

# Newsletter

Issue No.10 - July 1999



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## NEWSLETTER EDITOR:

Rupert Purchase  
38 Sergison Close, Haywards Heath  
West Sussex RH16 1HU  
Tel: 01444 455673

e-mail [rp@rupertpurchase.prestel.co.uk](mailto:rp@rupertpurchase.prestel.co.uk)

## TOVS Total Ozone Analysis (Dobson Units) Climate Prediction Center/NWS/NOAA 13/06/99



120 150 180 210 240 270 300 330 360 390 420 450

Map of the distribution of the ozone layer above Antarctica, 13<sup>th</sup> June 1999.  
Obtained from Climate Prediction Center, Washington DC.  
Ozone depletion – see p.21

## RSC Environmental Chemistry Group Officers

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Dr Peter O'Neill, Dean of the Science Faculty  
University of Plymouth, Drake Circus  
Plymouth, Devon PL4 8AA  
Tel: 01752 232984,  
e-mail [p.oneill@plymouth.ac.uk](mailto:p.oneill@plymouth.ac.uk)

### Vice-Chairman

Dr Leo Salter  
Centre for Science,  
Cornwall College, Pool, Redruth  
Cornwall TR15 3RD  
Tel: 01209 712911  
e-mail [l.salter@cornwall.ac.uk](mailto:l.salter@cornwall.ac.uk)

### Hon. Secretary

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

### Hon. Treasurer

Dr Trevor Pryce-Jones  
Department of Chemistry  
University of Hertfordshire  
Hatfield Campus, College Lane, Hatfield  
Hertfordshire AL10 9AB  
Tel: 01707 284570  
e-mail [t.pryce-jones@herts.ac.uk](mailto:t.pryce-jones@herts.ac.uk)

## Trace Element Contamination of Groundwaters and Soils

The last two issues of the ECG Newsletter have highlighted the plight of citizens in many parts of Bangladesh who have been inadvertently exposed to arsenic in their drinking water. The British Geological Survey (BGS) has been directly involved in surveying the extent of arsenic contamination of groundwater in Bangladesh, and **David Kinniburgh** and **Pauline Smedley** review the results and comment on the geological conditions which have caused this problem for this edition.

Arsenic contamination is not just confined to the developing countries. In parts of New Hampshire in the USA, arsenic has been found in a number of domestic wells used as a source of drinking water. Levels of up to 180 micrograms/L are reported in some instances by the investigators (Stephen C. Peters *et al.*, *Environmental Science & Technology*, 1999, **33**(9), 1328-1333), a result they suggest of the weathering of bedrock material rather than from anthropogenic contamination.

Nearer home arsenic contamination of soil – a consequence of past mining activities – is posing a potential health risk, especially for children, in South West England. **Professor Margaret Farago**, a committee member of the Environmental Chemistry Group, presents some of the results of surveys by the Environmental Geochemistry

Research Group at Imperial College of soils and wastes contaminated with high levels of arsenic in the West Country.

Arsenic contamination is part of a more general problem of exposure to trace elements. **Dr. Barry Smith**, also from the BGS and a committee member of the ECG, describes examples of other trace element contaminants found in groundwater and the need to extend the vigilance in surveying elements adopted in this country to the third world.

### Arsenic Contamination of Groundwater in Bangladesh

#### Nature and Scale of the Groundwater Arsenic Problem in Bangladesh

As has been highlighted in earlier editions of this Newsletter, there is a widespread and serious problem of arsenic contamination of groundwater in the deltaic plains of Bangladesh and West Bengal, India. Groundwater is used extensively for the rural drinking water supply as well as for irrigation. The arsenic is of natural origin and has probably been present in the groundwater for thousands of years. However, most of the wells have been drilled in the last 10-30 years. The problem was first observed in West Bengal in the 1980's but it is only in the last couple of years that an extensive arsenic testing programme has been undertaken in Bangladesh. It is now estimated that there are ten million wells in Bangladesh alone – most are private wells that supply a few families and the number of contaminated wells probably exceeds one million. In terms of the population exposed, the Bengal Basin is the most serious groundwater arsenic problem in the world. Bangladesh has a population of 120 million people and there are probably some 20-30 million people exposed to groundwater above the Bangladesh standard of 0.05 mg/L (some

estimates put the figure as high as 70 million people). Estimates from West Bengal are considerably less but are likely to number several million people. So far several thousand people in Bangladesh have been identified with arsenic-related disease (arsenicosis) but the fear is that this number could increase greatly if the present situation is allowed to continue.

