THE ROYAL SOCIETY OF CHEMISTRY

ENVIRONMENTAL CHEMISTRY GROUP

Bulletin

July 2004

CONTENTS

ECG Bulletin – July 2004

This issue of the ECG Bulletin may be seen on the Internet at http://www.rsc.org/lap/rsccom/dab/scaf003.htm

Chairman
Dr Brendan Keely,
Department of Chemistry,
University of York,
Heslington,
York YO10 5DD
Tel: 01904 432540
bjk1@york.ac.uk

Vice-Chairman & Honorary Treasurer
Dr Andrea Jackson,
School of the Environment,
University of Leeds,
Leeds LS2 9JT
Tel: 0113 233 6728
andrea@env.leeds.ac.uk

Honorary Secretary
Dr Leo Salter,
Centre for Science,
Cornwall College,
Trevenson Road,
Pool,
Redruth,
Cornwall TR15 3RD
Tel: 01209 616192
l.salter@cornwall.ac.uk

BULLETIN EDITOR
Dr Rupert Purchase,
38 Sergison Close,
Haywards Heath,
West Sussex RH16 1HU
Tel: 01444 455673
rp@rupertpurchase.demon.co.uk

Chairman's report

The repercussions of arsenic contamination of drinking water in Bangladesh have been described in several past issues of the *ECG Bulletin*. This human tragedy has drawn together scientists from many disciplines in an effort to understand the geological circumstances of this disaster, how the drinking water might be purified, the mechanisms of arsenic toxicity, and the likelihood that other countries could become similarly affected. In this issue of the *Bulletin*, these themes are further explored:

- First we are grateful to the editorial staff of the *Journal of Environmental Monitoring* for allowing us to reproduce a review article by Mike Sharpe on the global aspects of arsenic contamination.

- We have featured previously the British Geological Survey's (BGS) work on monitoring for arsenic contamination in the UK (*ECG Bulletin*, July 2003). Now we report a survey by the BGS of a disused arsenic and copper mine in Devon.

- The latest in a series of proceedings from the SEGH* International Conferences on Arsenic Exposure and Health Effects was published in 2003, and Leo Salter takes the opportunity to review this book for the *Bulletin*.

- The 22nd European Meeting of SEGH was held this year at the University of Sussex. Arsenic contamination and remediation were the topics for many of the papers and posters at this meeting, and we are grateful to Professor Mike Ramsey from the Centre for Environmental Research at Sussex University for permission to reproduce some of the posters. (The selected posters accompany the version of this *Bulletin*, which appears on the RSC Website).

- For next year's Distinguished Guest Lecture, we will expand further on the relationship between health and exposure to metals and metalloids in the environment with a presentation by Professor Jane Plant from the BGS.

BRENDAN KEELY,
University of York,
June 2004

* Society for Environmental Geochemistry and Health

Deadly waters run deep: the global arsenic crisis

This article was written by Mike Sharpe (MS Consulting), Contributing News Editor for the Journal of Environmental Monitoring (JEM) and was first published in JEM Volume 5, issue 5, 2003, pages 81-85N.

As any reader of detective stories knows, arsenic is the murder's poison of choice.

However, the symptoms and signs of chronic exposure appear to differ between individuals, population groups

The most contentious point in the scientific debate has been the assumption that the toxicity of arsenic increases linearly (i.e. uniformly) in proportion to increases in its concentration.[10,11] Virtually all known toxicological processes follow a sublinear model–i.e. increases in cancer risk are negligible at low doses. Critics say the NRC accepted that only sublinear models were plausible but was forced to opt for the linear model instead because it could not agree on which sublinear model was correct. This, they claim, led to a conclusion in favour of a lower arsenic standard that was not supported by the science.

