THE ROYAL SOCIETY OF CHEMISTRY

ENVIRONMENTAL CHEMISTRY GROUP

Newsletter

Issue No.7 January 1998

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http://chemistry.rsc.org/rsc/ecg.htm

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Chairman's Report on Activities during 1997

When the decision was taken to separate the Environment Group (as was) from the Industrial Affairs Division of the Society and relaunch it as the Environmental Chemistry Group, under the auspices of the RSC's Scientific Affairs Board, the main motivation was the belief that environmental chemistry was sufficiently mature as an independent discipline within the overall science of chemistry that it should stand alone, alongside the traditional three branches of chemistry.

This belief was shared by the vast majority of the Group's members who voted positively for the change. I believe that environmental chemistry is an independent, mature, discipline (witness the very large number of university courses now offered in the subject, the existence of the Environmental Chemistry Division within the American Chemical Society, and the recent establishment of a similar Division within the Federation of European Chemical Societies) and that the decision was the correct one. However one unforeseen and undesirable consequence of the Group's realignment within the Society has been the less active participation in the Group of RSC members with employment and/or interests in the chemical industry. The Committee of the Group is concerned about this and wishes to redress the balance somewhat. We have an opportunity to do this at the forthcoming AGM *by electing one or more members who are actively employed in the chemical industry onto the Committee.* Of course, this requires prior nominations and, if you too would wish to see a greater "industrial" emphasis in the Group's activities, I would urge you to play a part in this process.

The Group has had another successful year, with meetings on a range of subjects. Ensuring sufficient attendance at symposia remains a problem, but after a lengthy recent discussion, the Committee concluded that we should continue to view the organisation of scientific symposia as our main function. However it was recognised that a variety of formats, locations and durations would be desirable. In addition, it was concluded that publication of the Newsletter is an important and useful function, and this will certainly continue. We would like to thank the Editor, Dr Rupert Purchase, for his continuing efforts with the Newsletter.

While in a thanking mode I would also like to express my gratitude to a retiring member of the Committee, Geoff Dickes. Mr Dickes is a past Chairman and Treasurer of the Group and has been a steadying hand during my own period of tenure as Chairman. On your behalf, I thank him for his dedicated service to the Group.

Nick Hewitt
Chairman, December 1997

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(from March 1998)

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Environmental Law Focus

Anthony Hobley of Cameron McKenna and a committee member of the Environmental Chemistry Group reports on some recent developments in environmental law.

As always in the rapidly changing field of environmental law there have been many developments in both legislation and policy over the last few months. A selection of the more significant developments is discussed below.

Contaminated Land - Delays In Implementation of the Contaminated Land Regime

The basic provisions of the new contaminated land regime (the **"Contaminated Land Regime"**) were put onto the statute book by Section 57 of the Environment Act 1995, but have still not been brought into force. It now looks increasingly likely that the delay in their implementation will be further extended, possibly as far ahead as 1999.

The purpose of the **Contaminated Land Regime** is to deal with the historical contamination of land. It will complement existing procedures for cleaning-up contaminated land, such as planning law, waste management licensing, IPC, and the statutory nuisance provisions. The Contaminated Land Regime makes provision for the identification and remediation of contaminated land in England, Scotland and Wales. It will be enforced primarily by local authorities and to a lesser extent, in England and Wales, by the Environment Agency, and in Scotland, by the Scottish Environmental Protection Agency. In basic terms, each local authority will be under a duty to inspect its area from time to time and identify "contaminated land".

Contaminated land is defined on a risk-based approach such that to be contaminated there must be significant harm resulting or a significant possibility of such harm or pollution of controlled waters. An integral part of the risk-based approach is the identification of a source-pathway-target relationship or "pollution linkage".

The enforcing authority, once it has identified such contaminated land, will then have the power to serve a remediation notice on an "appropriate person" (or "persons") requiring clean-up of contaminated land. Failure to comply will be a criminal offence backed by substantial fines and the power for the enforcing agency to do the remediation work itself and charge the "appropriate person". There are complicated provisions to determine who are "appropriate persons", but the latter include the original polluter and, if the original polluter cannot be found, the present owner of the land.

The main reason why the **Contaminated Land Regime** cannot yet be brought into force is that the provisions in the Environment Act 1995 only set out the principles and outline of the regime. They will be substantially supported by statutory guidance which is still in draft form. The consultation process is still ongoing and has already taken a very long time. Latest estimates from the Department of the Environment, Transport and the Regions (DETR) are that the final text of the guidance may be settled by mid-1998 at the earliest, but it could be much later.

A further factor which is delaying implementation is the need to put a funding system in place for the new regime, which will require that substantial resources be given to enforcing authorities in order for it to work effectively. Matters probably have not been helped by the Government's pre-election promise not to increase public spending above the plans inherited from its predecessors for its first two years in power.

Water Pollution - New Anti-Pollution Works Notices Provisions

The Environment Agency is likely to be given much tougher powers in combating water pollution in the early part of 1998 when an amendment to the Water Resources Act 1991 (the "WRA") comes into force. The amendment, contained in Schedule 22 to the Environment Act 1995, inserts new sections, 161A to 161D, which contain the anti-pollution works notices provisions. A consultation paper including draft regulations was issued by the DETR in August 1997, and DETR sources indicate that the new provisions may be brought into force as early as February 1998.

Historically, the powers of the Environment Agency (and the National Rivers Authority before it) to combat water pollution under the old section 161 were limited to the power to enter a site, get work done and charge the polluter. However, these powers were rarely being used because the Agency had never been provided with the finance to back such operations. The new sections 161A to 161D will overcome this problem by giving the Environment Agency power to serve **"works notices"** on any person who has caused or knowingly permitted matter either to be present in any controlled waters or to be present at a place from which it is likely to enter controlled waters. Matter is defined as any poisonous, noxious or polluting matter or any solid waste matter.

A **"works notice"** will require the business on which it is served to carry out any works specified and therefore to incur the expenditure itself. The amount will depend on the nature of the works. The Environment Agency could otherwise undertake the works itself, using its existing powers under Section 161 of the WRA, and then recover its expenses. The new provisions simply provide a different mechanism for the works to be carried out. It may be that where a business carries out preventative or remedial works itself, the cost will be less than if those works are carried out by the Agency. Moreover, the intention is that works notices will in many cases prevent water pollution from occurring, thereby avoiding the higher costs of remediation after the incident, as they can be served before the pollution of water actually takes place, when the polluting matter is in a place "from which it is likely to enter controlled waters".

Before serving a works notice, the Environment Agency will have to consult the person on whom the notice is to be served about the works or operations

which it is proposed to specify. Following consultation, works may be carried out either without the need for a works notice to be served, or in accordance with a notice.

These provisions are much simpler than the new **Contaminated Land Regime** (see above) and consequently they are likely to provide a much more usable power for the Environment Agency in seeking the clean-up of contaminated land in the vicinity of controlled waters. Due to the fact that they were contained in a schedule entitled "Minor and Consequential Amendments", these new provisions were subjected to almost no scrutiny or lobbying during their passage through Parliament and consequently they are unfettered by many of the safeguards, complicated and otherwise, which are a feature of the new Contaminated Land Regime.

In August 1997 the DETR issued a consultation paper which included draft regulations and discussed the relationship between these provisions and the contaminated land legislation mentioned above. In particular the draft regulations provide for the content of works notices, appeals against works notices, payment of compensation by the person on whom the notice is served in respect of the grants of rights of entry, and particulars in respect of works notices which must be contained in the Agency's pollution control registers.

Many commentators are now of the view that these works notices provisions which are to be inserted into the WRA will be of greater significance than the whole Contaminated Land Regime. In fact the Government have gone so far as to say that if a substantial number of remediation notices are served under the Contaminated Land Regime they will judge it to have been a failure. It is viewed as a safety net to deal with the worst cases of historic pollution; the clean-up of contaminated land will still be effected to a large extent through planning laws dealing with the redevelopment or change of use of such land, under which land contamination may be a material planning consideration and planning permission will not be granted if the proposed use will result in the contamination of land. It is not clear whether the same view holds for the new works notices under the Water Resources Act.

Furthermore, there is new European legislation on the horizon, namely, the draft Water Framework Directive. This will require the identification of all diffuse and point sources of water pollution and require all waters in the EU to have acquired "good status" by the year 2010. This is an extremely ambitious target and in order to achieve it regulators in each of the member states would need to remediate many of the diffuse and point sources of contamination identified. Bearing in mind that the remediation of groundwaters and other water resources is likely to take upwards of a decade in some cases, the new works notices will provide a ready tool to apportion liability for the costs of this clean-up and to realise another central aim of the directive, namely, the achievement of the polluter pays principle should the draft directive be adopted in its present form.

Waste - Proposed EC Directive on the Landfill of Waste

The current waste management licensing system in the UK was enacted by Part II of the Environmental Protection Act 1990. Changes may be in store for the way in which we dispose of and regulate waste due to proposed legislation from Brussels. The European Commission has put forward a new proposal for a Directive on the Landfill of Waste which may well be adopted by the end of 1998, in which case it could be incorporated into UK law by the year 2000. Proposals for a Landfill Directive have been around for several years, but the previous draft by the Commission, first published in 1991, was eventually rejected by the Parliament in May 1996 for being too weak in terms of environmental protection. In March 1997 the Commission agreed and adopted a new proposal which goes further than the previous draft in several respects. In its present form the draft Directive, which has yet to finish going through The Community legislative process, would mean:

- A substantial reduction in the amount of biodegradable municipal waste sent to landfill, with member states being required to set up a national strategy with the following targets:

  by 2002 a reduction to 75 per cent of the total amount produced in 1993;
  by 2005 a reduction to 50 per cent of the 1993 figure;
  by 2010 a reduction to 25 per cent of the 1993 figure;

- A ban on the landfilling of certain wastes by specified deadlines, including whole new tyres within 2 years from the date of the Directive coming into force and shredded tyres within 5 years of that date;

- A ban on the co-disposal of hazardous and non-hazardous waste;

- A requirement for pre-treatment of all waste going to landfills;

- An increase in the costs of landfill to reflect the true costs of the effect they have on the environment. The minimum price, to be charged by all public and private landfill operators, would have to cover the full costs of:

  the set-up and operation of the landfill; and site closure and after-care costs for a period of at least 50 years;
  increased controls and monitoring procedures in the operational phase of the landfill and a detailed closing procedure.

In the UK, where 85 per cent of all municipal waste is currently landfilled, the proposed Directive will increase the cost of the disposal of waste by landfill, and the burden will fall on both the operators and regulators of landfill sites. The Commission's aim is to harmonise the costs of disposal between member states and to reduce the cost differentials between landfill and other treatment methods in order to encourage what it regards as more sustainable methods of waste disposal, such as recycling and incineration with energy recovery.

The UK government has contested certain aspects of the Commission's proposed Directive. Whilst stressing its support for the Directive's tough approach to regulation, it is opposed to the compulsory deadlines for the reduction in the landfilling of biodegradable waste. It is claimed that this would force everyone towards incineration without

giving them the flexibility to consider the range of more sustainable methods of waste disposal. Those opposed to the compulsory deadlines point out that although methane, a by-product of landfills, is a powerful greenhouse gas, landfill can be a sustainable option for biodegradable waste where there are efficient systems for capturing and utilising that gas. In response to the concerns expressed by the UK and several other member states, that are heavily reliant on landfill, it seems likely that the proposed Directive will be amended to the extent that the compulsory deadlines will be revised and put back significantly.

Assuming that the new draft is not rejected by Parliament, the Directive is expected to be adopted towards the end of 1998. The UK will then have to implement its provisions by drafting regulations before 30th June 2000. It is clear that the Directive, in whatever form it is eventually adopted, will have significant implications for the operators of landfill sites and suppliers of environmental technologies.

