recent years with regard to both their undergraduate and postgraduate provision. Whilst it would be foolish to ignore the fact that some of this change is, at least in part, an attempt to attract maximum income through maintaining and even enhancing student numbers, it is also clearly a response to the changing needs of employers and a way to utilise staff expertise / interests and available resources.

The focus on environmental, analytical and applied chemistry at Plymouth, each with its own named undergraduate Honours Award, is a logical consequence of this, although we also offer joint Honours schemes which allow students to study chemistry with another subject. These courses are not 'diluted' traditional chemistry programmes, nor is there a 'dumbing down' of standards. Instead, they are purposed designed programmes put together following consultation with industry. Each programme builds on basic theoretical principles (as with any good chemistry degree) but is then tailored to provide students with enhanced practical skills and a knowledge base directly relevant to the named degree.

Undergraduate and Post-graduate Courses

Our four undergraduate chemistry programmes, BSc (Hons) Environmental Chemistry, BSc (Hons) Analytical Chemistry, BSc (Hons) Applied Chemistry and MChem Applied Chemistry, are accredited by the Royal Society of Chemistry.

During the last couple of years we have also increased our postgraduate portfolio. For some years, the Department has had a lively and productive research community of 50-60 PhD students and around 12-15 postdoctoral fellows studying chemistry related topics and usually with industrial sponsorship. However, our involvement at MSc level has been modest other than through joint programmes with other Departments. The successful introduction of a new suite of MSc programmes last year with an emphasis on environmental and analytical topics has now changed this to provide a complete portfolio at all levels.

Analytical Techniques for Coursework

I suggested above that there was merit in focusing on available resources. One of the key features of all of our chemistry programmes is our 'hands-on' approach to teaching. For example, students reading Environmental Chemistry are involved in an extensive fieldwork programme, which allows the students to plan and execute their own sampling strategy, prior to sample preparation and analysis using state-of-the-art analytical instrumentation.

We are fortunate to have well equipped modern laboratories and so students will actually get to use everything from the more basic UV and IR bench instruments through to GC, HPLC, FTIR systems and then NMR, GC-MS and high resolution ICP-MS instruments. This approach we feel makes our programmes a little different to similar programmes in other institutions, and is particularly well received by the students and future employers. Of course this approach also comes at a cost – modern instrumentation is expensive and if used for research purposes (as ours is), there are potential conflicts of interest, for example damage and contamination – I am sure you could add to the list! In practice however, if carefully managed the impact of these 'negative' features can be minimised and in most cases eliminated altogether. The 'positives' associated with this approach

in terms of the student experience however, far outweigh the concerns since although theory sessions, demonstrations and computer simulations can all provide valid and essential background, we feel that they are no substitute for first hand experience under the watchful eye of an experienced user.

Research Activities

There are four research foci within the Department:

- Analytical Chemistry
- Marine Chemistry
- Organic Geochemistry and
- Environmental and Fluids Modelling.

The major objectives are to:

- Enhance the existing international expertise in chemical measurements and instrumental techniques;
- Harness this measurement expertise to provide novel techniques and approaches for the acquisition of high quality environmental analytical data, both in the laboratory and in the field and;
- Use these data to elucidate biogeochemical cycles, study environmental (particularly aquatic) processes and develop diagnostic modelling tools (e.g. EcoS, Pore-Cor, PROTEUS).

Analytical Chemistry research specialises in: (1) Speciation studies using atomic spectrometry and mass spectrometry and (2) *in situ* monitoring using flow injection techniques.

Analytical Instrumentation

Atomic spectrometry research provides high quality data on trace metal concentrations in environmental matrices, and coupling with, for example, LC and GC has provided unique speciation information. Both aquatic (freshwater and marine) and terrestrial studies are ongoing, with a focus on Se, As, Hg, Pb, Sb, Sn, and U. We also host the highly successful Speciation 21 Web site funded by the EU (http://www.speciation21.plymouth.ac.uk/).

The new **high resolution ICP-MS** instrument and clean room facility provides unique opportunities in Environmental Health and Marine Chemistry. Fundamental studies related to sample introduction, novel instrument design (e.g. a particle beam interface coupled to a low pressure ICP-MS), isotope dilution assays and application of chemometric methods to aid data interpretation maintain the group's international reputation.

Flow injection (FI) research is directed at designing and deploying remotely deployable instrumentation to provide unique, high quality environmental data, with good temporal and/or spatial resolution.

Shipboard instrumentation with **chemiluminescence** (CL) detection has been used for ocean scale underway mapping of dissolvable iron, particularly in the context of iron fertilisation. The instrumentation provided recent iron measurements (detection limit 40 pM) for the Southern Ocean SOIREE fertilisation experiment and was also used to map iron in the Atlantic Ocean (AMT transect). This research has also produced CL methods for Cu, Co & Mn and instrumentation for shipboard deployment in estuarine and coastal waters with high particulate loads.