Bangladesh: a country in crisis

One area where the health effects of arsenic exposure are beyond doubt is Bangladesh[12, 13] (see *Analyst*, 1994, **119**, 168N for one of the earliest reports on this).[14] In the mid-1990s it emerged that arsenic had contaminated well water in parts of the Bengal Delta. This is the coastal floodplain of numerous rivers, including the Ganges and is shared by Bangladesh and the Indian state of West Bengal. The latest surveys estimate that around 36 million people in the Bengal Delta are drinking contaminated water, and 150 million are at risk.[15]

Ironically, the crisis has its origins in development efforts to give the people of the region access to safe drinking water. Until the 1970s, most villages in Bangladesh and West Bengal had either dug shallow wells, or collected water from ponds or rivers–and regularly suffered cholera, dysentery and other waterborne diseases. Instead, development agencies advised local people to bore deep "tube wells" into the water aquifers to reach clean, pathogen-free water. Up to 20 million of these tube wells were dug. Unfortunately the drilling hit precisely the depth of arsenic-rich rock.

Hydrogeologists have determined that the source of the problem is rocks naturally rich in arsenic which were eroded from the Himalayas thousands of years ago and deposited by the region's rivers. The arsenic-bearing sediments became buried and lie about 50 to 75 m beneath the surface. Until relatively recently, however, arsenic was not recognised as a problem in water supplies and the standard water testing procedures did not include tests for it. The role of alluvial aquifers as a potential source of arsenic in groundwater is now much better understood [Box 1].[16, 17]

WHO experts predict the situation will get much worse and should be considered as a public health emergency. "It is reasonable to expect marked increases in mortality from internal cancers once sufficient latency has been reached," says Professor Allan H. Smith of the University of California, a WHO adviser.[18] Studies in other countries where the population has had long-term exposure to arsenic in groundwater indicate that one in ten people who drink arsenic-contaminated water may ultimately die from cancer. Dramatic increases in such deaths and cases have been reported in Taiwan, Chile and Argentina.

In Britain the issue has ended up in court, with 750 Bangladeshis suing the British Geological Survey (BGS), which assessed more than 50 wells in 1992.[15] BGS was paid by the UK Overseas Development Agency from development aid funds to conduct a hydrochemical baseline survey of the tube-well water quality in Bangladesh and assess its toxicity to humans. The claimants say BGS should have tested for arsenic, but

trace elements which are therefore not routinely tested for in groundwaters unless there is independent evidence to suggest its presence. In 1992 such evidence did not exist in relation to Bangladesh, since alluvial plains of the sort which underlie much of Bangladesh were not generally recognised as posing an arsenic risk. We now know that a number of such areas of the world do have enhanced levels of arsenic in groundwaters."

The British High Court did not agree and in May 2003 dismissed BGS's application to strike out the claim. Aid agencies have a "duty of care" to those they aim to help, the judge said. The case is due to return to court early next year, when the BGS will have to answer why it failed to carry out the arsenic tests.

Meanwhile, new research across India's Ganges Basin suggests that the crisis in the sub-continent could extend much farther than previously thought. According to epidemiologist Dr. Dipankar Chakraborti of Jadavpur University, the Bengal Delta "may be only the tip of the iceberg".[19] Untold numbers of the region's 450 million residents could be exposed to dangerous levels of the element in their drinking water. He is calling for urgent regionwide water-well analysis. "The arsenic problem intensified during a period of long neglect. Our earlier mistakes must not be repeated," he says.

Tipped-off to a spate of cancer deaths and skin lesions in the village of Semria Ojha Patti in the Indian state of Bihar, Chakraborti's team sampled wells in the village. Half contained five times the accepted safe limit of arsenic; one in five wells had 30 times the safe level. Bihar is 500 kilometres west of the Bengal Delta and is geologically akin to much of the Ganges Basin. The research in Bihar has sparked fears that similar arsenic contamination in Vietnam, Thailand and Taiwan could also be more widespread.

Research for a global problem

The issue of arsenic in drinking water is now recognised as a global problem. Relevant research is being undertaken on many fronts.

Treatment technologies

A number of established technologies are effective in reducing arsenic in drinking water. These include:activated alumina filters, anion exchange, distillation, reverse osmosis, and nanofiltration.[1, 2] Also, as a safeguard against organic arsenic, granular activated carbon filtration may be used.

While many large water systems are equipped with these treatment technologies, they may be less amenable for use by small community water systems or individual households. As part of its Arsenic Rule Implementation Plan, EPA has committed to sponsor further research and development of more cost-effective technologies as well as technical assistance and training to operators of small systems to reduce their compliance costs.[20] Around US$20 million has been pledged for the period 2002/2003.