Waste - Reclassification of Certificates of Technical Competence in Waste Management

Part II of the Environmental Protection Act 1990 established a comprehensive waste management licensing system. Section 74 states that a person is not "fit and proper" to hold a licence unless the management of the activities to be authorised under the licence is or will be in the hands of a technically competent person. **The Waste Management Licensing Regulations 1994** provide for the assessment of technical competence by reference to certificates of technical competence awarded by the Waste Management Industry Training and Advisory Board ("WAMITAB"). Subject to certain transitional provisions which are soon to expire (see below), Regulation 4 states that a person is technically competent if, and with few exceptions only if, that person holds an appropriate certificate and a table in the Regulations sets out the relevant certificates for each type of facility.

Changes to this table are made by **The Waste Management Licensing (Amendment) Regulations 1997** (SI 1997 No. 2203), which came into force on 9th October 1997. They make changes to the certification requirements for physical and chemical treatment facilities and transfer stations to reflect the decision by WAMITAB to award separate "level 4" certificates in relation to clinical or special waste on the one hand and biodegradable waste on the other. Level 4 certificates relating to special waste only will no longer be awarded. In addition, the range of relevant certificates for civic amenity sites is extended.

When the new system of certification was originally brought in, transitional provisions were put in place to allow existing site managers to be deemed to be technically competent in the light of their previous experience within the waste industry. These transitional provisions were designed to give them time to re-qualify under the new system. These exemptions are due to expire on 10th August 1999, but according to a recent press release from the DETR, of the 7,000 managers originally estimated to need a new certificate of technical competence, less than 50% have so far started working for them and only 10%, that is approximately 250 people, have obtained one.

Integrated Pollution Control - UK Implementation of the IPPC Directive

The DETR has issued its first consultation paper on the UK implementation of EC Directive 96/61 on Integrated Pollution Prevention and Control (IPPC). Although an "integrated" regulatory system already exists in the UK in the form of the Integrated Pollution Control (IPC) system, the provisions of the Directive are significantly different in a number of areas and changes to the national system will be needed.

The present system of environmental control for industrial processes was introduced by Part I of the EPA, which created a system for the control of emissions from the larger and more polluting industrial concerns. This is split into two systems namely, IPC which covers the more seriously polluting processes and regulates emissions to all three environmental media (water, air and land), and Air Pollution Control (APC) which covers less polluting processes and regulates emissions to air only. IPC is regulated by the environment Agency and APC by local authorities. Operators carrying on specified "prescribed processes" listed in the Environmental Protection (Prescribed Processes and Substances) Regulations 1991 (as amended) must obtain prior authorisation. Authorisations are issued subject to conditions in relation to the way the process is operated and anti-pollution measures which must be used.

The IPPC Directive places obligations on all member states of the EU to adopt an integrated approach to the prevention and control of pollution within a specified time-scale. Its stated objective is to achieve a high level of protection for the environment as a whole by means of measures "designed to prevent, or where that is not practicable, to reduce emissions" to air, water and land. Although not dissimilar to the UK's present IPC regime, implementation of the IPPC Directive will require some significant changes. The DETR consultation paper, published in July 1997, was the initial stage in the implementation process. There was also a consultation paper issued by the Ministry of Agriculture, Fisheries and Food on the application of IPPC Directive to the intensive livestock sector.

The DETR consultation paper, whilst mainly concerned with the transposition of the IPPC Directive into UK law, also reviews the differences between the IPC and IPPC regimes. The main changes will be:

- The number of industrial installations subject to integrated regulatory control will increase. Unlike the IPC system which regulates "processes", the IPPC Directive applies to "installations". This will widen the net of regulatory control to cover some installations which are not presently covered under IPC. The DETR has estimated that about 7000 more installations will come under IPPC in England and Wales, including: certain waste management sites (mostly landfills currently regulated under the waste management licensing system); certain installations currently regulated through a combination of APC (local authorities) and trade effluent consents and/or discharge consents for emissions to controlled waters (statutory undertakers/Environment Agency); intensive pig and poultry plants; and

food and drinks plants.

- The environmental issues considered in the regulatory control process will increase. The IPPC Directive aims to do more than simply control emissions of polluting substances and will broaden the scope of control to include such considerations as energy efficiency, contaminated land, noise, vibrations, consumption of raw materials, waste minimisation and accident prevention. There will also be a link between IPPC permits and environmental impact assessments, which frequently cover the same issues.

In addition to these main changes there are a number of additional differences between the current IPC system and the requirements of the IPPC Directive, which will require implementation. The IPPC Directive contains no provision corresponding to the "triviality" exemption under the IPC system, under which processes are exempt from control where they release quantities of controlled substances specified as "trivial". Also the IPPC system will require notification of all changes to installations which might have environmental consequences, rather than only changes which will involve a breach of conditions as under IPC.

A second consultation paper from the DETR is due for publication on the 5th January 1998, which will take forward the key issues from the first paper and include some more concrete proposals. The consultation process is then likely to continue with several more papers, probably on a more sector focused basis, before draft legislation is put forward. There has been no decision yet as to whether implementation will be through primary or secondary legislation. The UK, along with the other member states of the EU, has until October 1999 to implement the provisions of the IPPC Directive.

This article has focused on a selection of the most recent developments in environmental law. Needless to say, there are many other topical issues in this field which it has not been possible to cover, such as the new version of Operator and Pollution Risk Appraisal (OPRA) recently published by the Environment Agency, the registration of businesses with packaging waste obligations under the Producer Responsibility Obligations (Packaging Waste) Regulations 1997, and the new regulations to implement the National Air Quality Strategy. Further developments will be addressed in the next **Environmental Law Focus.** Advice on the above matters or any other environmental law issue is available from the author.

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December 1997

The Environmental Geochemistry Research Group at the Robert Gordon University, Aberdeen

The Environmental Geochemistry Research Group at the Robert Gordon University, led by Dr Keith Nicholson, has attracted over one million pounds in research funding since its inauguration in 1991. In this article **Dr Nicholson**, a committee member of the Environmental Chemistry Group, describes recent results from three of his current projects.

The group has a wide range of interests and activities which cover aquatic, soil, marine and urban environments in the UK, mainland Europe and Australasia. Three key areas of current research (described in more detail below) are:

The use of manganese oxides for controlling metal mobility in the environment;

The behaviour of boron in the environment;

Stone soiling, cleaning impacts and decay mechanism on historic buildings and monuments.

Other projects in various stages of progress include:

Multimedia applications in environmental geochemistry education ; environmental training in oil pollution risk & reduction; hydrodynamic-geochemical modelling of effluent plumes; copper in steam sediments from distillery effluents; geothermal fluid chemistry and environmental impacts.

Adsorption of Metal Cations on Manganese Oxide-Coated Filter Sand: a Novel Method for Water Treatment

(Bruce Thomson, Mark Eley and Keith Nicholson)

Manganese oxides, present in fresh waters, are deposited onto the sand filter beds of water treatment plants when the water is treated with lime and chlorine. Manganese oxide coated filter sand used in our experiments was obtained from water treatment plants in NE Scotland. One such plant, the Forehill treatment works, extracts some 14 million litres of water per day, and the water has a Mn content of 60-80 mg/litre. After filtration the Mn content falls to 10-20 mg/litre. The manganese oxides deposited on the filter sand are chemically homogeneous (Eley and Nicholson, 1995) and provide a consistent source of naturally occurring manganese oxides.

It is well known that manganese oxides have a strong adsorptive capacity for metal ions (Loganathan and Burns, 1973; Murray, 1975). However these studies were carried out with synthetic manganese oxides whose adsorption characteristics might differ from the manganese oxides present in filter sand.

To check this, we carried out adsorption studies by shaking 1g of filter sand in the presence of aqueous solutions of Cu, Ni, Fe and Cd nitrates in the concentration range 1-10 ppm. After equilibration had been achieved the metal concentration in

the supernatant liquid was determined using atomic absorption spectroscopy. The amount of metal cation adsorbed is the difference between the initial concentration and that remaining in the supernatant.

We confirmed the adsorptive properties of manganese oxides but found that the extent of adsorption of metal cations by manganese oxide coated filter sand is influenced by pH as well as by the nature of the metal cation. For example for Cu the extent of adsorption at pH 3 is 20%, but this increases to 90% at pH 6. The adsorption of Zn and Cd is similiar over the same pH range with some 60% of the added metal cations adsorbed at pH 7. No adsorption of Ni takes place at pH 3 or 4 and only 44% of added Ni is adsorbed at pH 7. Over a pH range of 3-7, about 90% Pb is adsorbed and is the cation least affected by pH. Overall we found the adsorption of Pb, Cu, Cd, Zn, Cd and Ni to be (in decreasing order of adsorption) Pb>Cu>Cd>Zn>Ni in the pH range 3-7.

The presence of soil humic-fulvic acids in natural waters will promote chelation reactions with metal ions and influence the adsorption of metal ions by the manganese oxide coated filter sand.

Our preliminary findings indicate that 10 ppm of humic acid causes a significant decrease in the adsorption of Cu. This effect is more pronounced for low Cu concentrations (1ppm) which showed a decrease in adsorption of 14% compared with higher Cu concentrations (10ppm) where a 4% decrease was observed when compared with the % Cu adsorbed in the absence of humic acid.

Attempts to model the adsorption isotherm indicate that the data mostly obey the Langmuir equation, although there is some evidence to show that the Freundlich model may be more suitable for freshly deposited oxides.

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Boron in the Environment: Sources, Impacts and Determination

(John Wood and Keith Nicholson)

Concern over increasing boron levels in rivers which receive domestic and industrial effluent was highlighted in a recent EU report (EC Scientific Advisory Committee, 1996). Boron accumulation results from the repeated re-use of increasingly limited surface water supplies and the lack of removal of boron by conventional treatment methods. The EU report also revealed a lack of recent toxicity or monitoring data for boron. Concern over boron levels has also been expressed in the USA (US Department of the Interior, 1990) where an estimated 32,000 tonnes of boron effluent are discharged annually.

The predominant cause of boron discharges world-wide is from their use in detergents (*ca.* 40%), but other sources include agricultural products (Grinstead and Wheaton, 1971); coal (Wong, 1984); nuclear (Wong, 1984) and geothermal (Nicholson, 1992) power stations; mining (Okay *et al*, 1985); and the glass and ceramics industry (Busani and Timellini, 1993). Additionally borates are a common component of domestic discharges.

Borates are not removed by conventional water treatment processes, and at high levels may actually destroy bacteriological-based treatment systems (Wong, 1984).

In England the problem of boron accumulation is potentially acute because of a combination of a high population density, a large use of detergents and increasingly low flow-rates in surface water supplies - a situation which will be exacerbated if climate change predictions prove correct.

The need to monitor boron levels is further strengthened by the use of surface water as a source for potable and agricultural supplies. Although boron is an essential element for plant growth, the range between acceptable and toxic boron concentrations is small.

A simple, rapid method for the routine monitoring of boron in waters, effluents and sludges is needed. The latter is of particular importance given the impending disposal of sewage sludge onto agricultural land. The WHO potable water limit for boron is 0.3 mg/kg; however, the recommended determination methods (DOE Standing Committee of Analysts, 1980) are based on spectrophotometric techniques which lack the required precision and/or detection limit.

Our investigation used ISE, AA and IC methods for the determination of $B(OH)_3$ or $B(OH)_4^-$ - the most common dissolved boron species based on the equilibrium $B(OH)_3 + OH^- = B(OH)_4^-$.

The pK for $B(OH)_3$ is 9. When pH > pK $B(OH)_3$ then $B(OH)_4^-$ becomes dominant and is the main species above ca. pH 11. Prior to this study, little work had been undertaken on the adaptation of IC or the fluoroborate electrode to this application.

The tetrafluoroborate ion-selective electrode can be reproducibly calibrated to 0.001 mg/L of boron (B) and shows a linear Nernstian response down to 0.35 mg/L B. Reproducibility at 0.1 and 1.0 mg/L B is better than 0.5%. Electrode sensitivity declines significantly below 0.035 mg/L B and this was determined to be the practical detection limit. Minimum equilibrium times increase with decreasing concentration ranging from 1 minute at 5.0 mg/L to 10 minutes at <0.05 mg/L B. A pH hysteresis effect was observed between pH 2-12. Effects of pH are minimised if samples are adjusted between pH 3.5 and 5.0 before analysis.