Submersible and land based instrumentation with **spectrophotometric** detection enables the monitoring of nutrient fluxes with high temporal resolution. A terrestrial instrument, incorporating array detection, has provided phosphate data to support modelling studies at lysimeter and catchment scales. The Analytical Chemistry group has also designed novel electrochemical sensors for monitoring nutrients in freshwaters.

Marine Chemistry research comprises field measurements, process studies and modelling. The prime activities of the group are to:

1. Design and validate new methods for determining metal species in the marine environment;
2. Carry out field measurements of dissolved and particulate metals and use the field measurements in the evaluation of significant marine chemical processes;
3. Quantify the rates and extent of the processes;
4. Parameterise chemical processes for inclusion in hydrodynamic models and contribute to the development of decision-support systems for end-users.

Specific activities include the determinations of spatial and temporal variability of dissolved and particulate metals in UK waters (Humber, Mersey, Tamar and Tweed estuaries; North Sea and Irish Sea) and international waters (e.g. contaminated estuaries in southern Spain, Ria de Averio, Portugal; Chupa Estuary, Russia); high resolution voltammetry for real-time determination of metal species for flux estimates and export budgets from estuaries; development of *in situ* measurement e.g. "Voltammetric *In situ* Profiler"; and processes studies, using radiochemical techniques, to evaluate partitioning of metals and hydrophobic organic molecules (HOMs; including PAHs, phthalates and surfactants). These studies provide a fundamental understanding of particle-water reactions and parameterise reaction constants for use in hydrodynamic models. conceptual models e.g. ECoS for prediction of contaminant distributions and transport of metals and HOMs.

Organic Geochemistry research is best known for its ability to tackle long-standing and intractable organic geochemical problems such as:

1. Rigorous identification of widespread and abundant sedimentary lipids from diatoms. Extensive studies of growth conditions and diagenetic reactions of these polyunsaturates have established surrogates for palaeosalinity.
2. Studies of the composition, occurrence, fates and effects of the so-called hydrocarbon 'hump' in petroleum.
3. Characterisation of polar oilfield chemicals (corrosion, scale inhibitors, de-emulsifiers) discharged from oil production platforms.

Radiolabelled analogues have been used to study sorption/desorption properties of

the chemicals onto North Sea particles (a similar approach is also being used to study diesel combustion and emissions). Data have been combined with hydrographic and physical data in a new computer model (PROTEUS) in use on North Sea platforms for simulation of oilfield plumes. The NERC funded Plymouth joint mass spectrometry facility is pioneering LC-MS studies of environmentally relevant chemicals.

Environmental and Fluids Modelling research focuses on models related to environmental diagnostics and environmental impact assessment. The objectives are to:

1. Advance fundamental understanding of the migration of fluids in porous media; specifically tracers, nutrient pollutants and oil in soil, sand and sandstone;

2. Make accurate and innovative measurements of the flow properties e.g., viscosity, permeability of fluids, including tracers, pollutants and environmentally friendly refrigerants.

Current emphasis is on measurement and prediction of nutrient and NAPL (non-aqueous phase liquid) pollutant migration in terrestrial systems. Development and licensing of Pore level properties Correlator software (Pore-Cor), for environmental and materials research is a major activity.

I hope this brief overview of chemistry at Plymouth has provided an insight into our approach to teaching and our research activities. Further information can be found on our web site: http://www.env. plym.ac.uk

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Forthcoming symposium

Sustainable Development and the Environment

DATE: Wednesday March 20th 2002

VENUE: Loughborough University, Loughborough, UK

Sustainable Development and the Environment is a one-day meeting, which aims to promote the development of business and industry whilst protecting the environment.

The meeting, organised by the Centre for Environmental Studies in collaboration with the Centre for Hazard and Risk Management and the Business School at Loughborough University, will be based on the premise that environmental good practice is an opportunity not an obstruction to successful business.

The meeting will consider both policy developments at the European and UK levels and the development of good practice in environmental sustainability for business and industry.

The meeting will be of interest to managers in industry and business, consultants, local authorities, 'green' organisations, academics, researchers and students.

Registration fee (including lunch and refreshments): £100

Reduced rate for students: £25

Further details and a registration form are available via the following web link: http://www.lboro.ac.uk/research/cens/susdev_sem.htm
or contact: Dr Lois Child e-mail: L.E.Child@lboro.ac.uk

Preview the contents of

Essentials of environmental management

Business and the environment

The 'business-environment' interaction
Introduction to natural systems
Overview of key environmental concerns
Pressures and instruments for change

Tools for environmental assessment and review

Identifying environmental aspects and impacts
Prioritisation – determining significance
Environmental auditing and review
Life cycle assessment

Environmental management system processes

Overview of environmental management systems
Environmental policy
Environmental objectives and targets
Environmental management programmes and procedures
Environmental emergency preparedness and response
Allocating environmental responsibilities and providing training
Communication on environmental issues

Operational control

Principles of pollution prevention and control
Control of releases
Waste management
Process efficiency

Moving forward

Beyond operational control
Environmental management and sustainable development

Appendices

Glossary of environmental terms
ISO 14000 series standards
Selected sources of further information

Who should read *Essentials*?