As well as research, a strong emphasis is being placed on demonstrations of low-cost treatment technology. Twelve sites have already been selected for practical demonstrations of technologies and treatment techniques, and an invitation for a further round was launched earlier this year.

Appropriate technologies

Even technologies designed for small-scale community treatment systems may not be suitable for developing countries, as they are moderately costly and require technical expertise. Hence, international donors and aid agencies are funding research into appropriate treatment technologies and techniques that could be deployed quickly and effectively in southern Asia and other affected regions.

WHO, for instance, has sponsored a technique called STAR (Stevens Technology for Arsenic Removal) as an effective and inexpensive method for filtering out arsenic from household drinking water supplies.[18] The system uses a mixture of iron sulfate, calcium hypochlorite and sand as a filtering agent. Another filtration agent is laterite, a local raw material found throughout the Indian sub-continent.[16]

Genetic engineering

Another field of interest is the use of genetic engineering to create plants that could clean arsenic from contaminated soil and groundwater. Phytoremediation– the use of plants to absorb chemical pollution from soils–is a well established technique, but few naturally occurring plants thrive on toxic sites.

By inserting two bacterial genes into thale cress, *Arabidopsis thaliana*, US researchers have created a plant that not only grows well in the presence of arsenic but is able to store the toxin in its leaves.[21] The genes, from the bacterium *Escherichia coli*, make enzymes that digest arsenic compounds so they can be absorbed. The arsenic-rich leaves can then be harvested relatively easily and safely incinerated, making it ideal for phytoremediation. Eventually plants could be developed that might clean a contaminated site in just two or three years. The technique may also be

abs.93/aiae02opla alred relat-06194 Tw

work has made important breakthroughs here, suggesting mechanisms both for direct DNA interactions and co-carcinogenic effects. Other research into biomarkers of exposure seems to confirm that, for the same level of exposure, some people run a higher risk of developing cancer than others [Box 2].

Such findings should help us to develop a better informed public health response to the arsenic issue in both developed and developing countries.

BOX 2: Biomarkers of arsenic exposure

While the health effects of exposure to high levels of arsenic are significant and well documented, the impact of low to moderate level exposures remains unclear. Researchers at the Harvard School of Public Health, led by Dr. David Christiani, have studied biomarkers of exposure to arsenic and heritable susceptibility in two of the worst affected areas–Taiwan and Bangladesh. These studies are designed to fill important research gaps in our understanding of arsenic and human health.

The researchers are utilising a population-based approach, incorporating markers of exposure (drinking water arsenic, toenail arsenic, and measures of inorganic arsenic in urine), susceptibility (genetic polymorphisms in metabolizing genes), and outcome (squamous cell carcinoma of the skin, bladder cancer, and non-malignant skin lesions). In addition to studying the impact on health status including cumulative arsenic exposure, age, gender, and diet, they will examine the effect of gene polymorphisms in the Glutathione S-transferase (GST) superfamily of enzymes, which plays an active role in arsenic metabolism processes.

Similar research to date on bladder and skin cancer in Taiwan has revealed that:

- A person's ability to metabolize inorganic arsenic into less toxic metabolites (monomethylarsonic acid [MMA] and dimethylarsinic acid [DMA]) is directly related to the risk of both bladder and skin cancer. Methylation of DMA to MMA plays an important role in lowering, but not eliminating, the risk of skin and bladder cancer. Methylation of inorganic arsenic to DMA exhibits a weak effect in the opposite direction.
- In cases with similar methylation abilities and cumulative arsenic exposures, men had a higher risk of skin cancer, suggesting that additional behavioural or genetic factors may play a role.
- There is a significant relationship between smoking status, cumulative arsenic exposure, and increased risk of bladder cancer.
- The risk of developing skin cancer after long-term exposure to arsenic in drinking water was enhanced by certain genetic characteristics, most significantly by variation at codon 72 of the tumor suppressor gene p53.