The fluoroborate ion-selective electrode responds to the fluoroborate ion (BF_4^-), and samples therefore require the addition of hydrofluoric acid (HF) to convert the boron to BF_4^-. The formation of the fluoroborate ion was studied using the fluoroborate ion-selective electrode, and was found to be complete within 5 minutes for 1.0 mg/L B. Calibration graphs were linear to 1.0 mg/L B and usable down to 0.1 mg/L B.

Ion Chromatography (IC) using Dionex AS4A and AS5A-5m anion exchange columns, produced a good separation of

fluoroborate from common anions including chloride, nitrate and sulphate. Calibration was possible down to 0.001 mg/L B as fluoroborate, and analysis time per sample was 15 minutes. Detection limits using flame atomic absorption spectroscopy (FAAS) and graphite furnace atomic absorption spectroscopy (GFAAS) as detectors were found to be <10 mg/L and *ca.* 0.02 mg/L B respectively.

The fluoroborate ion-selective electrode is a cheap and relatively simple and rapid method for the analysis of boron, and can be applied to potable and waste water samples. However problems may occur with interfering ions and these may have to be removed prior to analysis. Ion Chromatography can be used to determine very low boron (mg/L) concentrations and the resulting fluoroborate peak is clearly separated from the common anions. Samples to be analysed must be free from organic ions and filtered thoroughly. IC is an ideal technique for the analysis of water samples and, with the appropriate pretreatment, soils and minerals.

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Building Stone Soiling, Cleaning Impacts, and Decay Mechanisms

(Susana Pombo Fernandez, Romeo V. Yordanov and Keith Nicholson)

Building stone in urban environments is commonly coated with biological and non-biological soiling. Non-biological soiling is caused by deposition of airborne particulate matter and precipitation of sulphate minerals as a result of mineral:rain-water interaction. The permeable nature of sandstones permits rain-water to enter building stone. After evaporation of this moisture, solutes from the stone can be deposited on its surface.

Biological soiling is the result of organic growths (algae, lichens, fungi and bacteria) on and within the stone surface. Excretion of organic acids and chelating agents by biological growth promotes stone decay. Algae, the predominant biolgical growth, also trap particulate matter.

Physical and chemical cleaning methods may be used to remove such soiling, each of which can have deleterious effects on the appearance and conservation of the building facade. The impact of chemical cleaning methods depends on the mineralogy of the stone and the cleaning agent used. Staining, bleaching, salt efflorescences are all potential consequences of chemical cleaning methods. Stone-cleaning chemicals are of two types: alkalis (*e.g.* 25% w/w NaOH), used for their degreasing action, and acids (*e.g.* 14.7% w/w HF & 19.2% H_3PO_4), which remove soiling. Biocides may also be used as part of the cleaning programme in an attempt to prevent or delay future re-colonisation by biological growths.

Investigations of wash-off waters, and examination of the stone subsequent to cleaning with a range of commercial cleaning agents, show Si and Al loss from the stone through mineral dissolution. Fe is also mobilised by the acids. The agents appear to clean the stone by dissolving the stone underneath the soiling layer, rather than by dissolving the soiling layer itself. Salt residues from the cleaning agents are evident in the stone, with the amount retained ranging from 20-100%. Soluble salts migrate into the stone to depths of 10-20 mm below the stone surface, with sodium salts attaining greater depths than fluoride or phosphate. Cleaning agents and stone porosity determine the proportion of material retained and the depth of penetration.

This work has clear implications for the cleaning and conservation of historic buildings and monuments, particularly those with fine carvings which would be eroded by a harsh cleaning regime. As a result of this study recommendations for those who clean stone facades have been developed.

Studies on the effects of hydrofluoric acid washing of sandstones which have a high feldspar and kaolinite content have shown that these minerals readily dissolve in the hydrofluoric acid causing solubilisation of aluminium and silica (Labrid, 1975; Shaugnessy, 1981). The particle size distribution of powdered stones has been studied during HF treatment in an attempt to produce a kinetic model for the dissolution process (Thomson, 1992).

We have investigated the chemical and physical effects of commercial HF when applied to two powdered sandstones: one containing components such as clays and feldspars, which due to their reactivity are expected to be attacked in the first instance by HF; and the other consisting of a high proportion of silica.

The effects of two different HF concentration solutions (1.5M and 5M) on the particle size distribution of the two sandstones was examined using a Mastersizer analyser. This technique uses the laser light scattering principle. The two sandstones, identified as Blonde and Red, showed a different particle size distribution for the same acid treatment. This can be explained by their different mineralogies. The Red sandstone has a larger content of clays such as kaolinite, vermiculite and illite compared to the Blonde which has only traces of kaolinite. Hydrofluoric acid will attack clays and release aluminium as well as other elements from their structure. The EDX results from the washes in (1) commercial hydrofluoric acid (1.5M) and (2) NaOH (20%) followed by commercial hydrofluoric acid, showed how the Red sandstone released more S, K, Na and Fe for both treatments while the Blonde sandstone type released more Al and Si after acid treatment.

Hydrocarbon contamination of the environment has been a widespread phenomenon during the last decades with

several severe oil-spill disasters. Oil is also continuously released through the bilge and fuel oil discharges of vessels, and this type of contamination accounts for almost 0.3 million tons of the annual hydrocarbon input to the worlds oceans (NRC, 1985) while the overall annual global input of hydrocarbons (HC) is estimated to be between 1.7 and 8.8 million metric tons. Some of the oil can reach buildings in the vicinity of the discharge, as occurred in Shetland with the Braer spill.

Biological growth on stone is already a recognised factor in building deterioration and is of a particular concern with monuments and cultural heritage sites. Webster *et al.* (1996) showed that both physical and biochemical mechanisms are involved in stone deterioration. It has also been observed that some organic by-products of the microbial activity can chelate minerals from the sandstone thus changing the stone properties. Other authors (Owen, 1991; Von Wedel *et al.*, 1989) have indicated that the HC can be used as carbon source by microrganisms and this ability has been extensively utilised for conducting bioremediation experiments.

The main objective of our work was to assess the possible effect of hydrocarbons on biofilm growth on sandstone and its potential deleterious effect on buildings. In a series of laboratory trials, the effect of HC on microbial growth was studied. The methods selected to quantify biofilms growing on sand particles have been described elsewhere (Yordanov *et. al.*, 1996). In our studies changes in autotrophic biomass are measured by using hot ethanol to extract of chlorophyll-a which is determined by UV at 665 nm. The use of a laser-induced-fluorescence method is also under consideration. The number of viable bacteria is determined as colony forming units (CFUs) on R2A. Measurement of the overall biomass is carried out using a modified method of Lowry *et al.* (1951), cited in Yordanov *et al.* (1996), for cell protein determination.

Initial results from our work show chlorophyll levels remained low and no differences were observed during the first 4 months of the biofilm development. Epilythic microbial biomass has been measured during the early colonisation and growth phase of its development. The initial results show higher bacterial and overall biomass in an oil-enriched environment. The CFUs have increased almost 20-fold since the beginning of the experiment in the HC samples (8.3×10^7) and were twice higher than the control group. The same trend was observed for the cell protein measured as Folin reactive material (FRM) which was 2.4 mg cm^{-2} stone surface in HC samples, and 1.2 mg cm^{-2} in the controls. This is probably a reflection of the increased amount of available carbon on the sandstone surface.

The availability of HC to the microorganisms depends on many factors such as HC concentration, ambient temperature, oxygen, nutrients *etc.* Degradation of HC is influenced by their composition, and saturated hydrocarbons usually degrade faster. The increased biofilm growth may affect the sandstone either directly by release of metabolites, or by changing the physical structure of the stone during fluctuations in the ambient temperature (*i.e.* freeze / thaw conditions) which may be linked to the production of extracellular polymeric substances. Therefore higher biofilm growth may be expected to promote greater deterioration of the sandstone.

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Dr Nicholson's group is open to suggestions for collaborative work in any of the areas of research described above or in related topics. The address for correspondence is:

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Keith Nicholson
December 1997

Research in Environmental Chemistry at the University of East Anglia

The University of East Anglia (UEA) at Norwich has perhaps the largest number of environmental chemists working in an academic setting in the UK. **Dr John Sodeau** reviews some current research activities.

Introduction

The chemists are located in three centres of study: the School of Chemical Sciences, the School of Environmental Sciences, and the Climatic Research Unit. On the research side, a concerted effort on laboratory studies, field measurement, and modelling is carried out by 10 members of Faculty. These individuals are supported by some 50 PhD students and postdoctoral Fellows. At the undergraduate level, a BSc (Hons) programme in Environmental Chemistry is offered and is, in fact, one of the longest established such degrees in the country. MSc courses in Climate Change, Atmospheric Science and also Analytical Science are also available to suitably qualified candidates.

So much for a summary of activities here. Let's delve a bit deeper with a whistle-stop tour of the research carried out by the most chemically-based teams at UEA followed by a profile of our teaching programmes.

Some Current Areas of Research in Environmental Chemistry

Peter Brimblecombe's work is directed toward studies of gas-solid, gas-liquid, and solid-liquid partition involving atmospheric aerosols and cloud droplets. This is relevant to understanding: the behaviour of trace compounds and their removal from the atmosphere; and the physical state and chemical behaviour of aerosol populations.

Tim Jickells' group follows two main themes. (i) *Contamination problems in coastal areas.* Nutrient and metal behaviour in coastal areas, including intertidal sediments and salt marshes, are studied. In particular, the fluxes of nitrogen and phosphorus are calculated and their effects on coastal waters are monitored. (ii) *Metal and nutrient inputs to the oceans from the atmosphere.* These are studied using similar protocols as the coastal work and the emphasis is again on quantifying the inputs and their effects.

Peter Liss's work centres on the exchange of a variety of trace gases, including dimethyl sulphide, carbon dioxide, non-methane hydrocarbons and organo-halogens, across the air-sea interface. Within this broad area more detailed work is performed on the biological and photochemical factors controlling trace gas concentrations in surface sea-water. The processes of exchange across the air-sea interface and the role that such exchanges have in the global cycling of elements are also studied.

Stuart Penkett's research is directed towards field measurement of chemicals such as hydrocarbons and halogenocarbons in areas as diverse as the North Norfolk coast, Mace Head in Ireland and Cape Grim in Tasmania. The main analytical technique employed is gc-ms and the results are used, for example, in calculations of atmospheric lifetimes for molecules and tests of chemical processing of hydrocarbons by hydroxyl radicals.

John Plane's activities break down into two areas. (i) *The chemistry of the upper atmosphere,* where the particular focus is on the metallic layers which form in the upper mesosphere as a result of meteoric ablation. Models of their neutral and ionic chemistry are constructed by making laboratory kinetic measurements of pertinent reactions, using a laser pulsed photolysis/laser induced fluorescence apparatus and a fast flow tube coupled to a mass spectrometer. (ii) *The oxidant chemistry of the troposphere,* where the group has concentrated on developing the technique of differential optical absorption spectroscopy for trace species such as the nitrate radical. NO_3 is observed by this technique over a path of several kilometers through the lower atmosphere. A new instrument has recently been constructed to measure vertical profiles of species up to the tropopause.

John Sodeau's research group is involved in the study of low-temperature heterogeneous chemistry. The main results regarding "Ices" & Ozone Depletion are discussed at greater length later in this article but if time/energy does not permit you to get that far then you can "interact" with the relevant chemistry on:
http://www.uea.ac.uk/~c058/

MSc Level Programmes

Three main topics, of interest to environmental chemists, can be studied at UEA. The first is Atmospheric Science (contact: g.bigg@uea.ac.uk), the second is Spectroscopic and Physical Methods of Chemical Analysis (contact: u.jayasooriya@uea.ac.uk) and the third topic is Climate Change (contact: m.kelly@uea.ac.uk).