- health, safety and environmental professionals and managers responsible for environmental management
- other professionals, managers and directors whose role includes company environmental performance
- education and training professionals who provide courses with an environmental management content
- students, professionals and managers taking an environmental management course

The Federation of European Chemical Societies (FECS)

Division for Chemistry and the Environment (DCE)

Division Meeting in Nicosia, 6th October 2001

John Holder, a Committee Member of the Environmental Chemistry Group, reports on the current activities of the FECS Division of which he is Secretary.

The Committee met in Nicosia on Saturday 6th October 2001, as guests of the Cyprus Institute of Chemistry and its President Dr Kyriacos Tsimillis. The work of the Division has been recognised by the Italian Chemical Society. Allan Astrup Jensen the Division Chairman has been awarded the Medal of the ICS Environmental Chemistry Division reserved for non-Italians and Sergio Facchetti, a Division Member, the Italian Medal at a ceremony at Rosignano Solvay in Livorno on 5th June 2001.

The main business of the meeting concerned preparations for the next three FECS International Conferences on Chemistry and the Environment, **8th FECS International Conference on Chemistry and the Environment – 'Chemistry for a Sustaining World'** to be held in Athens 31 August-4 September 2002.

The first Announcement and Call for Papers has been issued and an announcement placed in the Greek Chemical Society Journal. Three thousand hard copies of the Announcement, provided by ecomed publishers have been distributed to environmental chemists throughout Europe. The announcement had also been posted on the Division website.

The Chairs of the eight themes are:

1. Air Quality and Exposure (Chairs: Hartmut Frank, Herman van Langenhove)
2. Water and Sediment Quality and Treatment (Chairs: Fritz Frimmel, Maria Teresa Vasconcelos)
3. Soil Quality and Remediation (Chairs: Toomas Tenno, Costas Michael)
4. Anthropogenic Chemistry (Chairs: Valery Petrosyan, John Holder)
5. Environmental Management (Chairs: Allan Astrup Jensen, Sergio Facchetti)
6. Education in Environmental Chemistry (Chairs: Uri Zoller, Miltiades Karayannis)
7. Olympic Games and the Environment (Chairs: Panayotis Siskos, Ramon Mestres)
8. Conservation of Ancient Monuments (Chairs: Luciano Morselli, Nikos Katsanos)

There was detailed discussion of the conference programme, venues, plenary events and number of parallel sessions. Training courses, workshops, cultural evenings and poster sessions with prizes for young scientists will be arranged. It was suggested that some of the poster presenters should be selected for three-minute blitz oral presentations. The conference will be located at the University in Athens and expects 300-500 participants.

Abstracts (one page) must be received by the end of March 2002 for evaluation, extended abstracts for publication on the Web by the end of July. The Second Announcement giving full details of the arrangements will be issued in January 2002

9th FECS International Conference on Chemistry and the Environment to be held in Moscow in 2003.

The Rector and Dean of the M.V. Lomonosov University in Moscow have agreed that the meeting can be held at the University, and the Mayor of Moscow has agreed to chair the Organising Committee. The conference title has not yet been finalised but a draft First Announcement is in preparation with a view to having the final version available for Athens. The Conference proposed date is late June 2003.

10th FECS International Conference on Chemistry and the Environment

The planning of the 10th FECS Conference, which is to be held in Italy in 2004, is still at an early stage. The Italian Chemical Society has agreed to join the organising group. Possible venues include the Universities of Florence, Venice or Bologna. The latter has an excellent new conference centre. It remains to be decided what the topic will be and whether the conference will be general and multidisciplinary or whether it would focus on two or three main issues.

25th Anniversary Booklet

The division is preparing a booklet of its history to coincide with the 25th Anniversary of the first meeting. Minutes of all 25 years of meetings have been collected but the history will focus mainly on the eight International Conferences and will also contain anecdotal material from former Chairmen (they were all men) and members.

Committee Structure

The Division now has five Committees covering Water, Soil, Air, Education and Sustainable Chemistry and plans further committees including Chemical Toxicology. Active members are sought for all these and methods of conducting business not entailing excessive travel are being sought.

Environmental Science and Pollution Research

The Divisional co-operation with the journal *Environmental Science and Pollution Research* published by ecomed continues to be fruitful. The FECS Website http://www.scientificjournals.com/espr/fecs/) has been updated and it is hoped that the registration form for the 8th FECS conference will frequently be used: http://www.scientificjournals.com/espr/fecs/8thConf.2002

The 8th FECS conference has been announced in detail in ESPR No. 4/2001. Selected papers from the 7th FECS Conference in Porto have been published in ESPR No. 4/2001 following the ESPR abstracts issue Special 1/2000. The publishers hope that FECS members will subscribe to the journal in greater numbers.