These findings have important public health significance, suggesting that at the same level of exposure, some persons are at higher risk of cancer development than are others. Efforts to protect the more susceptible among us will ensure protection for all.
Adapted from: ref 23.

References

1. United Nations Synthesis Report on Arsenic in Drinking Water, World Health Organisation, 2001. www.who.int/water_sanitation_health/dwq/arsenic3/en/

2. Arsenic in Drinking Water, WHO Factsheet No. 210, World Health Organisation, 2001. www.who.int/inf-fs/en/fact210.html

3. Arsenic in drinking water may accelerate artery disease, Sci. Am., 26 March 2002, citing paper published in Circulation: *J. Am. Heart Assoc.* www.sciam.com

4. Arsenic compounds may cause genetic damage by a direct mechanism, press release, EPA National Health and Environmental Effects Research, citing paper in the 16 April 2001 edition of *Chem. Res. Toxicol.* www.epa.gov/nheerl/ordpr/2001/pr_041901.pdf

5. Arsenic in drinking water may be linked to cancer Dartmouth study finds, press release, Dartmouth Medical School, Dartmouth, NH. www.dartmouth.edu/dms/news/

6. Cadmium studies suggest new pathway to cancer, *J. Environ. Monit.*, 2003, **5**, 67N.

7. Arsenic in Drinking Water, National Research Council, 1999 and 2001 Update. ISBN 0-309-06333-7. www.nap.edu/catalog/6444.html

8. Mary Tiemann, Arsenic in Drinking Water: Recent Regulatory Developments and Issues, RS20672, Congressional Research Service, 2001, National Library for the Environment: www.ncseonline.org

9. For news reports on revisions of the arsenic standard see: *J. Environ. Monit.*, 2001, **3**, 20N, 38N & 85N.

10. Arsenic, Drinking Water, and Health, A Position Paper of the American Council on Science and Health, ACSH, 2002. www.acsh.org

11. S. Milloy, National Research Council poisons arsenic debate, Fox News, 27 April 2001. ww.foxnews.com

12. Researchers warn of impending disaster from mass arsenic poisoning, press release WHO/55, World Health Organisation, September 2000. www.who.int/inf-pr-2000/en/pr2000-55.html

13. For further information on the Bangladesh crisis see: Arsenic Crisis Information Centre, http://bicn.com/

acic/; SOS Arsenic.Net, www.sosarsenic.net; and The London Arsenic Group, www.es.ucl.ac.uk/research/lag/as/

14. D. Das, A. Chatterjee, G. Samanta, B. Mandal, T. R. Chowdhury, G. Samanta, P. P. Chowdhury, C. Chanda, G. Basu, D. Lodh, S. Nandi, T. Chakraborty, S. Mandal, S. M. Bhattacharya and D. Chakraborti, *Analyst*, 1994, **119**, 168N–170N.

15. John Vidal, *Deadly waters*, report in *The Guardian*, 8 May 2003. www.guardian.co.uk

16. P. Bhattacharya *et al.*, Genesis of arseniferous groundwater in the alluvial aquifers of Bengal Delta Plains and strategies for low-cost remediation, presented at the *Dhaka Arsenic Conference* February 1998, Arsenic Crisis Information Centre: www.bicn.com/acic/resources/infobank/dch98-02conf/confpap.htm

17. For further papers on science of arsenic in groundwater see: session

Arsenic bioaccessibility and speciation in soils at an abandoned arsenic mine in SW England

Possible sources of arsenic

and for the Bere Alston background soils (PBET As median: 7 mg kg^{-1}). The results suggest that bioaccessible As is a better measurement than the total As content when considering risk assessment, and bioaccessibility data have clear implications for site-specific risk assessments.

Chemical sequential extraction data have been used to help elucidate the nature of the physico-chemical forms of As in the soils and mine waste material. Chemometric data processing allows characterisation of the matrix by resolving the number and composition of the physico-chemical components present. The most significant component contains mainly iron, As, and traces of sulphur, and is extracted in the last part of the test.

Further evidence of the Fe-As association comes from scanning electron microscopy, which shows As-rich, iron oxyhydroxides coating the surface of altered waste fragments and clastic grains (Figure 1). The coatings show various microfabrics from colloform iron oxyhydroxide to more crystalline coatings (fine-needle-like crystals).