BSc(Hons) in Environmental Chemistry

This undergraduate degree programme is designed for students who wish to understand chemical processes in the environment and to apply their knowledge of chemistry to environmental concerns. It is taught jointly by the Schools of Chemical Sciences and Environmental Sciences with an overall 50:50 content. Students acquire a general understanding of chemistry, together with more specialised knowledge which enable them to explore the chemistry of the earth's crust, hydrosphere and atmosphere. In the third year students undertake a research project in the School of their choice. For further information on the course and a guide to application, email: m.nicol@uea.ac.uk

The "Hole" Story

I was asked me to focus on research in environmental chemistry at UEA for this Newsletter article, but the studies going on here are so wide-ranging that I could have filled 10 editions with results if I had given everybody a free rein. So I decided not to do that. Instead only one topic is on offer. Yes, as I flagged it

above: my own group's experiments.

Over the last ten years, scientists have become increasingly concerned about the influence of cold surfaces on chemical processes in the stratosphere. For example, microparticle ice crystals such as those found in polar stratospheric clouds (PSCs) are now thought to be the key influence on ozone-depletion mechanisms over Antarctica.

Our effort to investigate heterogeneous "ice" phenomena uses a variety of spectroscopic and surface chemistry techniques (*e.g.* Reflection-Absorption Infrared Spectroscopy, RAIRS) to probe the interaction of various chlorine-containing compounds on extended ice surfaces.

In 1992 we published our initial FTIR spectroscopic measurements (on the interaction of hydrochloric acid with a low-temperature, water-ice surface) [1] which provided the first experimental evidence for the suggestion by Molina *et al.* [2] that ionic mechanisms could be involved in the re-activation chemistry of halogens by PSC surfaces.

We have subsequently shown that the ionization process is a key to understanding the mechanisms by which stratospherically important chemicals such as N_2O_5 and $ClONO_2$ (chlorine nitrate) interact with water-ice [3-5]. Our most recent finding is that the temperature of the surface provides an important control over the ionization process.

Putting all our results together gives the following chemical mechanism for the transformation of "inactive" chlorine to its "active" variety on water-ice at 180K.

$$HCl + H_2O \rightarrow H_3O^+ + Cl^-$$
$$ClONO_2 \rightarrow {}^{\delta+}ClONO_2$$
$${}^{\delta+}ClONO_2 + H_2O \rightarrow [H_2OCl]^+ \ldots NO_3^-$$
$$[H_2OCl]^+ \ldots NO_3^- + H_2O \rightarrow HOCl + H_3O^+ + NO_3^-$$
$$HOCl + Cl^- + H_3O^+ \rightarrow Cl_2 + 2H_2O$$

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Afterword

The heart of environmental chemistry is, of course, the study of chemistry but to function successfully in modern-day research we have found at UEA that sets of lungs and limbs from other scientific disciplines are also required. For example, the development of novel instrumentation able to quantify trace gases, an appreciation of the biosphere and its functions, good mathematical abilities *etc, etc* all play their part here. Indeed even for the broad church that chemistry represents, spectroscopists, kineticists, thermodynamicists, synthetic chemists and quantum calculators have all found a research niche in which their techniques can be applied to the study of the environment. So go spread the gospel.....and sing and walk.

John Sodeau
December 1997

The Royal Society of Chemistry's Scientific Forward Look: The Response of the Occupational and Environmental Toxicology Group

The Environmental Chemistry Group's response to the RSC's Scientific Forward Look appeared in the last issue of this Newsletter and this draft document has now been submitted to the RSC as part of the Society's overall initiative in the Foresight programme.

The RSC's **Occupational and Environmental Toxicology Group** (formerly called the **Toxicology Group**) has also identified areas of research, to which resources should be directed over the next decade, in their Scientific Forward Look. The need to find alternative methods in toxicology is one of the recommendations in the ECG's submission, and this theme is further emphasised in the Occupational and Environmental Toxicology Group's report. Other toxicological problems arising from air, land and water pollution are also described, and it seems appropriate to reproduce in full this group's submission as the first of two articles on the Scientific Forward Look in this Newsletter.

The Scientific Forward Look is part of the RSC's association with the UK government's Technology Foresight Programme (also explained in the last issue of this Newsletter). The momentum for this exercise continues, and **Martin Hunt** from the Royal Society of Chemistry at Burlington House who is coordinating the RSC's response, summarises the next stages of the RSC's involvement in a second article.

Scientific Forward Look: The Response of the Occupational and Environmental Toxicology Group

This document is a submission by the Occupational and Environmental Toxicology Group for inclusion, in whole or in part, into the Scientific Forward Look of the RSC. It should, in the final compilation, be considered with that of the Environmental Chemistry Group since elements of this proposal are concerned with chemistry in the environment. The Occupational and Environmental Toxicology Group perceives that there are important toxicological issues in all areas of the environment. To present a comprehensive list of future aims is impossible but the following examples are illustrative of some of the issues we see as important today. They are issues for which resources will be required in the next decade.

Air Pollution

It is now accepted that air pollution, particularly urban air pollution, presents important health problems. Airborne particulate matter, particularly that fraction of the total mass with aerodynamic diameters below 2.5 μm ($PM_{2.5}$), is probably responsible for the deaths of certain compromised individuals although a biologically plausible mechanism has yet to be proposed. Of particular concern are the oxides of nitrogen of which nitrogen dioxide (the name in common usage in pollution discussions) is considered the most important. This compound is a pollutant of both indoor (domestic gas burning) and outdoor (traffic exhaust) pollution. Outdoors, in the presence of sunlight, it is a pro-oxidant involved in the complex chemistry leading to ozone and peroxyacetyl nitrate (PAN). Oxidants in the air, including ozone and PAN, may have a role in the aetiology of asthma but are not the only causes. Health effects following exposure to polluted air arise from the toxic action of low levels of a mixture of compounds. This exposure can occur indoors or outdoors remembering that most people spend most of their lives in an indoor environment. Very little work has been done so far on the toxicity of such mixtures or on low-level exposure to such mixtures. There are tremendous problems, particularly with the latter, but they may not be insurmountable.

There is also the problem of threshold (for non-carcinogens) which is best dealt with in the context of pollution. The current regulatory assumption for genotoxic carcinogens is that the only dose-effect relationship is quasi-linear with no threshold, although this is now regularly challenged. In reality, life would be impossible if this concept were slavishly followed since analytical chemistry continues to advance the sensitivity of measurements: the model used therefore is *de minimus* (1) and not one based on the Delaney clause (1). More work is still needed on low-level exposure to keep this as a scientific rather than a political subject. This whole area is one in which international co-operation should be sought.

Land and Water Pollution

There are many toxicological problems concerned with reclamation whether of land, water or of materials. Fortunately, living on an island, most problems in the UK are domestic. Waste recycling and recovery of raw materials together with separation of toxic components present problems which are multi-disciplinary in nature. The problems of waste disposal, whether composting or incineration, are more in the realm of the toxicologist.

There is an additional role which comes from our membership of the EU. The problems of mainland Europe are also the UK's problems. The disintegration of the Soviet Union and the emergence of several countries as contenders for membership of the EU have widened the area of concern. The more so as the EU may accept countries whose environmental record is poor. The problems of Central and Eastern Europe, for example, cannot want a better illustration than that of the Danube which flows through some 10 countries and is both sink and water source for most of them. 'Cleaning-up' will require new science.

Education & Communication

Unfortunately there is a climate of fear surrounding 'chemicals'. Fear does not beget good science although it does promote regulation and litigation. Overall it creates a climate which is wasteful of resources. It may be facile to say that education should start in the schools but there is little doubt that most students leave full-time education with little knowledge of science (but perhaps significant prejudice). To remedy this, the government should lead rather than follow and should try to remove some of the inaccuracies and misconceptions in the nation's collective consciousness. Perhaps a toxicology module could become part of the biological sciences curriculum. Education at all levels is important. It is probably fair to say that the most basic ideas of risk, hazard and dose are generally not understood. It is important for government to understand that there will be a continuing need for toxicity studies to help in deciding courses of action. Politicians are too ready to indulge in knee-jerk reactions to broadsheet shock-horror stories without taking sound scientific advice.

Laboratory Science and Technology

Probably the most important goal in classical toxicology is the need for reliable short term tests, which may be *in vivo* or *in vitro* (but preferably the latter), to replace lifetime studies. While the savings in time and money will be considerable, short-term tests are also politically an important goal since they will reduce reliance on long-term animal tests with their attendant social problems. However, such tests must be real and not rely on the surrogate end-points which are currently seducing the pharmaceutical industry. Thus, the next ten years should see advances in the methods by which toxicity studies are carried out. Cell culture techniques should improve and the results from them become better applicable to the real world. At the present time such *in vitro* modelling is difficult to relate to studies in whole animals. Knowledge about the mechanisms of toxic action is particularly important since it is through this knowledge that we are able to identify problems before they occur and to design safer materials to replace existing hazards.

Since the public expect total safety in medical treatment, studies in the toxicological sequelae of drug treatment, including the emerging techniques of gene therapy, will be necessary into the foreseeable future. A related issue is the effects on the population of herbicides, pesticides and hormones including chemicals which mimic the effect of hormones. Here education is as important as toxicology. Genetic modification of plants may introduce toxicological problems: there is the example of solanum alkaloids being bred back into potato tubers in the search for a better cultivar. Whether there are any toxicological problems inherent in the genetic modification of animals remains to be seen but they should not be discounted.

There are several techniques which are still probably in their infancy including computer based simulations, *e.g.* Quantitative Structure-Activity Relationships (QSAR), combinatorial chemistry and high throughput screening with its large output of novel compounds which are challenging toxicological resources and existing methodology. These newer techniques will need to work closely together to allow their benefits to be realised.

Note

(1) The infamous Delaney clause (after Senator Delaney) in the legislation of the United States seeks to protect the American people from any food additive or food use product which gives a positive result in a carcinogenicity test regardless of how the test was carried out. The *de minimus* concept aims to return sanity by accepting that minimal exposure may produce no discernible health risk. Rather than change the law and delete the Delaney clause, the Americans vote each year to continue with the de minimus concept.

RSC Occupational and Environmental Toxicology Subject Group
October 1997

The Royal Society of Chemistry's Scientific Forward Look: Future Developments

The renewed impetus to the Society's Scientific Forward Look was given in early 1997, when briefings and operating timetables were provided to all Chairs and Secretaries of the Subject Groups operating under the umbrella of the Scientific Affairs Board and its Divisions. The initial objective was to have the reports of individual Subject Groups ready by the end of September 1997.

At the start of the exercise, Analytical, Dalton, Faraday, Industrial Affairs, and Perkin Divisions adopted a broadly similar approach. Each Division decided to draw together the views of its own Subject Groups into a composite report. In most instances, a small working party was established early on to coordinate the individual Group activities and to prepare the Divisional report. Exchange of information between Divisions was encouraged and findings deemed of relevance to other Groups were identified. Of particular importance were thought to be breakthroughs in the analytical field which were needed for progress in other areas of chemistry. For the Divisions, the objective was to have the composite reports ready by the end of the year.

For the Interdivisional Groups the situation is somewhat different because these Groups, as their affiliation implies, do not have a single focus within the main areas of chemistry. However, Interdivisional Groups which have interests in common with the five main Divisions have liaised with the Divisions and, in addition, the reports of the Interdivisional Groups will be drawn together by Society staff.

Inevitably, because of the pressure of work on those actually preparing the responses of the Subject Groups, there has been some slippage in the timetable. However, the overall exercise has gone well and a great majority of the Groups have submitted a Scientific Forward Look. The Divisional reports, in most instances, have been, or are being drafted and there will be a meeting of Divisional Presidents in early January 1998 to discuss the findings of the exercise.