JOHN HOLDER
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November 2001

Environmental information at the RSC's Library and Information Centre

Searching the Literature

Searching CD-ROMs and other literature available in the Royal Society of Chemistry's Library and Information Centre (LIC) is offered free of charge to individual members of the RSC and to Corporate Members of the LIC as part of our Chemical Enquiry Helpdesk (CEHD) service. Urgent enquiries or those requiring extensive research may, however, attract a charge.

With an ever-increasing public awareness of environmental issues, the CEHD is becoming an invaluable source of information not only for RSC members but also for members of the public. Recent examples of queries from RSC members and others, which have been dealt with by our CEHD, include:

- An RSC member wishing to locate data on relative amounts of carbon monoxide produced by specific industrial processes.
- A student working on a project on arsenic contamination of groundwater in Bangladesh.
- A PhD student researching the biodegradation of surfactants.
- A researcher enquiring about future trends in stack gas monitoring.
- An RSC member looking for toxicity data on carmoisine with respect to human health and the environment.
- An RSC member seeking information on environmental monitoring of mercury from stack emissions and industrial processes.

At the CEHD we will endeavour to find an answer for all enquiries, however, if we do not have the information you require and feel that another organisation may be better equipped to handle your enquiry we may refer you to them.

For further information on the Chemical Enquiry Helpdesk please visit our web page at: http://www.rsc.org/lic/cies.htm

To submit a request to the LIC you can complete the online form on our web page: http://www.rsc.og/library

or send us a fax or e-mail, please find contact details below:

Fax: +44 (0)20 7287 9798
E-mail: library@rsc.org

This service is offered separately to online database searching for which there is a reduced charge for members. If you would like more information on this service please visit our web site at:

http://www.rsc.org/lic/cies.htm#online

Environmental chemistry information at the LIC

The LIC's collection on environmental chemistry is continuously being expanded and updated. The following is a list of the main sources of environmental chemistry information available at the LIC:

CD-ROMs:

Environmental Chemistry, Health and Safety (RSC)
Croner's Environmental Management & Environmental Case Law
Croner's Substances Hazardous to the Environment
Croner's Waste Management
Handbook of Environmental Data on Organic Chemicals
Dictionary of Substances and their Effects (DOSE) (print and CD-ROM) (RSC)
Chemical Abstracts CD-ROM (1977-1996)
Chembank
- Registry of Toxic Substances and their Effects (RTECS)
- Hazardous Substances Data bank (HSDB)
- Toxic Substances Control Acts (TSCA)
- Integrated Risk Information Systems (IRIS)
- Oil and Hazardous Technical Assistance Data System (OHMTADS)
- Chemical Hazards Response Information System (CHRIS)

OSH-ROM
- Occupational Safety and Health databases including HSELINE (Health and Safety Executive), MHIDAS (database on chemical accidents) and CISDOC (from the International Occupational Safety and Health Information Centre (CIS) of the UN International Labour Organization (ILO))

Textbooks:

IARC Monographs on the Evaluation of Carcinogenic Risks to Humans
IPCS Environmental Health Criteria (WHO)
Environmental Contaminant Reference Databook
Croner's Waste Management
Croner's Environmental Management
European Community Environmental Legislation
Directory of Substances and their Effects (DOSE)

Journals:

Bulletin of Environmental Contamination and Toxicology
Croner's Waste Management Magazine
Environmental Protection Bulletin
Environmental Science and Technology
Environmental Toxicology and Chemistry
Green Chemistry (RSC)
Industry and the Environment
Issues in Environmental Science and Technology (RSC)
Journal of Environmental Monitoring (RSC)
Journal of Toxicology and Environmental Health
Pesticide Outlook (RSC)
Process Safety and Environmental Protection
Radiation Research
Toxicology and Applied Pharmacology

Water 21
Water Quality International
Water Research
Water SA
Water Science and Technology

Online via STN:

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Meeting report: The Aerosol Society

The Aerosol Society held their 12th Annual Conference at the University of Bath from 18th – 19th June 2001. **Dr Alison Curnow** reports.

The meeting was organised by The Aerosol Society and focussed on the **Generation, Behaviour and Applications of Aerosols**. There were approximately 70 delegates including two plenary guests (Dr Urs Baltensperger, Paul Scherrer Institute, Switzerland and Professor John Staniforth, Vectura Ltd., Bath), 25 speakers and a number of poster presentations.

Proceedings commenced with the first plenary speaker Dr Urs Baltensperger (Paul Scherrer Institute, Switzerland) discussing the *Physico-chemical properties of atmospheric aerosols*. This talk outlined the great diversity of analytical methods required to physically and chemically characterise the complex nature of atmospheric aerosol particles. Dr Baltensperger's work is supported with experimental data collected at both a source site (urban Milan, Italy) and a remote site based high in the Swiss Alps (Jungfraujoch Research Station, Switzerland, 3580 m asl).