X-ray absorption near edge structure (XANES) analysis indicates that As(V) is the dominant oxidation state in the mine waste materials and soils. Quantitative fits of EXAFS spectra using theoretical standards indicate As(V) in tetrahedral coordination with O and second and third -neighbour Fe atoms, ruling out the presence of major arsenopyrite. Second and third neighbour As-Fe EXAFS distances imply either adsorption of the As onto an iron oxide/hydroxide substrate or incorporation of the As into a mixed metal oxide phase. The two different As-Fe distances may reflect the presence of doubly oxo-bridged and singly oxo-bridged species.

Acknowledgments This article is published with the permission of the Executive Director, British Geological Survey. Dr Helen Taylor of the BGS helped in the acquisition of the XAFS/XANES data. Dr John Charnock, Daresbury, provided assistance with data interpretation. Tony Milodowski, BGS, carried out the SEM work.

BEN KLINCK, BARBARA PALUMBO, MARK CAVE and JOANNA WRAGG,
British Geological Survey,
Keyworth,
Nottinghamshire
May, 2004

Book review

Arsenic Exposure and Health Effects

W. R. Chappell, C. O. Abernathy, R. L. Calderon, D. J. Thomas (Eds.)
Elsevier 2003, pp 533, ISBN: 0-444-51441-4, £100.00

This book records the proceedings of the Fifth International Conference on Arsenic Exposure and Health Effects to be organised by SEGH (the Society of Environmental Geochemistry and Health), and which took place in July 2002 at San Diego, California. The genesis and history of these conferences from 1992 to the present day (the Sixth Conference is in July 2004) is admirably set out in the book's Preface which delineates the increasing US and global interest in arsenic exposure with a range of countries being represented (Bangladesh, India, Nepal, Thailand, China, Slovakia and others).

This volume includes contributions from many of these regions and is divided into sub-sectors covering Occurrence and Exposure, Epidemiology, Biomarkers and Animal Models, Mode of Action, Intervention and Medical Treatment, and Water Treatment and Remediation. So, in a way, something for everyone. My own interest was drawn by the several papers which examined the Mode of Action where a battery of biomolecular techniques had been focused on elucidating the mechanisms of arsenic toxicity – particularly in relation to carcinogenicity. The nature and consequences of oxidative stress induced by arsenic, the effects of antioxidants and signalling cascades induced by arsenic were clearly and authoritatively discussed. In particular, the paper by Kitchin and co-workers ("Some Chemical Properties Underlying Arsenic's Biological Activity") was illuminating.

The thread that links Occurrence (Eight papers variously from India, Nepal, Slovakia, Canada, California, Viet Nam) through modes of action and medical effects becomes uncertain when chronic low dose effects need to be demonstrated epidemiologically – and without such a demonstration legislation, intervention and remediation will be deprioritised. Although exposure in some areas of the world is apparent at a population level (for instance in Kshitish Saha's paper "Grading of Arsenicosis: Progression and Treatment" – photos not for the squeamish!), methods for identifying low levels of exposure and for monitoring the consequences of such exposure are difficult, expensive and fraught with complexity. The papers relating to these issues offer much of interest.

So, I am enthusiastic about this text if a little overwhelmed by the detail. The book is a massive source of literature references and the papers themselves are often introduced by reviews and summaries which would feed easily into a lecturing programme. I don't think it's the sort of book I will be lending.

Dr LEO SALTER,
Cornwall College,
Pool, Redruth, Cornwall

Meeting report: How useful will genomics, proteomics and metabonomics be to assess chemical risk in humans?

The RSC's Occupational and Environmental Toxicology Group (OETG) held a one day meeting in September 2003 at the Society of Chemical Industry, London to discuss the use of 'omic' technology in the risk assessment of chemicals. One objective was to compare the present states of technology with the promised potential. The targeted audience consisted of those people involved in risk assessment but not currently versed in the technological advances. This was reflected successfully in the background of registrants who mainly came from industry, occupational health orientated academia and government organizations. Speakers from academia and industry provided an excellent framework and stimulations for discussion. Not only were the technologies discussed but the problems in their potential use for human risk assessment processes. **Andy Smith**, Chairman of the OETG reports.