In many ways, the alluvial sediments of Bangladesh are ideal for groundwater development. The sediments are characterised by fining upward sequences of sand, silt and clay with the medium to fine sands making good aquifers. The unconsolidated sediments can be drilled readily by hand down to depths of 80 metres or more. The water table is generally high, typically less than 7 m below ground level, which means that ordinary suction hand pumps are able to extract the water in most places. The high rainfall ensures that the aquifers are fully recharged each year. This combination of circumstances has led to the extensive exploitation of groundwater in recent years, a policy that has been encouraged by government and other agencies. The development of wells has been responsible for the reduction of infant mortality from diarrhoeal diseases, and the achievement of food-grain self-sufficiency through groundwater irrigation.

The shallow (or main) aquifer at depths of 10-70 m has been most extensively exploited and is the main source of the arsenic problem. Groundwater from depths of more than 150-200 m appears to be essentially arsenic-free. Most of the deep wells are in the coastal region where the increased depth is necessary to avoid salinity in the shallower aquifer. However, this observation has recently been confirmed by the low arsenic concentrations found in deep wells sunk by the Bangladesh Government's Department of Public Health Engineering (DPHE) in the severely arsenic-affected regions further north.

### Historical Perspective and Groundwater Surveys

Arsenic contamination of groundwaters was first detected in Bangladesh in 1993 by the DPHE. The area identified was Chapai Nawabganj, in the far west of

## BOX 1: ARSENIC IN DRINKING WATER

Arsenic is a highly toxic element. In some areas of the world, an important form of human exposure is through drinking water. Chronic ingestion of arsenic can lead to various diseases. The early diagnostic signs of poisoning are skin problems such as a change in pigmentation and the formation of hard patches or keratoses, especially on the hands and feet. These may take five to fifteen years of exposure before they become visible. Chronic arsenic ingestion is also thought to lead to an increased incidence of various cancers particularly of the skin, bladder and lung. The most effective treatment is to provide arsenic-free water. The current World Health Organisation (WHO) guideline value for arsenic in drinking water is 0.01 mg/L but the standard still used by many countries including the UK, USA, Bangladesh and India is based on the pre-1993 WHO guideline value of 0.05 mg/L. There has been much discussion in recent years about the safe level of arsenic in drinking water and both the US Environmental Protection Agency and the EC are planning to lower their standards in the near future.

West Bengal which had been found to be extensively contaminated in the 1980's. More extensive contamination in Bangladesh was confirmed in 1995 when additional surveys showed high arsenic contamination in wells across much of southern and central Bangladesh. At the same time, cases of chronic arsenicosis were being recognised by health professionals.

Since 1995, evidence of the extensive contamination of Bangladesh groundwater has been collected by a large number of organisations. Arsenic surveys carried out in 1996 and 1997 by the Dhaka Community Hospital in association with Professor Dipankar Chakraborti of the School of Environmental Studies (SOES), Jadavpur University, Calcutta were crucial in raising public awareness to the extent of contamination. These surveys involved the analysis of water samples collected from the homes of arsenic-affected patients and confirmed the severity of the arsenic problem. However since the samples from these surveys were not collected in a randomised manner, they could not provide reliable statistics for the overall extent of contamination.

BGS first became involved in Bangladesh in late 1996 under a programme to study groundwater arsenic problems in Argentina, Bangladesh and Thailand, funded by the Department for International Development (DFID). In February 1997, a groundwater survey of Chapai Nawabganj confirmed the severity of the arsenic contamination with concentrations being found up to 2.4 mg/L. On-site redox measurements showed the reducing nature of the groundwater which was also reflected in the arsenic speciation – approximately half of the arsenic was present as As(III) although the As(III)/As(V) ratio was very variable. The near-neutral groundwaters also often contained unusually high concentrations of iron, manganese and phosphate and

had a high alkalinity. Significantly, the sulphate concentrations were very low, typically less than 1 mg/L. This points away from the 'pyrite oxidation' hypothesis, then favoured by scientists from West Bengal for explaining the source of the arsenic.

Since that time, a larger BGS study has been commissioned by DFID in collaboration with the Government of Bangladesh. A Rapid Investigation Phase began in January 1998. Mott MacDonald Ltd was subcontracted to act as local consultants and to carry out some of the groundwater modelling. Priorities were to collate existing arsenic data and to carry out a survey of what were believed to be the worst-affected areas using a sampling strategy based on a uniform spatial coverage and specifically without using any prior information about the extent of arsenic contamination. This survey covered about 2/3 of Bangladesh. Over two thousand samples were collected at an average sample density of one per 37 km<sup>2</sup>. The median arsenic concentration was 0.011 mg/l, just above the WHO recommended drinking water limit. The overall results showed that:

- the range was from <0.0005 mg/L to 1.67 mg/L;
- 20% have arsenic concentrations of less than 0.003 mg/L;
- 51% of the samples were above 0.01 mg/L (the WHO Guideline Value);
- 35% were above 0.05 mg/L (the Bangladesh Drinking Water Standard);
- 25% were above 0.10 mg/L;
- 8.4% were above 0.30 mg/L, and
- 0.1% were above 1.0 mg/L.