Two sessions on atmospheric aerosols then followed. Dr Colbeck (University of Essex) presented a *Subgrid scale investigation of the factors determining the occurrence of ozone and fine particles (sub-aero)*, Professor Donovan (Edinburgh University) concentrated on the real-time study of the *Chemical composition and size of atmospheric aerosols* and Dr Bower (UMIST) reported on the *Aerosol-cloud interactions* recently observed as part of the ACE-Asia intensive experiment conducted in spring 2001.

Dr Clement (QuantiSci, Wantage) gave two presentations as part of this session; *Fluctuations in aerosol and trace gas concentrations* and *Formation of a sulphuric acid aerosol* both studied in the upper troposphere of the atmosphere. Ms Emmerson (Lancaster University) used a Langrangian box model to represent simple aerosol processes in the atmosphere and discussed why the use of this sort of model under-predicted measured values of total primary PM_{10} every day in the two monthly periods studied. Dr Shiba (Graduate School of Osaka University, Japan) brought this session to a close with a presentation on *Competitive growth of cloud droplets attended with consumption of ambient water vapour*.

The final session of the first day concentrated on the electrical aspects of aerosols. Professor Henshaw (University of Bristol) started by giving an overview of aerosol science in his Physics Department. Dr Fews (also from this group) then presented *Kinetic modelling of mobility, mass and charging for ions, clusters, nanometre and micro sized particles*. This theme was developed by Mr Beaumont (Institute of Medicine, Scotland) who investigated the *Effect of aerosol charge on size-selective particle penetration through foam* principally to improve measurement methods for monitoring the occupational exposure of workers to airborne particles in the workplace. Mr Foat (CBD Porton Down, Salisbury) presented an experimental and computational investigation of aerosol electrostatics.

The second day of this conference commenced with the second plenary speaker Professor John Staniforth (Vectura Ltd, Bath) giving an overview of pharmaceutical aerosol formulation. This started a very interesting session on the health effects of aerosols. Dr Clayborough (Aventis Pharma, Cheshire) discussed the *Development of a computational model for the prediction of drug delivery to the human respiratory system* and was mainly concerned with accurately predicting uptake of inhaled medication. The *Design and characterisation of the shell model lung – a novel aerosol testing device* presented by Ms Hopkins (University of Bath) continued this important theme. Dr Allen (University of Bristol) then presented some novel research on the transmission of infection in a hospital environment through the electrostatic charging of biological airborne aerosols.

I then had opportunity to present some of my own health related aerosol research, which has investigated the ability of airborne particulate matter (PM_{10}s) to produce DNA damage in cultured human lung fibroblasts. This preliminary *in vitro* investigation has shown that incubating these cells with PM_{10}s produces a strong cytotoxic effect, killing all the cells within a five-day period. Investigation after 48 hours, using single cell gel electrophoresis (the comet assay) showed that the cells exposed to the particulate matter exhibited four times the level of DNA damage as that observed in similarly treated but non-PM_{10} exposed controls. This genotoxic effect was found to be highly significant ($p < 0.002$) using an unpaired student's t-test.

Physics and optics was the next topic of interest and involved a series of talks on the use of this discipline to investigate aerosols. This was followed by a session on instrumentation mainly concerned with equipment used to characterise or quantitate aerosols and the final session of the meeting focussed on aerosol emissions. Dr Booker (Booker Systems Ltd., Towcester) presented the *Development of a continuous mass-monitor for both ambient and automotive particle measurements*. Dr McAughey (AEA Technology Environment, Abingdon) gave an interesting talk on the *Aerosolisation of blood by exhalation*, which applied classical aerosol mechanics and respiratory physiology measurements to forensic cases where blood was thought to originate from the victim exhaling. The final presentation of the meeting was the preliminary findings of a study where high-volume collection of urban PM_{10} had been undertaken (Dr Moreno, Cardiff University).

This compact two-day meeting was highly informative and managed to draw together a diverse range of presentations in the field of aerosols in a coherent manner. It provided an excellent and rare opportunity for researchers from the whole spectrum of different scientific backgrounds to meet and discuss their aerosol-based research.

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Meeting report: Wetlands and the community

On Thursday January 31st 2002, CIWEM (The Chartered Institution of Water and Environmental Management) held a one-day conference ***Wetlands and the Community*** at the Institute of Mechanical Engineers, Westminster. The conference was organised by Terence Dalton Ltd and was supported by the EA, RSPB, Thames Water, Entec, the Waterways Trust and the Countryside Council for Wales. The conference celebrated World Wetlands Day and was opened by Michael Meacher (Minister for the Environment). Nine papers were presented to around 100 attendees. **Leo Salter** reports.