Everything is on course to have a full Royal Society of Chemistry report ready by the end of 1998 to feed into the next round of Foresight, which starts in early 1999. As well as its role in the Foresight programme, this report will also be given to the UK research councils to assist in their planning processes.

The Society's commitment to the *Technology Foresight Programme*, initially through dissemination meetings, then by the very successful *Technology Car Boot Sales* and the *Scientific Forward Look* initiative has been recognised and acknowledged by the present government. In October 1997 there was a meeting between the Society's President, Professor Eddie Abel, senior RSC staff members and officials from the Office of Science and Technology (OST) to discuss the next round of Foresight and the Society's participation in it. This was followed by a formal invitation to the President from the OST for the Society's comments on how the next phase of Foresight should be planned and implemented.

As a consequence of the invitation, a survey was carried out among members of the Scientific Affairs Board and the Chairs and Secretaries of the Subject Groups involved in the Scientific Forward Look. Because of limited time, it was not possible to widen the survey. The response received was encouraging and there were clear messages of support for our involvement in the next phase of Foresight and we were able to pass on a set of recommendations to the OST. Our report was sent to the OST on 11 December 1997. Copies of the findings of the survey have also been passed to Subject Group Chairs and Secretaries. Members wishing to obtain a copy should contact either John Brophy or Martin Hunt at Burlington House.

Martin Hunt, Royal Society of Chemistry, Burlington House
15 December 1997

Environmental Chemistry at the University of Hertfordshire

Introduction

The University of Hertfordshire offers a wide range of course units in subjects related to the environment. Building on a foundation of chemistry, these are available to students in various combinations to provide honours degree level study in Environmental Chemistry.

Starting from a common first year programme for all students on the degree scheme, and continuing with a core of chemistry course units, students are able to choose broadening modules from a range of areas to reflect their interests and abilities.

The development started with the long-standing chemistry degree programmes at Hertfordshire, with their range of specialist final-year options, which include Analytical Chemistry and Industrial Chemistry. The Industrial Chemistry option includes studies in the operation of the chemical industry, and of the types of processes involved, their products and by-products, and also considers the legal framework within which the industry operates. This obviously provides one basic theme for the Environmental Chemistry degree. The Analytical Chemistry courses deal with the range of techniques available to the modern analytical chemist, and are presented, in part, in terms of problems to be solved and techniques to be employed. The need to monitor and control emissions from chemical plant

provided one very useful set of analytical examples, and another theme for the Environmental Chemistry degree programme.

Parallel with the above, the Department of Environmental Sciences has long experience of running a broadly-based degree scheme, with options in Environmental Monitoring and Protection, which includes a substantial chemistry input, and in Ecology, as well a degree in Geology. The provision, in 1991, of a **degree in Environmental Chemistry**, therefore formed a natural link between these two areas.

BSc Courses in Environmental Chemistry

The University has adopted a modular degree structure that is common across all subject areas. The size of the modules is such that eight modules in each year make up the normal loading for an honours degree student, with the degree programme requiring a lower rate of study. The first year of the Environmental Chemistry programme contains four modules of Core Chemistry and two modules of basic Maths and Computing, common with the Chemistry degree students and taken alongside them. It also contains two modules from the Environmental Studies programme that provide an introduction to Biodiversity, Habitats and Ecosystems.

In their second year students continue with the study of four modules of Core Chemistry, with courses that also develop the use of spectroscopic methods for the identification of organic compounds, and provide an introduction to Analytical Chemistry. A double modular environmental course deals with the use of both chemical and biological methods for the monitoring of change in the environment. At this stage they can also make a choice between a more chemically or environmentally oriented programme, with the final two modules coming either from a further study of Chemistry or from a course in Ecological Systems.

Third year students are strongly encouraged to take advantage of a period spent either in a work placement in the UK, or in study or work placement at a university elsewhere in the EU, in the USA or in Canada. Work placements have ranged from the almost purely chemical, with experience of the use of analytical chemical techniques in the water industry, to the strongly environmental, with work in a country park. The latter involved a mixture of taking part in a research programme on the movement of metals in sediments together with carrying out a series of vegetation and invertebrate surveys. Interestingly many placements have also followed the balanced mixture of subjects in the degree programme, with students making use of their chemical knowledge in a strongly environmental context, such as work in the environmental sections of companies in the pharmaceutical industry and in environmental consultancies. Students are always strongly advised to take advantage of placement opportunities, since our experience over a number of years with both Chemistry and Environmental Chemistry has been that Sandwich students on average perform better at the final assessment than do their full-time equivalents.

The final year follows the pattern established earlier, the core consisting of a double modular course looking at current issues in the chemistry of the atmosphere, of soils and of water, with a strong emphasis on the application of the chemical concepts in terms of their environmental relevance. All Honours Degree students also take a double modular project, as well as choosing option studies from a list that includes Environmental Analytical Chemistry and Quality Assurance, Case Studies in the Monitoring of Environmental Systems, Industrial Chemistry, and Environmental Management.

The project is seen as an extremely important component of the final year. Students choose from a range of topics that have included:

- the development and validation of analytical procedures for samples of environmental interest;
- water quality investigations in river corridor surveys;
- the design and setting up of a database for the water industry of potential polluters;
- the use of computer modelling to investigate the role of aromatics in tropospheric ozone generation;
- the removal of metals from wastewaters using solvent-impregnated resins.

MChem Degree

A new MChem degree in Chemistry is currently being offered at Hertfordshire with a four-year programme involving a substantially enhanced research project, and it is planned to offer a similar MChem degree in Environmental Chemistry on the same pattern.

Research

Opportunities for research exist at both MPhil and PhD level in both full-time and part-time courses. Professor Michael Cox, Quentin Appleton and Terry Bailey work with a team in Clean Technology, particularly in the application of extractive techniques to the clean-up of effluent streams, the recovery of metals from wastes and the remediation of contaminated land. Trevor Pryce-Jones and Ranjeet Sokhi from the University's Atmospheric Science Research Group are using computer modelling for the reactions occurring in the lower atmosphere. Professor Michael Evans, Brian Woodget and Sara Evans are involved in the application of analytical techniques to problems of environmental interest, including vehicle emissions. Steven Hall, together with Dick Fenner of the Faculty of Engineering, are working on problems in waste water treatment caused by some potential industrial discharges.

Overseas links

Good overseas links exist between Hertfordshire and universities in France, Germany, Greece, Ireland and Portugal, and opportunities exist for students to spend one year on placement at these universities. In addition the university has an EU contact under the Tempus programme to develop new Environmental Protection degree schemes at two universities in Poland, and some student exchange is included in this contract.

Applications

Enquiries about the schemes should be addressed to the Admissions Tutor: Dr Peter Pye, Department of Physical Sciences, University of Hertfordshire, Hatfield, Herts AL10 9HS (Phone 01707 284562, Fax 01707 284644).

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The Federation of European Chemical Societies and Environmental Chemistry

John Holder, a committee member of the Environmental Chemistry Group, reports on the current activities of the Federation of European Chemical Societies in environmental chemistry.

In 1977 the Federation of European Chemical Societies (FECS) established a Working Party on Chemistry and the Environment (WPCE) composed of environmental chemists appointed by their national chemical societies. The RSC was a founder member together with chemical societies in Austria, Czechoslovakia, Germany, Israel, Norway, Poland, Spain, Switzerland, Italy, France and Sweden. The Working Party was joined shortly afterwards by representatives from Finland, Denmark and Bulgaria. The Environmental Chemistry Group nominates a member of this Working Party on behalf of the RSC.

The Working Party meets roughly twice a year and has, so far, organised five European scientific conferences on environmental chemical themes:

- Chemical Pathways in the Environment - Paris, 1980
- Air Pollutants Affecting Plants - Lindau (Germany), 1984
- Risk Assessment of Environmental Chemicals - Guildford, 1988
- The Challenge of Strategies for Waste Reduction and Waste Management in the Chemical Industry - Vienna 1992
- Pesticide Chemistry for Sustainable Agriculture - Budapest, 1995.

Scheduled future meetings are:

- Atmospheric Chemistry and Air Pollution - Copenhagen, 1998
- Trace Metal Speciation in the Aquatic Environment - Porto 2000.

The first Chairman of the Working Party was Dr Clement Troyanowoky (France) (1977-84) who was succeeded by Geoff Dickes from the Environmental Chemistry Group (1984-90), then by Professor A. E. Hackl (Austria) (1990-93) and Dr György Mihályi (Hungary) (1993-96), and the current chairman is Dr Alan Astrup Jenson (Denmark).

FECS is a non-profit making organisation, whose objective is to promote the advancement of chemical sciences in Europe. Its activities are sponsored by national chemical societies. The RSC and the Hungarian Chemical Society provide secretariats for FECS in London and Budapest respectively.

The Working Party on Chemistry and the Environment currently has 21 members from Germany, the UK, France, Italy, Spain, Portugal, Belgium, Austria, Denmark, Norway, Ireland, Latvia, Estonia, Finland, Poland, Hungary, Slovenia, Greece, Turkey, Switzerland and Ukraine. Additional members are expected during the next year from Cyprus, the Czech Republic, Holland, Russia, Slovakia and Sweden.

Last year, FECS introduced a structure in which working parties with more than 20 members and with broad activities became Divisions. Currently there are Divisions for Food Chemistry, Chemical Education, and Analytical Chemistry. It is expected that the WPCE will reach divisional status during 1998.

Sub-groups within WPCE are being considered in the following areas: Water Chemistry and Pollution; Water Management and Supply; Atmospheric Chemistry and Air Pollution; Soil Chemistry and Terrestrial Pollution; Pesticide Chemistry; Persistent Organic Pollutants; Radioactive Waste; Endocrine Disrupters.

The aim of the sub-groups will be to build up and maintain a European network of specialists in a particular topic, to discuss research ideas and areas for co-operative research, and to organise specialist meetings. Members of the subgroups need not necessarily be members of the Working Party.

In order to inform, inspire, and help the development of environmental chemistry as an academic discipline, the WPCE is producing a survey of undergraduate and postgraduate environmental chemistry courses and is assessing environmental chemistry textbooks currently in use.

The intention is to strengthen links with national environmental chemistry groups for a broad exchange of information on meetings and other activities. Websites and Newsletters are regarded as important communications tools in this regard and the ECG Newsletter and the revised RSC Website have been commended by the Chairman.

In order to publish news, papers, and conference proceedings, the WPCE has entered into an agreement with the journal *Environmental Science and Pollution Research* published by Ecomed and edited by a former long-standing member of the Working Party, Professor Otto Hutzinger. An editorial appeared in Volume 4 No. 3 of the journal setting out future plans and listing the current membership.

I took over representation of the RSC from Geoff Dickes in 1996 and have attended the last three meetings in Copenhagen (October, 1996), London (June 1997) and Vienna (September 1997). I have agreed to be nominated as Secretary of the Working Party at its next meeting in Bordeaux in April 1998.

John V. Holder, Department of Chemistry, University of Central Lancashire
October, 1997

Further information on FECS may be found on the RSC's Website.

Environmental Training: the IEM Certificate in Environmental Management

The Engineering Employers' Federation (EEF) in collaboration with the Institute of Environmental Management (IEM) have developed a short course for those whose work requires a knowledge of current environmental legislation and practice. **Paul Reeve** from the EEF and a member of the Environmental Chemistry Group describes this course in more detail.

Companies and other organisations are having to incorporate environmental thinking into their plans and operations as a result of legal requirements and mounting stakeholder pressure. In particular, there is increasingly a need to respond to environmental demands from key customers.

Those companies that are effectively addressing environmental issues are finding that there are significant business benefits to be gained in terms of market advantage, organisational culture and increased efficiency.

Environmental policy developments include the introduction of a wide range of traditional regulatory measures, and increasingly 'market-based' measures such as voluntary schemes and environmental taxes.

A key example of this is the international environmental management system standard - ISO 14001. This was adopted in 1996 and has also become the UK and European standard, completed by the EU Eco-Management and Auditing Scheme - EMAS.