Only about 1% of the samples from deep wells (greater than 200 m depth) were contaminated above the Bangladesh standard. This compares with 41% of wells in the shallower aquifers.

There is a distinct regional pattern in the arsenic-affected areas with the most

contaminated area to the south and east of Dhaka. This reflects variations in the type of sediments and the spatial distribution of deep and shallow wells. Combining this map with the population density map shows that the greatest density of exposed people is likely to be south-east of Dhaka where high arsenic concentrations coincide with a high population density. There are also quite large areas in the north and north-west of Bangladesh where only the occasional well is contaminated. A detailed map of the survey results can be downloaded from the BGS web site at [www.bgs.ac.uk/arsenic](http://www.bgs.ac.uk/arsenic)

### Cause of the Arsenic Problem

The groundwater arsenic problem in Bangladesh arises because of an unfortunate combination of three factors: a geological source of arsenic (arsenic is present in the aquifer sediments), mobilisation (arsenic is released from the sediments to the groundwater) and transport (for arsenic to accumulate it must not be flushed away in the natural groundwater circulation).

#### *Geological source of arsenic*

There have been insufficient analyses of the aquifer sediments to provide a regional picture of their arsenic concentration, but current data suggest that the sediments usually have concentrations in the range 2-20 mg/kg, only slightly greater than typical values found elsewhere. The precise mechanisms of arsenic release are still uncertain but it is likely that the original sources of arsenic existed as both sulphide and oxide minerals. Oxidation of pyrite in the upland catchments outside Bangladesh and during transport downstream would have released soluble arsenic and sulphate.

## BOX 2: ARSENIC IN GROUNDWATER

The concentration of arsenic in most groundwaters is below 0.01 mg/L but in some parts of the world, much higher concentrations occur naturally. The range can be very large – concentrations of up to several mg/L are found in parts of China, Chile, Argentina, Bangladesh and West Bengal, and lower but significant concentrations are being discovered in groundwater in many other parts of the world. High concentrations occur where a number of key factors overlap: there needs to be a source of arsenic in the host rock, hydrochemical conditions must favour the release of arsenic from the sediment to the pore water, and there must be a hydrogeological regime that prevents the rapid flushing of the released arsenic from the aquifer. Arsenic mobilisation can occur under both reducing and oxidising conditions. It usually occurs where groundwater flow is sluggish as in deltas with their low hydraulic gradients, in inland basins in semi-arid areas or in 'dead-zones' of deep aquifers.

The sulphate would have been lost to the sea but much of the arsenic, as As(V), would have been sorbed by the secondary iron oxides formed. These oxides are present as colloidal-sized particles and physical separation of the sediments during their transport and reworking in the delta region would have resulted in their separation along with the bound arsenic. Since the finer-grained sediments tend to be concentrated in the lower energy parts of the delta, this is likely to be the main reason for the greater contamination observed in the south and east of Bangladesh.

### *Mobilisation of the arsenic - redox processes*

Redox processes are important in the Bangladesh arsenic problem. Burial of the sediments, rich in organic matter, will lead to the strongly reducing groundwater conditions observed. The process has been aided by the high water table, the presence of fine-grained surface layers which impede entry of air to the aquifer and the short timescale over which the sediments have been buried. Microbial oxidation of the organic carbon has depleted the dissolved oxygen in the groundwater. The highly reducing nature of the groundwaters has led to the reduction of some of the arsenic to As(III) and possible consequent desorption of arsenic. Further reduction has led to the partial dissolution of the iron oxides with resultant release of iron and additional arsenic.

### *Transport of arsenic within the aquifers*

Annual fluctuations of the water table, typically about 5 m, will only affect groundwater and arsenic movement in the very shallow layers, down to about 20 m. At greater depths, groundwater is thought to move slowly as a result of the low regional gradients found in the delta. Many of the arsenic-affected aquifers have been deposited in geologically recent times – the last 10,000 years. There

has been insufficient time to flush the arsenic from the shallow aquifer.

## The Future

Many national and international organisations are considering how to overcome the arsenic problem, and the World Bank has recently granted a loan to the Government of Bangladesh to begin the process of mitigation. The task ahead is enormous and it is clear that there is not going to be a single, simple solution for the whole of Bangladesh. There are many options including:

- use of surface water with treatment;
- sinking deep wells into the arsenic-free aquifer;
- rain water harvesting;
- use of dug wells tapping the very shallow aquifer;
- treatment of contaminated groundwater at various scales (hand-pump, municipal well).