In her paper, *Water, Life and Culture - the Water Framework Directive* Kirsty Lewin (Head of Water Policy, RSPB) used the following definition for wetlands,

"Wetlands are transitional areas between wet and dry environments: they range from permanently or intermittently wet land to shallow water and water margins. The term can describe marshes, swamps and bogs, some shallow waters and the intertidal zone. When applied to surface waters, it is generally restricted to areas shallow enough to allow the growth of rooted plants. Wetlands support their own unique communities of plants and animals, and the health of their ecosystems is directly and immediately dependent on the water cycle and its management."

The paper described the integral role that wetlands play in the hydrological cycle – and particularly their role as storage for floodwaters. The paper also addressed the manner in which the EC Water Framework Directive (WFD) referred to wetlands (Articles 1, 1(a), 4 and elsewhere). Some of the information presented in the paper is well known but frequent restatement makes it no less salutary,

"Approximately 42% of the SSSI network (in England) is currently in unfavourable condition, with 29% of fen, marsh and swamp, and 50% of rivers and streams in that category. Most of England's watercourses (over 60%) have heavily modified banks while over 150 SSSIs may be affected by water abstraction licenses."

Dr Andrew Hicklin (EA, Somerset Levels and Moors Officer) spoke on *Flood Management, Communities and the Environment – a strategy for the Somerset Levels and Moors*. The Somerset Levels and Moors have been designated an SPA (Special Protection Area) under the EU Habitats Directive and a Ramsar wetland of international importance. Dr Hicklin described the plethora of issues that need to be resolved " . . . to achieve sustainable agricultural, flood management and conservation objectives in Somerset . . . ."

The Levels and Moors are the largest remaining area (20%; 60 000 ha) of lowland wet grasslands in England; they attract internationally important numbers of over-wintering fowl and support important assemblages of aquatic plants and invertebrates. A number of SSSIs (18; 12 of which are SPAs), 27000 ha of Environmentally Sensitive Areas (ESA) and 2000 separate farming enterprises occupy an area of which 635 km^2 is below sea level and for which 18 autonomous Internal Drainage Boards, 2000 landowners and the EA share responsibility for watercourses. The management issues are profound! The EA is working to bring together local communities, farmers, drainage agencies and conservation stakeholders to develop a package of measures to deliver integrated, sustainable water and land management that brings both socio-economic benefits and environmental outcomes.

Tony Dearsley (Environmental Manager, Thames Water) spoke on *Wetland creation for Biodiversity and Community Benefit* and described the programme of wetland creation and enhancement schemes undertaken since 1989 by Thames Water. The company has complete land ownership of 6 SSSIs and part ownership of a further 14. Ten of this total are wetland habitat, some are SPAs and Ramsar sites. Three case studies were presented; Tring STW (a new hide and lagoon enhancement in Buckinghamshire), Shrike Meadow (Farmoor Reservoir, Oxfordshire) and Kempton Nature Reserve (Local Nature Reserve (LNR), SSSI, SPA and Ramsar Site) Hounslow. In the Kempton LNR the decommissioning of a reservoir was used as an opportunity to clear the site, resculpt the base of the reservoir, include reed beds, gravel islands and open water and create was has become the first successful breeding site for Avocets in inland Britain. Hence Thames Water has worked with local communities to create wetland habitats that have contributed to local, national and regional biodiversity particularly in urbanised areas.

Further presentations were given by Sarah Fowler (EN) and Bryony Coles & Robert Van de Noort (University of Exeter) – who talked on the importance of wetlands as a cultural resource and their archaeological value. Lyn Jenkins (EA) spoke on *Lessons Learned from the Wise Use of Floodplains Project* and John Woodruff (Countryside Council for Wales) discussed his experiences accessing the Heritage Lottery Fund. The conference closed with papers on *The Importance of Understanding Hydroecology in Wetland Management* (John Pomfret and Steve Betts (Entec)) and *Wetland Research Needs* (Andrew Baird, University of Sheffield).

The conference gave a clear view of the goals and value of wetland projects. There were excellent case studies of mechanisms by which environmental actions can be advanced by agencies in conjunction with interest groups. These mechanisms have a general applicability for environmentalists. The conference re-emphasised the need for close stewardship of finite water resources. Man's immediate needs do occasionally have to be compromised in favour of habitat, ecology and sustainability. Finally, although it was not perhaps the purpose of the conference, I did feel that there was (is) a need to look at the ways water quality is researched in wetlands and the ways in which physicochemical

changes indicate the need for and progress in remediation, improvement and environmental health.

NOTE: 'Ramsar' refers to the Convention on Wetlands, signed in Ramsar, Iran, in 1971, an intergovernmental treaty, which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. There are presently 130 Contracting Parties to the Convention, with 1140 wetland sites, totalling 91.7 million hectares, designated for inclusion in the Ramsar List of Wetlands of International Importance.