To assist in the training of key personnel in environmental management, EEF has developed the **IEM Certificate in Environmental Management** with the *Institute of Environmental Management (IEM)* - the UK's leading professional body. This nationally accredited qualification will benefit both the company and the individual - giving delegates a comprehensive understanding of environmental issues relevant to business issues and hands on experience of practical environmental management techniques.

Valuable to the company and to the individual, the course will benefit personnel at all levels within the organisation - from Supervisors to Directors.

The Certificate is designed for candidates from a range of businesses - not just manufacturing companies.

Course Structure

The course comprises a total of two weeks tuition (including syndicate work and typically, a site visit), followed by an examination. Candidates are then required to undertake a short project, usually in their place of work, to demonstrate their ability to understand and apply environmental management techniques.

Course Aims

After completing the course, the candidate should be able to:

- Outline the main environmental issues and understand their relevance to business;
- Understand how UK and EU environmental policy is implemented and identify the principal environmental legislation and other policy measures affecting business;
- Outline the main regulatory regimes and identify sources of best practice advice;
- Understand the main requirements of effective environmental management systems;
- Understand and apply key environmental management techniques;
- Identify cost effective options for controlling the environmental aspects of company activities.

Assessment

This is through a written examination paper and a carefully structured project, verified by the IEM. Successful candidates will be awarded the IEM foundation certificate.

Associate Membership of the IEM

In December 1996, the Institute of Environmental Management (IEM) announced that candidates who successfully complete the Certificate were eligible for Associate Membership of the Institute.

Over 150 candidates have been through the course since its launch in October 1996. The consistently high performance of successful certificate holders in the IEM's independent Associate Membership assessment has meant that the Institute is satisfied that Certificate holders can be directly accredited to Associate Membership, AMIEMgt.

The success of the course was reiterated in a survey of participants who stated high levels of satisfaction with tuition and course materials. All participants interviewed said they would recommend the course to colleagues.

From January 1998 the delivery of the Certificate Course (under licence) will be opened to other course-providers. Associate Membership of the Institute is becoming widely recognised as the leading professional qualification in the area.

Anne-Caroline Peckham, Director of the IEM says:

"The Institute is particularly pleased to announce this new link between the certificate and Associate Membership of the Institute. With a substantial number of course-providers expected to apply to run the Certificate Course from next year, individuals seeking training can be

confident that they will have access to a course that has been specifically developed to meet the needs of those involved in environmental management".

Participants

The course is aimed at all industry sectors. Companies which have sent candidates on the course include:

Powergen, MoD, Kodak Ltd, British Gas Transco, Lucas Body Systems, and many smaller companies.

Syllabus

Key topics covered in the certificate course syllabus include:

- Environmental Policy and Legislation (sustainable development; UK and EU framework; regulatory requirements; market based measures);
- Environmental Aspects of Operations (releases to air, water, land; abatement techniques; and clean technology; waste minimisation;energy management);
- Environmental Management (getting started, and following through a management system; ISO 14001 and EMAS; establishing significant environmental aspects and impacts; benefits and priority setting).

Subjects include key environmental issues such as the greenhouse effect, ozone depletion, air pollution, water, waste and contaminated land; and management techniques including auditing, risk assessment and life cycle assessment.

For further information on IEM certificate courses or for a licence to run a course please contact Abigail Ferris at the EEF (tel. 0171 222 7777).

Paul Reeve, CChem, MRSC
Head of Safety and Environment, EEF
November 1997

[*Editor's Note:* The EEF and the IEM are both independent of the Royal Society of Chemistry, and information about the course leading to the IEM Certificate in Environmental Management does not imply an endorsement by the RSC].

Meeting Report: Environmental Technology Network Meeting and Environmental Technology Car Boot Sale

After the success of the Inorganic Chemical Technology 'Car Boot Sales', The Royal Society of Chemistry held an Environmental Technology 'Car Boot Sale' alongside the environmental exhibition, Solutions '97, in Manchester on September 11th 1997. **John Brophy and Mario Moustras** from the RSC report on the day's proceedings.

This event was jointly organised by The Natural Environment Research Council (NERC), The Joint Environmental Markets Unit (JEMU), The Environmental Industries Commission, The Biotechnology and Biological Sciences Research Council (BBSRC) and The Engineering and Physical Sciences Research Council (EPSRC).

The aim of the day was to facilitate environmental technology partnership between companies and university and Government research groups and to highlight some of the Government programmes and funding sources.

Programme

The day's programme included:

- A three hour networking session where participants presented posters to advertise or seek collaboration on all aspects of environmental technology. Fifty- six posters were presented;
- Three short talks which gave the audience:

  an industrialist's view of the technical challenges and opportunities for the future (presented by John Worwood of the BTR Group);

  an overview of the work of the Research Councils together with an outline of specific research programmes relevant to the environmental industry (presented by Dr Mike Tricker of the Technology Interactions Group at the NERC); and

  an outline of new developments in environmental policy, the prospects for the UK environmental industry and support available from public sources (presented by Dr Colin Hicks from the Environment Directorate at the DTI);
- A discussion forum in which delegates had the opportunity to form an Environmental Technology Network and to ask any questions relating to the day's events.

Recommendations from the Meeting

The following recommendations were made at the meeting:

- An Environmental Technology (ET) Network of academics, companies and other relevant organisations should be formed.
- This Network should maintain an up-to-date Directory of Research Interests.
- A regular network newsletter should be produced which should include updates on sources of expertise from universities and information on the new initiatives from the DTI and the Research Councils. There should be a special edition of this newsletter with a 100 word summary on the year's progress from each delegate.

- The ET Network should be connected to NEST with a web page linking researchers with end-users who have real problems.
- A meeting dedicated to funding sources for collaborative R&D, consultancy *etc.* should be organised where schemes were explained in more detail.
- Special interest groups should be formed to focus on a specific area of environmental technology.
- Evening meetings of the network should be held to allow SMEs, who are extremely short of free time, to attend.
- A session should be included at the next ET Car Boot sale to discuss and identify problems arising or likely to arise from legislation.
- The poster session was particularly useful and more time could be given to this element. It could run all day next time alongside other focus topics.
- The emphasis on clean-up technology should change to include clean technology to reflect global trends and anticipate the winning response.

For a more extended account of the day's proceedings and the poster presentations plus a list of the participants, please contact Dr Mario Moustras at the RSC, Burlington House.

John Brophy & Mario Moustras
The Royal Society of Chemistry.
December 1997

Meeting Report: Dispersion Modelling - Techniques for Dispersion Modelling and Development of Good Practices

The sixth meeting of the UK Dispersion Model Users Group (UK-DMUG) was held at Olympia, London on November 11th 1997. **Dr Leo Salter**, the Secretary of the Environmental Chemistry Group, reports on the day's proceedings.

UK-DMUG is now part of the NSCA (National Society for Clean Air and Environmental Protection) and provides an independent forum for discussion and exchange of information for all air dispersion modellers. The broad aims of the group are to: improve the performance of available air dispersion models by influencing model developments, in accordance with the needs of the modelling community; and to foster the improvement of dispersion modelling techniques through improvements in communications and dissemination of knowledge within the user community.

The purpose of this sixth meeting of the group (which was also part of a NSCA workshop) was twofold: to develop recommendations for modelling building wake effects on the dispersion of air pollution; and to identify a number of modelling topics as future study areas for the group.

The meeting had two sessions. The first session included presentations which described the influence of buildings and their effects on the dispersion of pollutants released from stationary and transient sources. The second session included papers on a wider range of topics.

The meeting also allowed for the exchange of information on modelling and local authority air quality management.

The conference was attended by around 140 representatives from industry, local authorities, research & academic institutions and government bodies such as the Environment Agency (EA). This significantly increased attendance compared with previous years was no doubt related to a need for local authorities to review and assess air quality management following the introduction by central government of the National Air Quality Strategy (NAQS).

With the stimulus given to modelling techniques by the NAQS (and by the Environment Agency), my reaction to the information presented at this meeting was one of concern about the robustness, accuracy, and value of the models currently available for dispersion modelling.

Computer software is able to present the best looking data ever, and there is always the pitfall that user-friendly software, easily accessed data inputs and wonderfully presented outputs can lead to a false sense of security in the value of the predictions made by computer models for planning decisions.

The lack of agreement between the UK-ADMS model (1), the ISC3 model (2) and wind tunnel experiments in the predictions concerning the dispersion of pollutants from sources, in all but the most ideal of circumstances, is perturbing. Further problems arise with the accuracy of these predictions because the models require meteorological data which are currently ill-defined.

The relative ease and low cost of use of modelling processes make them attractive to cash-limited local authorities who have the task of implementing the NAQS. In my opinion there needs to be a particular circumspection in replacing direct continuous monitoring of air quality by these (currently) unsatisfactory models. Models and monitoring must be developed in conjunction in order to provide an overview of a particular problem.

Many of the problems related to mapping air pollution were addressed by **Dr Kirsty Smallbone.** In particular she demonstrated how critical were the number of spatial and temporal data measuring points to the appearance of the final air pollution contour map. Equally the "perceived truth" associated with data presented in map forms is high, and data presented in this form are less likely to be "interrogated" than those displayed in tabular or graphical forms.

The meeting was an important forum both for those who develop dispersion models and for the end-users, and highlighted for

me the naive state of the models currently on offer.

A list of speakers and papers follows:

Building Wake Effects

- What Effects do We Need to Consider? (Prof Alan Robins, University of Surrey)
- How do ISC3 and UK-ADMS (and Other Models) Handle Buildings? (David Harvey, Atmospheric Dispersion Modelling Ltd.)
- What do We Need for the Future? (Dr David Hall, Building Research Establishment)

Modelling Topics

- Appropriate Meteorological Data to be Used within Dispersion Models (Prof Bernard Fisher, University of Greenwich)
- Modelling Atmospheric Chemistry: the Formation of Nitrogen Dioxide (Huw Edmunds, Cambridge Environmental Research Consultants)
- Data Presentation (Dr Kirsty Smallbone, University of Brighton)
- The Role of Dispersion Models in Developing Local Air Quality Management Plans (Dr Alison Simmons, Walsall Metropolitan Borough Council and Bob Appleby, City of Birmingham)

Leo Salter, Research Director, Cornwall College
November, 1997

Note
(1) UK-ADMS; United Kingdom Atmospheric Dispersion Model System (developed by Cambridge Environmental Research Consultants Ltd and the UK Meteorological Office).

(2) ISC3; Industrial Source Complex (a dispersion model developed by the US Environmental Protection Agency).

Meeting Report: Environmental Sensors: Needs and Prospects

The RSC's Industrial Affairs Division in association with the Materials Chemistry Sector and the Environmental Chemistry Group held a one-day meeting on November 14th 1997 at University College London (UCL) on Environmental Sensors.

Part of this meeting included the **RSC's John Jeyes Lecture** delivered by **Professor David Williams, UCL.** The following report has been provided by Dr Darren Reynolds, University of Hertfordshire.

Chemistry of Sensors for Environmental Measurement

(Prof. D. E. Williams, University College London)

The resistivity of semiconducting oxides at elevated temperature is very sensitive to trace concentrations of reactive gases in the atmosphere (e.g. O_3 and CO), and this property can be exploited in the design of new materials for environmental sensors. For example, the response of a semiconducting platinum-tin oxide to CO was commercialised by Taguchi in 1960. The behaviour of semiconducting oxides towards reactive gases can be modified by depositing onto the surface of the oxide small particles of catalytically active metals. Selectivity of response has been investigated with a range of gases including CO, CH_4, H_2, H_2S, NH_3, and NO_2 with the aim developing a new generation of hazardous gas monitoring equipment.