The challenge is partly technical – to design systems that work reliably and that are both acceptable and affordable in rural Bangladesh. But the problem also throws up many institutional challenges. The solution must be organised by the rural communities themselves and this will require a massive educational programme. Above all, the scale of the problem makes implementing even a simple solution demanding. The problem requires a long-term solution but also demands immediate, emergency action.

There is clearly a need for the rapid testing of a large number of wells. For practical reasons, this needs to be done mainly using field-test kits and there has been a lot of effort in testing and refining existing kits. Most traditional field test kits are based on the generation of arsine gas and its detection by mercuric bromide paper. These methods have a detection limit in the region of 0.05-0.10 mg/L – adequate for locating the worst affected

wells but not sensitive enough for detecting arsenic at the current WHO limit.

Meanwhile the World Bank has plans for a rapid screening of all wells in Bangladesh over the next 18 months. We are working with the DPHE to complete the survey of the northern part of Bangladesh and are extending our water analyses to include a wide range of elements. We have also set up a water quality monitoring programme at three sites across Bangladesh to monitor changes with depth and time.

The discovery of severe arsenic contamination of groundwater in large parts of Bangladesh came as a shock to all concerned. It affects about a third of the wells in our Rapid Investigation Programme survey area and perhaps a quarter of wells in the country as whole. The Government of Bangladesh takes the problem extremely seriously, and donor agencies have pledged to assist. Understandably, there has been something of a media backlash against the use of groundwater. There have even been calls to abandon the use of groundwater completely. Less radical proposals call for a moratorium on all new government- or donor-sponsored drilling until the situation is clearer. Amidst this debate, it must not be forgotten that most wells are not contaminated. There is no reason why in uncontaminated areas the benefits that exploiting groundwater has brought to Bangladesh should not continue. A rapid and widespread return to the use of surface water without treatment would have its own human cost in the resultant rise in prevalence of diarrhoeal disease.

**David Kinniburgh and Pauline Smedley**

*British Geological Survey, Wallingford, OX10 8BB*

## Arsenic Contamination in South West England – A Legacy of Mining

The sources of arsenic contamination of drinking/irrigation waters, soils and dusts, which lead to arsenic in the food chain, are:

- naturally occurring arsenic-rich minerals or rocks, *e.g.* pyrite;
- mining and smelting of sulphide minerals and the resulting wastes;
- the burning of coal with a high arsenic content.

In many parts of the world such as Taiwan, India and Bangladesh, the ingestion of high arsenic levels in drinking water, contaminated from natural sources, has led to health problems. In South West England potential problems arise, not from drinking water, which mostly comes from

the public mains supply, but from high arsenic concentrations in soils and wastes as a legacy of the mining and smelting of sulphide minerals.

### Arsenic in Soils

From about 1860 to 1900 South West England was the world's major producer of arsenic. The principal minerals of economic importance were arsenopyrite (FeAsS), chalcopyrite (CuFeS<sub>2</sub>) and galena (PbS). Other local ores were cassiterite (SnO<sub>2</sub>) and stannite (CuSnS<sub>4</sub>). Mining and smelting activities have left a legacy of contaminated land, with abundant As- and Cu-rich mine tailings and other wastes. Further extensive areas of land were contaminated with fallout from the smelting process. Some 700 km<sup>2</sup> of land are affected (Abrahams and Thornton, 1987). Most of the contaminated area is agricultural with villages and small towns; urban development has sometimes taken place

on contaminated land.

Today, the remains of the old mining and smelting sites are on derelict contaminated land, with extensive areas of mine spoil and ruins of stacks and calciners. Recent sampling of these areas has revealed exceptionally high concentrations of arsenic in surface soils on and near mine wastes (Table 1). At such sites, large areas of land are unvegetated, because of both high concentrations of phytotoxic elements and lack of nutrients. Thus there is a high potential for the generation of respirable or ingestible dusts. It can be seen from Table 1, that the high levels of arsenic extend also to agricultural soils. These values can be compared with background values for soils from uncontaminated areas in South West England, where ranges of 18-27 micrograms/gram and 26-67 micrograms/gram of arsenic were found for Combe Martin (Johnson, 1983) and Wadebridge (Elghali, 1994) respectively.