Web link: http://www.ramsar.org/

LEO SALTER
February 2002

Recent books on the environment and on toxicology at the RSC Library

The following books and monographs on environmental topics have been acquired by the Royal Society of Chemistry library, Burlington House, during the period July 2001 to January 2002. Recent additions on health and safety and on toxicology are also included in this list.

Aquatic Toxicity of Mixtures
ECETOC, Brussels, 2001, ISBN/ISSN: 64 pp., Accession No: 20010603, West Gallery 615.9

Assessment and Reclamation of Contaminated Land
Hester, R.E. (ed.), Royal Society of Chemistry, Cambridge, 2001, ISBN/ISSN:085404275X, 164 pp., Accession No: IEST16, C 23A

Beryllium and Beryllium Compounds
World Health Organisation (WHO), Geneva, 2001, ISBN/ISSN: 9241530324, 71 pp., Accession No: 20020009, West Gallery 628.5

1,3-Butadiene: Human Health Aspects
World Health Organisation (WHO), Geneva, 2001, ISBN/ISSN: 9241530308, 73 pp., Accession No: 20020007, West Gallery 628.5

Casarett and Doull's Toxicology: The Basic Science of Poisons, 6th Edition
Klaassen, C.D. (ed.), McGraw-Hill, New York, 2001, ISBN/ISSN:0071347216, 1236 pp., Accession No: 20010419, Reference Shelves REF 615.9 R

Combustion Processes: Supplementary Guidance Note
Environment Agency, Bristol, 2001, ISBN/ISSN:011310183X, 34 pp., Accession No: 20010585, West Gallery 628.5

Contaminated Land (England) (Amendment) Regulations 2001
Stationery Office, London, 2001, ISBN/ISSN:0110288246, 2 pp., Accession No: 20010645, A 99 SI 2001/663

Contaminated Land (Wales) Regulations 2001
Stationery Office, London, 2001, ISBN/ISSN:0110903072, 25 pp., Accession No: 20010593, A 100 SI 2001/2197(W.157)

Cumene
World Health Organisation (WHO), Geneva, 2000, ISBN/ISSN: 9241530189, 28 pp., Accession No: 20010642, West Gallery 628.5

N,N-Dimethylformamide
World Health Organisation (WHO), Geneva, 2001, ISBN/ISSN: 9241530316, 56 pp., Accession No: 20020008, West Gallery 628.5

Diphenylmethane Diisocyanate
World Health Organisation (WHO), Geneva, 2001, ISBN/ISSN: 9241530278, 32 pp., Accession No: 20010325, West Gallery 628.5

Environmental Chemistry: A Modular Approach
Williams, I., John Wiley, Chichester, 2001, ISBN/ISSN:0471489425, 388 pp., Accession No: 20010674, West Gallery 628.5:54

Environmental Labels and Declarations: General Principles
British Standards Institution (BSI), London, 2001, ISBN/ISSN:0580386813, 4 pp., Accession No: 20010720, West Gallery 628.5

Environmental Management: Environmental Assessment of Sites and Organizations
British Standards Institution (BSI), London, 2001, ISBN/ISSN:0580387216, 19 pp., Accession No: 20010718, West Gallery 628.5:658

Environmental Protection Act 1990 (Amendment) (Scotland) Regulations 2001
Stationery Office, London, 2001, ISBN/ISSN:0110596455, 2 pp., Accession No: 20010589, A 100 SI 2001/99

Environmental Protection (Waste Recycling Payments) (Amendment) (England) Regulations 2001
Stationery Office, London, 2001, ISBN/ISSN:0110288262, 3 pp., Accession No: 20010644, A 99 SI 2001/661

Exposure Factors Sourcebook for European Populations (with Focus on UK Data)
ECETOC, Brussels, 2001, ISBN/ISSN: 119 pp., Accession No: 20010602, West Gallery 615.9

Financial Assistance for Environmental Purposes (Scotland) Order 2000
Stationery Office, London, 2000, ISBN/ISSN:0110595289, 1 pp., Accession No: 20010648, A 99 SI 2000/430

Genomics, Transcript Profiling, Proteomics Metabonomics: An Introduction
ECETOC, Brussels, 2001, ISBN/ISSN: 27 pp., Accession No: 20010304, West Gallery 615.9

Health Hazards of Depleted Uranium Munitions: Part 1
Royal Society, London, 2001, ISBN/ISSN:0854035540, 80 pp., Accession No: 20010302, West Gallery 614.8:623.4

Health, Safety and Risk: Looking After Each Other at School and in the World of Work
Warren, D., Royal Society of Chemistry, Cambridge, 2001, ISBN/ISSN: 08540 49592, 56 pp., Accession No: 20010432, Reading Room 37:54

International Environmental Technology: Annual Buyers' Guide 2001/2002
Pattison, M., Environmental Technology (Publications), London, 2001, ISBN/ISSN: 178 pp., Accession No: 0010375, Reference Shelves REF 058.7:628.5:62 R