Sensors are currently being developed which incorporate novel materials and fabrication techniques. These sensors must have improved selectivity (new target gases) and be able to reject certain interferences, such as humidity and alcohol, which are known to affect adversely resistance. Target gases are usually classified in terms of their reducing or oxidising nature. As a general rule N type semiconducting oxides exhibit a decrease in resistance to reducing gases, while P type oxides result in an increase in resistance in the presence of oxidising gases. There are exceptions however, and an important factor governing the properties of sensor materials is the density of surface acceptors. For example oxygen adsorbed on to the surface (as O_2^-, O_2^{2-}, O^-, O^{2-}) will react or displace reducing gases. Attempts are being made to exploit this surface property in new sensor materials.

Reference

Williams, D.E. and Moseley, P.T., Dopant effects on the response of gas-sensitive resistors utilizing semiconducting oxides, *J. Mater. Chem.*, 1991, **1**, 809.

Optical Materials and Methods for Environmental Monitoring and Sensing

(J. D Wright, University of Kent)

Technologies adapted from optical communcations and electronics in combination with current ideas from molecular receptor design offer a versatile and inexpensive opportunity for developing new chemical sensors and environmental monitors.

For example, the sol-gel entrapment of reagents gives an optically clear matrix with controllable pore sizes and controllable pore wall chemistry. This allows subtle control of the selectivity of reagents. Interaction of entrapped reagents can lead to changes in fluorescence, optical absorbance, or refractive index, and these changes are the basis for sensitive optical chemical sensing. In some cases the interactions are reversible leading to conventional sensor reponses. In other examples the changes are irreversible, producing materials in which trace environmental pollutants are concentrated, and which are therefore suitable for long-term monitoring studies.

Sol-gel-entrapped dendrimer molecules

which are selective for organic compounds have been developed. Detection of the drug ibuprofen after complexation with copper ions is an example of this technique.

Surface plasmon resonance (SPR) has been adapted as an optical detection method for sensors. (Surface plasmon resonance is explained on the Website http://www.chem.vt.edu/chem-dept/students/Earp/intro1.html).

Examples of the use of selective receptors coupled with SPR in environmental monitoring include a calixarene system sensitive to dichloromethane, and a method for measuring phenol. The latter was developed for a EU-funded project following the contamination of the water supply by phenol in the town of Ufa in the Bashkiria region of Russia.

Another novel optical detection system introduced for environmental monitoring is a badge which incorporates a colour reagent within a piezoelectric polymeric film. The colour change in the badge when it is worn during a working shift is measured by a variant of photoacoustic spectroscopy. The spot is illuminated, absorbed light generates heat, and the polymer expands creating stress and a charge across the piezoelectric film. Using a flashing LED source with a lock-in amplifier, this system can monitor a range of gases at a fraction of the cost of for example absorber tubes/gc-ms. (Further information from Piezoptic Ltd. email: sales@piezoptic.itl.co.uk).

(A description of Dr John Wright's work with optical chemical sensors may be found as part of the home page of the chemistry department at the University of Kent)

Probing the Atmosphere

(R.L. Jones, University of Cambridge)

Zenith Viewing Spectroscopy and Light Detection and Ranging (LIDAR) are two spectroscopic techniques used for monitoring the atmosphere. In Zenith Viewing Spectroscopy a ground-based spectrometer detects the optical scattering of atmospheric species (O_2 and N_2). The instrument is portable and relatively inexpensive, but since the system is based on the collection of photons it is only possible to make day-time measurements.

With LIDAR, a pulsed laser light is shone into the atmosphere and the back scattered signals from gases, aerosols and particles are collected and detected. Raman spectroscopy is used for water vapour profiling. LIDAR techniques are used to profile the chemistry of the stratosphere and troposphere.

(An account of Dr Roderick Jones' work including the use of LIDAR appears as part of the home page of the chemistry department at Cambridge University. Details about the *environmental applications of LIDAR* at the *Los Alamos National Laboratory* may be found on the Website: http://www-emtd.lanl.gov/td/special/LIDAR.html)

Smelling the Electronic Way: New Sensors for Monitoring the Environment

(T. Gibson, University of Leeds)

There has been rapid progress over the past ten years in the development of a detector, commonly referred to as an 'electronic nose', which is capable of recognising a particular smell or odour. Electronic noses are based on sensor technology and incorporate a series of chemical sensors which respond to the volatile chemicals within the headspace of a sample. Each sensor gives a characteristic response dependent upon the chemical interactions between the sample and the sensor. Automated pattern recognition algorithms are used to analyse the data collected by the sensors and to characterise the odour. Electronic noses detect odours recognised by the human nose but can also respond to chemicals which are odourless to humans.

The sensor array used in electronic nose instrumentation should ideally respond to all compounds in the sample headspace, but the number of sensors need to be relatively small for ease of data interpretation. Relatively non-specific sensors are therefore chosen. Sensor technologies which have been applied include quartz crystal microbalances, metal oxide (*e.g.* tin and zinc oxides) sensors, and conducting polymer (*e.g.* polypyrrole, polyaniline and polythiopene) sensors. Recent applications have used fiber optic and surface acoustic wave sensors.

The main drawback to this technology appears to be selectivity, the lifetime and reproducibility of the sensors, and the complex data manipulation that is required. The performance of these sensors is also highly dependent on relative humidity, temperature and the presence of 'polluting gases'.

(A list of academic and commercial institutions which are developing applications for the electronic nose appears on the Website

http://sch-www.uia.ac.be/struct/review/research@sales.html).

[Two other presentations were made at this meeting: ***Water Quality Sensors: The Environment Agency's Experience*** (T.M. Long, The Environment Agency) and ***Monitoring Trace Metals in Natural Waters*** (C.M.G. van den Berg, University of Liverpool)]

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Meeting Report: Arsenic & Antimony in the Environment

The RSC's Environmental Chemistry Group in conjunction with Imperial College organised a one-day seminar on December 3rd 1997 at Imperial College on Arsenic & Antimony in the Enviroment.

The meeting was introduced by **Dr Margaret Farago** from the Centre for Environmental Technology at Imperial College who pointed out that concerns about arsenic in the environment arise from the contamination of drinking water with arsenic from natural sources in some parts of the world and this has resulted in ill health, while in other areas arsenic from mining and smelting wastes is a problem. The morning session started with a review by **Professor Peter Craig**, De Montfort University, of arsenic and antimony in the environment. Professor Craig described the speciation of these two elements in nature and, in particular, methylated products and their relative toxicities.

Professor Kurt Irgolic, University of Graz, Austria, defined in more detail some of the organoarsenic compounds found in the terrestrial biota, including arsenocholine, arsenobetaine, and arsenic containing riboses found in mushrooms collected at an old As smelting site. An HPLC-HHPN-ICP-MS method allows such compounds to be identified and quantified.

Professor Marie Vahter, from the Karolinska Institute, Stockholm, Sweden, then discussed species differences in the metabolism of arsenic by mammals. Inorganic arsenic as (As(III)) is methylated in most mammals to methylarsonic acid (MMA) and dimethylarsinic acid (DMA) in a stepwise transfer of methyl groups from *S*-adenosyl-methionine. A South American (Andean) human population, exposed to relatively high levels of As in drinking water, excreted little MMA, unlike most humans, who excrete significant amounts.

Dr Alecos Demetriades, IGME, Athens, ended the morning session with an account of arsenic and antimony contamination in the Lavrikotiki Peninsula, Greece. This area has experienced many hundreds of years of mining and smelting and is highly contaminated with both arsenic and antimony. The possible risks to human health were discussed.

After lunch, **Professor Iain Thornton**, Centre for Environmental Technology, Imperial College, talked about the risks to human health from arsenic contamination in South West England. In Devon and Cornwall over 77 square kilometres of agricultural and urban land are contaminated with arsenic. Up to 2,500 ppm As have been measured in some soils and up to 460 ppm As in some household dusts. There have been no proven health effects associated with As in local populations, but a pilot study of arsenic species in urine has indicated that in an area of high arsenic contamination, biological exposure has occurred.

Dr Peter Swash, Department of Earth Resources Engineering, Imperial College, highlighted the problem of arsenic and mining wastes. Dr Swash outlined a number of potential options for the disposal of arsenic wastes, these include the production of arsenic ferrihydrite, calcium arsenates, crystalline ferric arsenates, arsenic cements and arsenical slags.

The final part of the meeting was devoted to a topic of recent media interest: *Antimony and Sudden Infant Death Syndrome - is there a link?* This session was introduced by **Dr Mike Cooke**, Royal Holloway College, University of London. It has been suggested that microbial generation (particularly that by the fungus, *Scopulariopsis brevicaulis*) of toxic, volatile stibines, from antimony compounds used as fire retardants in cot mattresses is the cause of Sudden Infant Death Syndrome (SIDS)

Professor Jack Pridham, Royal Holloway College, University of London reviewed the evidence for the possible microbial conversion of antimony trioxide or potassium antimonyl tartrate into methylated stibines. He concluded it is unlikely that trimethylstibine (TMS) could be generated in cots by microbial action in amounts of toxicological significance.

Dr Richard Jenkins, De Montfort University, focussed in more detail on the alleged culprit *Scopulariopsis brevicaulis*. Dr Jenkins discussed the potential for microbial production of volatile antinomy compounds in a cot environment, and stressed that various factors must be taken into account: oxidation in an aerobic environment, the inorganic Sb substrate and its bioavailability, and dimorphism in *Scopulariopsis brevicaulis*.

Dr Trevor Delves, University of Southampton, described the accurate measurement of antimony in biological tissue using ICP-MS. The concentrations of Sb present in post-mortem samples of blood liver and lung tissues from SIDS and non-SIDS babies do not support the hypothesis that antimony is the cause of SIDS.

Finally, in a survey of the analysis of antimony in mattressess and in house dust, **Dr Mike Thompson**, Birkbeck College, University of London, reported that there was no evidence of volatile stibine being produced from cot mattresses. However, relatively high levels of Sb were found in some house dusts. A study of antimony concentrations in SIDS households compared with matched samples is currently being undertaken.

Margaret Farago, Imperial College with an additional contribution from Fraser Kendall, Cornwall Skin Cancer Research Group, Cornwall College
December, 1997

Royal Society of Chemistry Publications

Review Series: Issues in Environmental Science and Technology

Subscribe to Issues in Environmental Science and Technology at Half-Price for 1998

The RSC review series, *Issues in Environmental Science and Technology*, was described in the third issue of this Newsletter (February 1996). The two volumes due to be published in 1998 are *Risk Assessment and Risk Management* (No. 9) and *Air Pollution and Health* (No. 10). We are pleased to announce that, once again, the RSC have agreed to make a 1998 subscription to the series available to *members of the RSC Environmental Chemistry Group* at half the annual rate, totalling £17.50 for the two volumes (instead of the full price, £35.00).

Air Pollution in the United Kingdom

The proceedings of a previous ECG symposium, *Air Pollution in the United Kingdom*, which was held at Lancaster University in September 1996 have been published by the Royal Society of Chemistry.

Air Pollution in the United Kingdom

Edited by C.N. Hewitt and G. Davison

Special Publication No. 210; 1997; Hardcover; ISBN 0 85404 767 0; viii+148 pp., £49.50.

Contents

Indoor Air Pollution; Urban Air Pollution in the United Kingdom; Rural Air Pollution in the United Kingdom; Global Air Pollution Problems - Present and Future; The Health Effects of Air Pollution in the United Kingdom; Current and Future Legislation - United Kingdom and Europe; Developments in Air Pollution Measurement Techniques; Quality Assurance and Quality Control of Ambient Air Quality; Subject Index.

For details of these RSC publications, please contact the Sales and Promotion Department at the RSC on tel: 01223 420066 / e-mail: sales@rsc.org

Publications for RSC Members from the RSC's Environment, Health and Safety Committee (EHSC)

EHSC Notes

The following **EHSC Notes** are available *free of charge* to RSC members from Bob Hazell at the Royal Society of Chemistry, Burlington House, Piccadilly, London W1V 0BN. Tel. No. 0171 440 3337 or 0171 437 8656 extension 3337.