**Table 1** Some reported ranges of arsenic concentrations in soils (0 -15 cm) from South West England

Use	Location	Range (micrograms/g)	Reference
S	Roseworthy	815 - 161,000	Frizzell, 1993
M/S	Poldice	432 - 37,600	Farago <i>et al.</i> , 1993
M/S	Devon Great Consols	120 - 52,000	Kavanagh <i>et al.</i> , 1995
M/S	Bottallack	66 - 494	Farago <i>et al.</i> , 1993
M/S	Levant	140 - 2,875	Farago <i>et al.</i> , 1993
M	Fraddam	334 - 460	Li and Thornton, 1993
M	Wheal Sister	24 - 31	Li and Thornton, 1993
S	New Mill Farm	210 - 925	Li and Thornton, 1993
M	Upland areas	60 - 2,500	Colbourne <i>et al.</i> , 1975
A	General SW England	Up to 700	Abrahams and Thornton, 1987
A	Tamar Valley	4 - 14,500	Kavanagh <i>et al.</i> , 1995
A	Leedstown	233 - 630	Pugh, 1994

S, old smelter area; M, old mine area; A, agricultural area.

### Exposure to Arsenic of the Local Population

Studies have shown that the local tap water supply is low in arsenic, but a small number of supplies from private wells have been investigated, and a few exceed the European Commission MAC (Maximum Allowable Concentration) of 50 micrograms/L (EEC, 1980). They are

thus above the range 2 to 20 micrograms/L for a revised standard under consideration by the United States Environmental Protection Agency, and the WHO provisional guideline of 10 micrograms/L (WHO, 1994). The question of arsenic concentrations in private well water supplies in South West England is to be investigated and estimates from this source cannot be made at present.

Concentrations of arsenic in food have also been found to be low, Xu and Thornton (1985). The arsenic contents of garden vegetables increased with an increasing arsenic content in the soil, but only lettuce exceeded 1 microgram/gram (dry weight). The arsenic concentrations for these vegetables were reported to be well below the statutory limit of 1 microgram/gram fresh weight. (Thoresby and Thornton, 1979).

Work by the Group has shown that between 58 and 76% of arsenic intake by cattle grazing on contaminated land resulted from the ingestion of soil along with the herbage (Thornton and Abrahams, 1983; Abrahams and Thornton, 1994). On contaminated land in South West England, where soil concentrations of arsenic ranged from 160-250 micrograms/gram, this resulted in a mean total intake of 53 mg/day arsenic. Further work has shown that for cattle grazing contaminated land, the total

daily intake is, on average, 137 mg of arsenic for low milk-yielding cattle and 220 mg of arsenic for high milk-yielding cattle. In comparison, the intakes for cattle grazing on uncontaminated land were 9 and 14 mg arsenic respectively.

One of the main routes of intake of arsenic in South West England from the ingestion of soil and dust, particularly by young children, is via hand-to-mouth activity. Investigations have been carried out to assess arsenic concentrations in garden

soils and within the home. Some values are given in Table 2. From literature data it seems reasonable, in order to make an assessment of arsenic intake by children in South West England, to assume that the young child will consume 50 mg/day of soil and 50 mg/day of dust. Using these values we conclude that it would be easy for young children to exceed the WHO Provisional Daily Intake (WHO, 1983) for inorganic arsenic of 2 micrograms/kg body weight, from soil and dust ingestion alone (Farago *et al.*, 1997).

**Table 2** Arsenic concentrations (micrograms/g) in garden soils and house dusts in South West England

Site	Soils			Dusts		
	n	Mean	Range	n	Mean	Range
Camborne/Hayle <sup>a</sup>	71	424	119-1130	74	81	9.2-330
Cornish villages <sup>bc</sup>	17	734	88-3950	15	67.5	14-147
Combe Martin <sup>a</sup>	72	29	18-72	76	14	2.4-66
Wadebridge <sup>b</sup>	5	41	24-67	3	14	7-22
Devon Great Consols <sup>d</sup>	15	4500	345-52600	13	1167	24-3740
Gunnislake <sup>d</sup>	71	365	120-1695	9	217	33-1160
Cargreen <sup>d</sup>	18	37	16-198	4	49	20-114

<sup>a</sup>Data from Johnson, 1983.

<sup>b</sup>Data from Elghali, 1994.

<sup>c</sup>Leedstown, Camborne, Carnkie, Chasewater

<sup>d</sup>Data from Kavanagh *et al.*, 1997

Kavanagh, *et al.*, (1997,1998) investigated the total exposure of residents of the Tamar Valley and measured the concentrations of urinary arsenic and its organo-metabolites. The results showed elevated levels of both organic and inorganic arsenic compounds in the 'exposed' population's urine when compared to those of the control group. From these results we conclude that populations in both Gunnislake and Devon Great Consols are chronically exposed to inorganic arsenic, since inorganic arsenic appears in the urine. The data also indicate that chronic exposure results from soil and dust ingestion of arsenic in a partially available form, since dust and soil appear to be the only significant exposure route (Farago *et al.*, 1997)