Can genomics contribute to the assessment of chemical risk in humans? **(Dr T. Gant, MRC Toxicology Unit).**

The current state of toxicogenomics was introduced by Dr T. Gant who described, firstly, the technological bases of gene arrays to detect changes in gene expression following experimental administration of drugs and chemicals. The importance of replicates, good study design and appropriate statistical analyses were emphasized. The ILSI/HESI (International Life Sciences/Health and Environmental Sciences Institute) collaboration was described which has aimed to examine the reproducibility of genomics on test toxicological samples between different laboratories and for various phenotypic endpoints. It has been clear that for some samples very different results have been achieved with different genomic systems. The more data the better was emphasized and the European Bioinformatics Institute in collaboration with ILSI was aiming to produce a toxicogenomics database. This would of course require a great deal of standardization of information acquisition across the toxicogenomic

field. Dr Gant described how patterns of gene expression with certain drugs and chemicals in experimental animals might be used to extrapolate to humans. Alternatively, the global gene expression changes could lead to greater understanding of the mechanisms of toxicity of particular drugs and chemicals. This could speed up drug development and could be taken in comparison with other data but not necessarily substitute for it. Whole networks of gene expression may be revealed not seen so far using other methods. In addition, the mechanistic bases of genetic variation in response to drugs and chemicals could now be explored in much more detail.

One of the challenges would be how to distinguish primary responses from secondary responses due to subsequent tissue damage. Temporal studies and model non toxic chemicals would be important approaches for comparison with human exposure responses at low

assessment to make cross species comparison if new biomarkers identified were to be of a use in human risk assessment.

Rational risk assessment in a changing world
(Professor A. Boobis, Imperial College)

So far much of the discussion had been of the potential of 'omic' technology but an important objective of the meeting was to discuss the current limitations for use in human risk assessment exercises. From his extensive experience Professor Boobis outlined his own view of present human risk assessment processes for chemicals and considerations for the use of the 'new' technologies in the light of evolving ideas and expectations. For instance, modest enlarged liver in rodents is no longer necessarily considered a toxic response but perhaps just adaptive. There are increasingly higher expectations of minimum risk but costs increase and there is great pressure for lowering animal usage. The genomics revolution and other advances in biomedical research may contribute to easier and more certain assessments. To identify new highly relevant biomarkers from 'omic' data much more mechanistic information will be required. However, resources can be limiting and often study designs and validation are unsatisfactory. In addition, biology is complex and there can be multiple interacting and parallel pathways leading to toxicity. Not all molecular changes are necessarily adverse or relevant and chemicals can have multiple unrelated affects. Species differences can be significant.

Professor Boobis pointed out that there must be quantitative relationships between any new potential biomarkers and adverse effects. Are there thresholds? We also have limited knowledge on what is normal variation within and amongst individuals. What governs homeostasis in an individual to maintain a constant environment, e.g. body temperature or fluid content, in response to chemicals? Finally, the role of risk assessment was to take on board advances in sciences but not to drive the development of science. ILSI/HES is trying to bring government and academic together with industry to develop the risk assessment process.

The number of issues raised in this last presentation stimulated a vigorous debate. It was clear that all three types of techniques were promising and provided complimentary information. Tremendous progress had been made in the last few years. Considerable developments and data generation were required, however, to reach the utopia of selectivity and sensitivity required for use in the field of non-drug chemical risk assessment for human studies.

Dr. A. G. SMITH,
MRC Toxicology Unit,
University of Leicester

This report originally appeared in the *Occupational and Environmental Toxicology Group Newsletter*, Spring 2004. The ECG thanks the OETG for permission to reproduce this article.