List of MAK and BAT Values 2001: Maximum Concentrations and Biological Tolerance Values at the Workplace
Deutsche Forschungsgermeinschaft, Wiley-VCH, Weinheim, 2001, ISBN/ISSN: 3527275096, 230 pp., Accession No: 20010611, Reference Shelves REF 614.8 R

Methyl Chloride
World Health Organisation (WHO), Geneva, 2001, ISBN/ISSN: 9241530286, 44 pp., Accession No: 20010326, West Gallery 628.5

Montreal Protocol on Substances that Deplete the Ozone Layer: As Adjusted and/or Amended in London 1990, Copenhagen and Vienna 1995, Montreal 1997, Beijing 1999
United Nations Environment Programme (UNEP), Nairobi, United Nations Environment Programme, 2000, ISBN/ISSN: 9280718886, 25 pp., Accession No: 20010604, Reference Shelves REF 628.5 R

Neurotoxicity Risk Assessment for Human Health: Principles and Approaches
World Health Organization (WHO), Geneva, 2001, ISBN/ISSN: 924157223X, 223 pp., Accession No: 20010423, West Gallery 615.9

Oil and Gas Processes: Supplementary Guidance Note
Environment Agency, Bristol, 2001, ISBN/ISSN:0113101848, 60 pp., Accession No: 20010584, West Gallery 628.5

Pharmaceuticals and Personal Care Products in the Environment: Scientific and Regulatory Issues
Daughton, C.G. (ed.), ACS, Washington DC, 2001, ISBN/ISSN:0841237395, 396 pp., Accession No: 20010578, West Gallery 615.1:628.5

Pharmaceuticals in the Environment: Sources, Fate, Effects, and Risks
Kummerer, K. (ed.), Springer, Berlin, 2001, ISBN/ISSN: 3540410678, 265 pp., Accession No: 20010365, West Gallery 615.2:628.5

Pollution: Causes, Effects and Control, 4th Edition
Harrison, R.M. (ed.), Royal Society of Chemistry, Cambridge, 2001, ISBN/ISSN:0854046216, 579 pp., Accession No: 20010318, West Gallery 628.52

Pollution Prevention and Control (England and Wales) (Amendment) Regulations 2001
Stationery Office, London, 2001, ISBN/ISSN:0110288084, 4 pp., Accession No: 20010643, A 99 SI 2001/503

Pollution Prevention and Control (Foot-and-mouth Disease) (Air Curtain Incinerators) (England and Wales) Regulations 2001
Stationery Office, London, 2001, ISBN/ISSN:0110294688, 3 pp., Accession No: 20010586, A 99 SI 2001/1623

Prescribed Waste (Wales) Regulations 2001
Stationery Office, London, 2001, ISBN/ISSN:0110902017, 6 pp., Accession No: 20010591, A 100 SI 2001/1506(W.104)

Prescribed Waste (Wales) (Revocation) Regulations 2001
Stationery Office, London, 2001, ISBN/ISSN:011090253X, 2 pp., Accession No: 20010592, A 100 SI 2001/2302(W.190)

Skin Sensitisation Testing: Methodological Considerations
ECETOC, Brussels, 2000, ISBN/ISSN: 27 pp., Accession No: 20010637, West Gallery 615.9

Vanadium Pentoxide and Other Inorganic Vanadium Compounds
World Health Organisation (WHO), Geneva, 2001, ISBN/ISSN: 9241530294, 53 pp., Accession No: 20020006, West Gallery 628.5

Waste (Foot-and-mouth) (England) Regulations 2001
Stationery Office, London, 2001, ISBN/ISSN:0110295129, 6 pp., Accession No: 20010590, A 100 SI 2001/1478

The latest in Environmental Chemistry...

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RENÉ P. SCHWARZENBACH, EAWAG, Dübendorf, Switzerland, PHILIP M. GSCHWEND, Massachusetts Institute of Technology, Cambridge, Massachusetts and DIETER M. IMBODEN, Swiss Federal Institute of Environmental Science and Technology, Dübendorf, Switzerland

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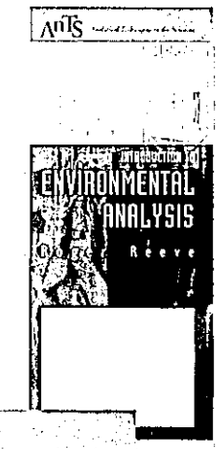

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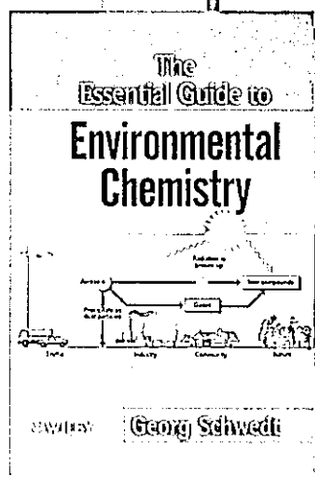

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