## Conclusions

It can be concluded that, although there have been local anecdotal reports of areas of high cancer mortality in some parts of Devon and Cornwall, there is as no evidence to show that cancer or ill-health is caused by high local concentrations of arsenic in soils, since no comprehensive

study has been carried out. We have demonstrated that in the contaminated areas of South West England, it would be easy for young children to exceed the WHO Provisional Daily Intake (WHO, 1983) for inorganic arsenic of 2 micrograms/kg body weight, from soil and dust ingestion alone. Allowing for a daily intake from food (11 micrograms), the major source in non-contaminated areas, an approximate daily intake of 15 micrograms is needed from soils and dusts to exceed the WHO Provisional Daily Intake by a child of body weight 13 kg. The results of the pilot urine investigation show that the study populations in South West England are chronically exposed to inorganic arsenic. The data also indicate that chronic exposure results from soil and dust ingestion of arsenic in a partially available form, since, apart from food, no other arsenic exposure route is likely (Farago *et al.*, 1997).

**Margaret Farago,**  
*Imperial College, June 1999*

All references in the text and further work may be found in the following key papers:

Farago, M.E., Thornton, I., Kavanagh, P., Elliott, P. and Leonardi, G., 1997, Health aspects of human exposure to high arsenic concentrations in soil in south-west England. In: *Arsenic: Exposure and Health Effects*, C.O. Abernathy, R.L. Calderon, W.R Chappell, (eds), 1997, Chapman and Hall, London.

Kavanagh, P., Farago, M.E., Thornton, I., Goessler, W., Kuehnelt, D., Schlagenhaufen, C. and Irgolic, K.J., 1998, Urinary arsenic species in Devon and Cornwall residents, UK. *The Analyst*, **123**(1); 27-30.

Thornton, I., 1994, Sources and pathways of arsenic in South West England: health implications. In *Arsenic Exposure and Health*, W.R. Chappell, C.O. Abernathy and C.R. Cothorn (eds), Science and Technology Letters, Northwood, pp. 61-70.

Thornton, I., and Farago, M.E., 1997, The geochemistry of arsenic. In: *Arsenic: Exposure and Health Effects*, C.O. Abernathy, R.L. Calderon, W.R Chappell, (eds), 1997, Chapman and Hall, London.

## Trace Elements in Groundwaters: A Need for Basic and Reliable Information

It has long been known that the distribution of chemical substances in the environment can influence animal and human health, and this has become a subject of much public concern in recent years. To date a great deal of attention has focused on the composition of drinking water for human consumption, particularly in respect of elements of anthropogenic origin such as lead, mercury, cadmium and nitrate.

However, it is increasingly recognised that the potable quality of many groundwaters, often used for drinking water supply, is strongly influenced by the presence (or absence) of naturally occurring trace elements. For example, in Bangladesh elevated levels of naturally occurring arsenic have caused significant health problems, and severely compromised the supply of potable water for a large proportion of the indigenous population.

Fortunately the occurrence of arsenic-rich groundwater supplies has received a great deal of study due to the acute and chronic toxicity of arsenic. However, as has been shown in Bangladesh, we still have much to learn about the distribution of trace elements in groundwaters used to supply water. This is especially so where unmixed local sources of groundwater are exploited for private supply, which is often the situation in rural communities world-wide. In such instances there is clearly a need for the systematic analysis of a wide range of trace elements in groundwaters, and in particular for those elements specified by current WHO water quality regulations.

Data from such systematic studies provide baseline information and indicate the presence or absence of potentially toxic trace elements in groundwaters on a regional basis. Local, national and international bodies responsible for setting standards can then reliably estimate the potential costs and benefits associated with the derivation of water quality standards. This is particularly the case in semi-arid environments where the

presence and mobility of potentially toxic trace elements that form mobile oxyanions such as B, U, Mo, V, Se are often enhanced. In the past the determination of some of these elements at environmental levels was extremely time consuming. However, the advent of reliable inductively coupled plasma-mass spectrometry (ICP-MS) and atomic fluorescence (AFS) technology coupled to high purity reagents have made systematic surveys of these elements routinely possible.

For example, in recent studies undertaken by the British Geological Survey (BGS) in North Africa and the Middle East (and funded by the UK Department for International Development, and the European Community), baseline levels of B, U, Mo, V and Se in a number of water samples taken from sedimentary aquifers from Cyprus and Jordan have been determined using ICP-MS and AFS. In one example extremely high levels of U, Mo, Se (>1,000, >700 and >200 ppb of U, Mo and Se respectively) were measured in groundwaters from two water supply wells and these have been attributed to the presence of a buried U ore deposit. The absence of such high levels from other wells in close proximity to these wells, within the same aquifer, indicates the considerable degree of heterogeneity that may be associated with the trace element composition of groundwater particularly where this is influenced by structurally controlled mineralisation. This finding emphasises the need for a systematic monitoring program rather than a monitoring program based on selective sampling, as is often used.