Individual Legal Responsibilities for Health and Safety at Work (1995)

Potency of Chemical Carcinogens (1995)

Additives in Food for Human Consumption: Post-Harvest Treatment Agents (1996)

COSHH : The "Competent Person" (1996)

Lethal Dose 50% - "LD50" (1996)

Pregnant Workers, Chemicals and the Law (1997)

Harmful Effects of Chemicals on Children (1997)

In preparation:

Laboratory Waste Management
Life Cycle Analysis
Risk Assessment at Work

Professional Briefs

The following **Professional Briefs** are also available *free of charge* from Bob Hazell at Burlington House.

COSHH in Laboratories

Guidance for Members Involved with Healthy Human Volunteer Experiments

Additives in Food for Human Consumption: General Considerations (1989)

Additives in Food for Human Consumption: Food Preservatives (1989)

Additives in Food for Human Consumption: Food Irradiation (1990)

Additives in Food for Human Consumption: Food Colours (1991)

Contaminated Land (1991)

Additives in Food for Human Consumption: Caramel Colours (1992)

Reproductive Risks of Chemicals at Work (1992)

COSHH and School Science (1993)

Additives in Food for Human Consumption: Enforcement of Control in the UK (1994)

Integrated Pollution Control (1994)

[Classification of Wastes (withdrawn) (1989)]

EHSC Guidance Booklets

Copies of **EHSC Guidance Booklets** may be purchased from Turpin Distribution Services Ltd., Blackhorse Road, Letchworth, Herts SG6 1HN, Tel: 01462 672555.

COSHH in Laboratories, Second Edition (1996)

Safe Practices in Chemical Laboratories (1989)

Guidance on Laboratory Fume Cupboards (1990)

Other EHSC Publications

The following monographs by the EHSC are a result of work funded by the CEC. These publications may be also be bought from Turpin Distribution.

Organo-Chlorine Solvents - Health Risks to Workers (1986)

Solvents in Common Use - Health Risks to Workers (1988)

Measurement Techniques for Carcinogenic Agents in Workplace Air (1989)

Long-term Neurotoxic Effects of Paint Solvents (1990)

Simple Guide on Management and Control of Wastes (1996)

A British Library Publication on Environmental Information

Environmental Information: A Guide to Sources

Nigel Lees and Helen Woolston

2nd edition, The British Library, 1997

ISBN 0-7123-0825-3; 267 pp.; £32.00

The second edition of this useful British Library guide has now been published. The structure of this book closely follows that of the first edition: the chapters are arranged by subject and within each chapter arranged by type of information (databases, printed sources and organisations). Extensive appendices give full bibliographic details on all the sources of information, plus contact and descriptive details on the organisations. In addition four new chapters have been written.

The chapters in this guide cover sources of environmental information for the following areas: Environmental information on the Internet; Government departments; Patents; Business, Law (UK, EU, International); Air pollution; Water pollution; Solid waste and waste disposal, Contaminated land and liability; Chemicals and the environment; Energy; Transport; Recycling; Noise pollution; Conservation and ecology; Agriculture and food.

Both the databases and printed sources cited in these chapters are international in scope, though the emphasis is on English language material. About 90% of the organisations referred to are UK-based and the remainder are international organisations.

This guide will be useful to those tackling the rather diffuse area of environmental information. It is not intended to be a comprehensive publication, rather a 'signpost' to the most efficient way to collect or find information on the environment.

The book may be obtained from Turpin Distribution Services Ltd, Blackhorse Road, Letchworth, Herts SG6 1HN. Tel: 01462 672555 (Fax) 01462 480947. Callers should ask for 'The British Library Section'.

Nigel Lees is Senior Marketing Officer at the Library and Information Centre of the RSC; **Helen Woolston** is Environmental Specialist for the BOC Group.

Book Offer

Special Offer for Royal Society of Chemistry Members

Energy and the Environment: Geochemistry of Fossil, Nuclear & Renewable Resources

Edited by Keith Nicholson, The Robert Gordon University, Aberdeen, Scotland

Publication date December 1997, approx. 200pp. Cloth: £75.00 ISBN 0-9520950-5-X

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Keith Nicholson, The Robert Gordon University, Aberdeen

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M.S. Jones, The Robert Gordon University, Aberdeen

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M.V. Chesire, C.A. Shand, K. Wood, S.Smith and G. Coutts, MLURI Aberdeen

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*R.L. Allan, A.B. MacKenzie, G.T. Cook and *I.D. Pulford, SURRC. East Kilbride and *University of Glasgow

Uranium Distribution and Radon Potential in the Mourne Mountains Area, Norman R. Moles and Michael J. Higgins, Queen's University, Belfast

Geochemical Barriers and the Transport of Iodine in the Secondary Environment: Implications for Radioiodine, Ron Fuge and *E. Louise Ander, University of Aberystwyth (*now Imperial College)

Transport of Radioactivity Indoors, M.J. Stenhouse, Intera Environment Division, Melton Mowbray

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Website http://www.thistlepress.co.uk/scientific/booklist.html

(Details supplied by Dr Keith Nicholson, School of Applied Sciences, The Robert Gordon University, Aberdeen AB25 1HG).

Forthcoming Symposia

Details of many meetings related to the environmental sciences to be held in the UK in the first half of 1998 are given in the leaflet *Environmental Science and Technology Meetings* which accompanies this issue of the ECG Newsletter.

Two other symposia on environmental topics have been organised by the **Environmental Chemistry Group** for the first half of 1998:

RSC Environmental Chemistry Group Distinguished Guest Lecture 1998

The 1998 ECG Distinguished Guest Lecture will be given by Dr Jan Pentreath from the Environment Agency (Website http://www.environment-agency.gov.uk/), and will be held on Wednesday 4th March 1998 at the Royal Society, Carlton House Terrace, London SW1 in the Wellcome Lecture Hall.

The title of Dr Pentreath's talk is *"Monitoring for Regulatory Purposes"*, and it will be accompanied by two other presentations.

The full programme will commence at 1.30 pm, and is also scheduled to include the AGM of the Environmental Chemistry Group. More details on this meeting will be sent to ECG Members in February 1998.

Environmental Chemical Processes Related to Fossil Fuel Combustion

Organised by the RSC Environmental Chemistry Group in association with AEA Technology, National Environmental Technology Centre, this two-day symposium is arranged for Wednesday 15 April and Thursday 16 April 1998 at the Weetwood Hall Conference Centre, Leeds.

The programme includes a series of invited presentations providing an overview of our current understanding of various aspects of the chemistry of fossil fuel combustion, the behaviour of the derived pollutants in the troposphere, and the metabolism of these pollutants in the body. There will also be an evening poster s ession to allow detailed presentation of more specific aspects of these areas. All participants are encouraged make a poster presentation.

For further information please contact:

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Oxfordshire OX14 3UP

Tel: 01235 463118 FAX: 01235 463005
e-mail: michael.e.jenkin@aeat.co.uk

The Federation of European Chemical Societies (FECS) Working Party on Chemistry and the Environment have organised the 6th FECS Conference on Chemistry in the Environment:

Atmospheric Chemistry and Air Pollution

H.C. Ørsted Institute, Copenhagen, Denmark, 26-28 August 1998

The main topics for discussion at this meeting will be: volatile organic compounds, oxidants/NOx, and particulates. For details of this meeting please contact the RSC's FECS representative Dr John Holder e-mail j.v.holder@uclan.ac.uk

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 RSC library, Burlington House, during the period July to December 1997. Recent additions on toxicology are also included in this list.

Chemical Safety: Fundamentals of Applied Toxicology: The Nature of Chemical Hazards, 2nd Edition

IPCS, Geneva, 1997, 258 pp., Accession No. 970866, Reference Shelves, 615.9:030.3 R

Consolidated List of Products whose Consumption and/or Sale have been Banned, Withdrawn, Severely Restricted or Not Approved by Governments

United Nations, New York, 1994, ISBN:9211301602, 936 pp., Accession No. 970777, Reference Shelves, 614.8 R

Contaminated Land and its Reclamation (Issues in Environmental Science and Technology No. 7)

Hester, R.E. and Harrison, R.M. (eds.), Royal Society of Chemistry, Cambridge, 1997, ISBN:085404230X, 145 pp., Accession No. IEST7, Bay C 23

Environment Agency: Review of the Inherited R&D Programmes 1995/96

Stationery Office, London, 1997, ISBN:0113101295, 77 pp., Accession No. 970655, West Gallery, 628.5:061.62

Environment Business Directory 1997/8

Hawkes, C. (ed.), Information for Industry, London, 1997, ISBN:0951837559, 336 pp., Accession No. 970644, Reference Shelves, 058.7:628.5 R

Environment in Your Pocket 1997: Key Facts and Figures on the Environment of the United Kingdom

Department of the Environment, London, 1997, 64 pp., Accession No. 970762, Reference Shelves, 628.5:311.42 R

Environmental Information: A Guide to Sources, 2nd Edition

Lees, N. and Woolston, H., British Library, London, 1997, ISBN:0712308253, 271 pp., Accession No. 970829, Reference Shelves, 025.5:628.5 R

Environmental Management: Life Cycle Assessment - Principles and Framework

British Standards Institution, London, 1997, ISBN:0580280713, 12 pp., (BS EN ISO 14040:1997), Accession No. 970870, West Gallery, 628.5:658

Environmental Protection Act 1990 (Commencement No. 18) Order 1996

Stationery Office, London, 1997, ISBN:0110633814, 9 pp., Accession No. 970731, (SI 1996/3056: C.94), A 100

Financial Assistance for Environmental Purposes Order 1997

Stationery Office, London, 1997, ISBN:0110641132, 2 pp., Accession No. 970674, (SI 1997/651), A 100

Humic Substances in Soils, Peats and Waters: Health and Environmental Aspects

Hayes, M.H.B. and Wilson, W.S. (eds.), Royal Society of Chemistry, Cambridge, 1997, ISBN:0854046992, 496 pp., (RSC Special Publication No. 172), Accession No. 970856, Reading Room, 547.992:061.3

Litter (Fixed Penalty) Order 1996

Stationery Office, London, 1996, ISBN:0110633806, 2 pp., Accession No. 970732, (SI 1996/3055), A 100

Molecular Markers in Environmental Geochemistry

Eganhouse, R.P. (ed.), American Chemical Society, Washington DC, 1997, ISBN:084123518X, 426 pp., (ACS Symposium Series No. 671), Accession No. 970931, West Gallery, 625.5:550.4:061.3

Principles of Environmental Sampling, 2nd Edition

Keith, L.H. (ed.), American Chemical Society, Washington DC, 1997, ISBN:0841231524, 848 pp., (ACS Professional Reference Book), Accession No. 970963, West Gallery, 628.5:542.22

Special Waste (Amendment) Regulations 1997

Stationery Office, London, 1997, ISBN:0110638816, 2 pp., Accession No. 970726, (SI 1997/251), A 100

Special Waste (Scotland) Regulations 1997

Stationery Office, London, 1997, ISBN:0110555252, 2 pp., Accession No. 970727, (SI 1997/257) (S.18) A 100

Special Waste Regulations 1996: Technical Assessment of Waste - Solihull,

Environment Agency, 1997, Accession No. 970867, Reference Shelves, 628.5:502.3R

Textbook of Modern Toxicology, 2nd Edition

Hodgson, E. and Levi, P.E., Appleton & Lange, New York, 1997, ISBN:0838588875, 218 pp., Accession No. 970901, West Gallery, 615.9

Waste Management (Miscellaneous Provisions) Regulations 1997

Stationery Office, London, 1997 ISBN:0110639065, 3 pp., Accession No. 970724, West Gallery, (SI 1997/351)

Workplace Atmospheres: Pumped Sorbent Tubes for the Determination of Gases and Vapours - Requirements and Test Methods

British Standards Institution, London, 1997, ISBN:0580283585, 18 pp., (BS EN 1076:1997), Accession No. 970869, West Gallery, 628.5:504.3

This issue of the ECG Newsletter was printed by Griffin House Printers, Haywards Heath