Environment, Sustainability and Energy Forum

The Environment, Sustainability and Energy Forum (ESEF) recently carried out a consultation exercise to obtain views on a proposal to change reporting arrangements within the Royal Society of Chemistry (RSC). RSC specialist interest groups with an interest in environmental matters, namely the Environmental Chemistry Group (ECG), Water Science Forum (WSF) and Occupational and Environmental Toxicology Group (OETG) were invited to change their reporting requirements so that they report to ESEF in the future. We were delighted to hear that both ECG and OETG have decided with go with Occupational le,lookh as orating we TmESEF in3 oreriesmur mentan intea more.oriesese activitSEFestwuilding

(i) Chemistry of the Natural Environment. The Forum is developing plans for a workshop on the Chemical Aspects of Climate Change later in the year which will bring together environmental chemists and other key scientific disciplines (e.g. biologists) to understand the key challenges facing chemists in understanding forcings and feedback mechanisms in climate change and to explore the challenges at the interface of chemistry and other disciplines. This workshop will set the context for RSC action in this area and form the first of a series of workshops in the subject

(ii) Sustainable Energy. ESEF is formulating new RSC energy policy which will outline the key priorities for chemistry and the chemical sciences which must be overcome to meet our future energy demands. We are also organising workshops and collaborating with other learned societies on energy conferences.

(iii) Green Chemistry. We are building on an RSC report published last year *Benign and Sustainable Energy Technologies* (http://www.rsc.org/lap/polacts/benign_report.htm) which makes several recommendations to further promote green chemical technologies. Activities here include organising workshops with organisations such as FIRSTFARADAY partnership on land and natural water remediation, workshops focussed on green products and developing links with the American Chemical Society.

ESEF is also active in developing RSC policy on topics which fall within its remit. For example, we are currently responding to the consultation on Defra's Sustainable Development Strategy. We are also formulating RSC position papers on current topical environmental issues such as air quality and many more.

If you would like more information about any of these activities then please contact **Dr Eimear Cotter**, Manager, Environment, Sustainability and Energy Forum on 020 7440 3333 or cottere@rsc.org

production of hydroperoxides can be substantially suppressed[9] where by reactions 3a and 3b dominate, implying net photochemical production of O_3 (*via* 4a and 4b) is favoured over hydroperoxide production. At much higher NO levels (~2 ppbv), termination reactions 2a and 2b dominate giving increased free radical scavenging.

In contrast to the effect of NO, other pollutants can cause raised peroxide levels. High levels of VOC and CO cause H_2O_2 concentrations to increase (e.g. reactions 5a and 5b) due to the increased availability of free radical species. Hence, peroxide concentrations are enhanced when there is higher VOC:NO_x ratios. This is in contrast to ozone, whose concentration increases with CO, VOC *and* NO_x.

ROOH in the Antarctic troposphere, however, have not been investigated to such an extent. Jacob and Klockow[18] measured H_2O_2 concentrations in ambient air, in conjunction with snow and firn cores, at the German Research Station, Neumayer. Despite diurnal

Results from the Jungfraujoch

A summary of results is shown in Table 2. The LoD was based on three times

Critical Reviews in Environmental Science and Technology, 1999, **29**, 175.
13. J. A. Logan, M. J. Prather, S. C. Wofsy, and M. B. McElroy, *Journal of Geophysical Research-Oceans and Atmospheres*, 1981, **86**, 7210.
14. W. G. DeMore, S. P. Sander, D. M.

The RSC's Library and Information Centre – An environmental chemistry knowledge centre

The foremost repository of chemical knowledge in Europe, the Royal Society of Chemistry's Library and Information Centre (LIC) at Burlington House is also an excellent source of information on the environment and environmental chemistry. The LIC has accumulated an impressive array of resources for chemists over 160 years – from rare journals to books covering all aspects of the chemical sciences. These days it also subscribes to electronic journals and databases. **Nazma Masud** from the LIC explains how the library's collections can benefit environmental scientists.

One of the latest additions to the LIC's

Forthcoming symposium

Faraday Division

Faraday Discussion 130

ATMOSPHERIC CHEMISTRY

The RSC Environmental Chemistry Group was fortunate in attracting three exceptional speakers for this year's Distinguished Guest Lecture and Symposium, which took place on March 3rd 2004 in the Meeting Room of the Linnean Society of London.