Baseline studies of the presence of trace elements in waters used or of potential use for public supply are also essential in estimating the potential impact of forthcoming legislation. For example, a strict adherence to the WHO recommended level for U (2 ppb) would mean the closure of approximately 50% of the water supplies studied in Jordan. Clearly this is not achievable in a country where water is in great demand. In line with WHO policy, the setting of a local revised guideline at a level capable of maintaining a significant degree of public safety and at the same time ensuring the availability of water was recommended. In practice this is relatively easy to achieve as > 95% of the sampled supplies

had U concentrations in the range of 2 to 5 ppb (a range also quite common in groundwaters from Derbyshire).

Of equal importance in Cyprus, none of the potable water supplies studied showed levels of U above 2 ppb. Whilst this might be considered, by some, to have been a negative outcome of the project, it emphasises that the negative result of a systematic survey has considerable value as resources can now be directed with confidence towards other areas of concern.

Similar studies of a wide range of trace elements are being undertaken on UK groundwaters, surface waters, and soils by staff from the BGS Hydrogeology and Analytical and Regional Geochemistry Groups. Such studies involving the systematic analysis of over trace 30 elements will significantly increase our understanding of the abundance of trace elements in the UK and form a baseline from which to revise or quantify the potential costs and benefits of issues relating to water quality.

Obviously undertaking such surveys in the developing world is of equal, or greater importance. However this cannot be achieved without the funding and development of analytical centres of excellence devoted to the systematic study of groundwater chemistry along with associated quality assurance and quality control protocols at a national level.

**Dr. Barry Smith**

*June 1999*

For further information contact: Dr Barry Smith, British Geological Survey, Keyworth, Nottingham, NG12 5GG or visit our web page at [www.bgs.ac.uk](http://www.bgs.ac.uk)

## Studies on the Disposition of Radionuclides in the UK

In two reports for the ECG Newsletter on radionuclides, **Dr. Kath Morris** from the Leeds Environment Centre describes the mobility of these elements in the environment, while **Dr. Jennifer Woodhouse** summarises her work on the pharmacokinetics of plutonium in man following occupational exposure. As a postscript, **Dr John Holder** profiles the founding father of transuranium chemistry, Dr. Glenn Seaborg, who died earlier this year.

### Radionuclide Mobility in the Natural Environment

#### Introduction

Anthropogenic radionuclides exist in the environment typically at concentrations far below those which represent a danger to the public. However, the long half-lives of some radionuclides, the fact that radionuclides exist at elevated levels at certain sites throughout the world, and the current nuclear waste inventory means that the study of their behaviour under natural environmental conditions is essential. This leads to some unique challenges for environmental chemists. This report focuses on the actinide elements, and reviews some past work on plutonium mobility in west Cumbria undertaken in collaboration with Dr Francis Livens, as well as introducing work I am developing at Leeds University in collaboration with colleagues from Earth Sciences.

#### Plutonium

The Sellafield reprocessing plant in west Cumbria, UK, has been reprocessing spent nuclear fuel to recover U and Pu since 1952 [1]. Associated, low-level aqueous waste streams have been discharged to the Irish Sea under licence

from the British government. Over time this has led to a substantial enhancement of concentrations of plutonium and other anthropogenic radionuclides in soils and sediments within the vicinity of Sellafield. For example, in the salt marsh used for this study concentrations of  $^{239,240}\text{Pu}$  are typically in the order of  $10^5$  Bq m<sup>2</sup> [2].