Dr Paul Monks (University of Leicester) opened the meeting with a presentation on *"Probing the troposphere from space"*. His description of the Earth System as a coupled multi-phasic land-sea-air system illuminated one of the salient reasons for satellite studies of the atmosphere – how can the Earth System be studied holistically unless from space? This is especially important in relation to long-range pollutant transport (twenty percent of any air pollution event is from a distant source) and for monitoring geopolitical initiatives such as Kyoto. However, Dr Monks also pointed out the difficulties associated with satellite measurements – the troposphere is a well-mixed layer some 10 km from the Earth's surface and there are problems with studying this layer through the whole bulk of the atmosphere from a satellite 800/900 km up in a Low Earth Orbit. He explained that the satellite systems are an integral part of a network of measurement techniques for studying tropospheric chemistry. Land stations such as those at Mace Head in Ireland and Cape Grim in Tasmania provide single site data (spatially limited) and flights by research aircraft such as the BAE-146 provide snapshot data (temporally limited) to a data repository and then comparisons can be made to the continuous global coverage from satellites – "… satellite measurements provide data which integrate the limited spatio-temporal scales of the each of the other techniques".

In the second talk of the afternoon – *"Remote-sensing of air-sea fluxes of CO_2: constraining the global $C0_2$ budgets"* – **Professor Jim Aiken** from the Plymouth Marine Laboratory (PML) described work at the Centre for Observation of Air-Sea Interactions and Fluxes (CASIX) in supporting NERC initiatives on the quantification and understanding of the Earth System. Data from satellites are used to study phenomena such as the air-sea fluxes of chemical species, surface plankta distributions, marine biogeochemistry, sea temperature and ocean circulation processes – but with a focus on carbon dioxide fluxes, the core carbon cycle and global climate. Models are needed to exploit these data and to quantify carbon fluxes; three-dimensional models with coupled biology are being used (North Atlantic Model, North-West European Shelf Model). Satellites provide data on winds, sea surface temperature, solar radiation, and ocean colour to modellers, and these are used as an input to model parameterisation and also to measure the success of the models' predictive capacities in relation to the carbon cycle. As always, the modellers seek more accurate data – which can only come from geostationary satellites.

Professor John Burrows (University of Bremen) closed the symposium with the **ECG 2004 Distinguished Guest Lecture** *"Viewing the Earth's environment from space: the challenges, the progress and the future."* He viewed the use of remote sensing via satellite as a means of obtaining objective data about the impacts of anthropogenic activities on the biogeophysical system, and delineated several crucial questions that needed a continuous programme of expansion in Earth Observation Systems. The enormous economic and social costs of climate change to the world community highlight the need for observations of emissions to the atmosphere – these are crucial for understanding the rate at which climate change is occurring and for detecting any successes in its amelioration. Ozone depletion was continuing to occur. The coupling of climate change with ozone depletion via phenomena such as the occurrence of polar meso spheric clouds meant that expectations of a post-

4 2ifhseeomb(Ctispehrti5 Tawn(e ciriR[(4c32N1a4l6r7w46TjD0 0)]1250c1.b0M0a.E2)o]nT-JTj*3-0.612-hs1e3Tcs0.c

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

Ionic Liquids as Green Solvents: Progress and Prospects
(ACS Symposium Series No. 856)
Rogers, R. D.; Seddon, K. R. (Eds.), American Chemical Society, Washington DC, 2003, ISBN: 0841238561

Nutritional Aspects of Bone Health
New, S. A.; Bonjour, J. (Eds.), Royal Society of Chemistry, Cambridge 2003, ISBN: 0854045856

Oriental Foods and Herbs: Chemistry and Health Effects
(ACS Symposium Series No. 859)
Ho, C. T.; Lin, J. K.; Zheng, Q. Y. (Eds.), American Chemical Society, Washington DC, 2003, ISBN: 0841238413

Optimising Pesticide Use

Edited by MICHAEL WILSON, Central Science Laboratory, UK

Brings together the wide range of scientific disciplines necessary to ensure best practice for pesticide use through monitoring what is used and improving how it is formulated and applied.

- An in-depth exploration of pesticide optimisation from the view point of industry and research scientist
- A unique combination of contributors covering the concept from