The environmental chemistry of plutonium is amongst the most complicated of any element, and is fundamentally dependent on its redox chemistry [e.g. 1]. Potentially, Pu has access to four oxidation states, Pu<sup>(III)</sup>, Pu<sup>(IV)</sup>, Pu<sup>(V)</sup> and Pu<sup>(VI)</sup> which may all behave very differently. The lower oxidation states form the simple cations, Pu<sup>(III)</sup> and Pu<sup>(IV)</sup>, which are readily hydrolysed due to their high charge density and thus are easily lost from solution. In contrast, the higher valency states form the dioxygenyl cations [Pu<sup>(V)</sup>O<sub>2</sub>]<sup>+</sup> and [Pu<sup>(VI)</sup>O<sub>2</sub>]<sup>2+</sup>, and are more soluble due to both their lower charge density and their ready complexation with common oxygen containing ligands such as CO<sub>3</sub><sup>2-</sup>. Within the Irish Sea environment studied here, the situation is somewhat simplified as thermodynamic calculations predict that plutonium will have access to only two oxidation states Pu<sup>(IV)</sup> and Pu<sup>(V)</sup>. Thus the solubility differences of the different species of Pu are reflected in the distribution coefficients for these ions with Pu(IV) (K<sub>d</sub> ≈ 10<sup>5</sup>) and Pu(V) (K<sub>d</sub> ≈ 10<sup>3</sup>). Within the Irish Sea Pu is predominantly in its reduced form and thus is observed to be mainly sediment bound. A fraction of this sediment bound Pu can then be transported by tidal motion to estuarine sites where it may be deposited. This has led to an accumulation of actinide elements, including Pu, in certain intertidal sediments on the west Cumbrian coastline. Therefore sites in this region offer a unique opportunity to observe the *in situ* environmental behaviour of radionuclides. In the work described here we examined the concentrations of dissolved plutonium in pore waters from a salt marsh on the Esk Estuary to assess the possible influence of microbially driven biogeochemical cycles on the solubility of the redox active plutonium in the natural environment.

#### Sampling and Analysis

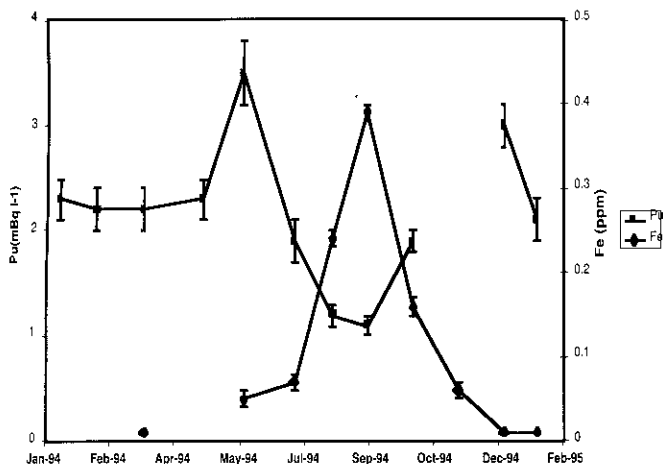
Pore water samples were collected at monthly intervals from the same sediment body on the salt marsh using porous cup samples which were emplaced into the marsh sediment. This allowed repeated sampling from the same site over a period of 12 months. The water samples were sub-sampled for major cation analysis (Fe, Mn, Na), treated to remove salt and organic matter, and plutonium was separated using a sequential radiochemical extraction. Plutonium was then measured using alpha spectrometry ( $^{239,240}\text{Pu}$ ). The low specific concentrations of these samples (≈ 0.1 pg l<sup>-1</sup>) meant that they were below detection limits for typical pneumatic nebulisation ICM-MS techniques. In addition, the low specific activity of these samples (≈ 1 - 4 mBq l<sup>-1</sup>) meant that alpha counting times extended into periods of weeks on some occasions. These analytical challenges highlight one of the practical difficulties in obtaining such data sets.

#### Seasonal Variations in Plutonium Solubility

The first data set from this field site illustrates the seasonal variability in plutonium solubility within the salt marsh sediments over a 12-month period (Figure 1). Data for Fe and Mn in the pore waters are also shown (Figure 2).

Pu concentrations appear to be inversely related to Fe and Mn concentrations. Concentrations in the collected pore waters rise in May, before Mn increases in July, and Fe increases in August. Pu concentrations then fall in June, July and August as Fe and Mn concentrations rise, Pu then rises again in December as Fe and Mn are removed from solution. This strongly suggests that microbially driven redox changes may be the controlling factor on plutonium solubility. The redox driven cycling of Fe and Mn in the environment is well established.





**Figure 1** Temporal variation in Pu and Fe concentrations in salt marsh pore waters

The situation for plutonium is obviously more complex. However, the data clearly illustrate the presence of a seasonal variation in Pu solubility apparently (inversely) linked to the redox cycling of Fe and Mn and which may ultimately be driven by biogeochemical cycles in the environment.

## Biogeochemical Cycling and Research Interests

Since taking my position at Leeds University I have extended my interests in biogeochemical cycling and am currently involved in a project with Dr Kurt Konhauser from the Earth Sciences department which examines uranium speciation under a range of conditions relevant to the natural environment. I have also extended my work into the more "stable" end of the periodic table, and am currently collaborating with Prof. Rob Raiswell, again from the Earth Sciences Department looking at acid mine drainage in south Yorkshire.

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**Dr Katherine Morris,**  
The Environment Centre,  
University of Leeds,  
Leeds.

LS2 9JT.

Tel: (0113) 233 6723

Fax: (0113) 233 6716

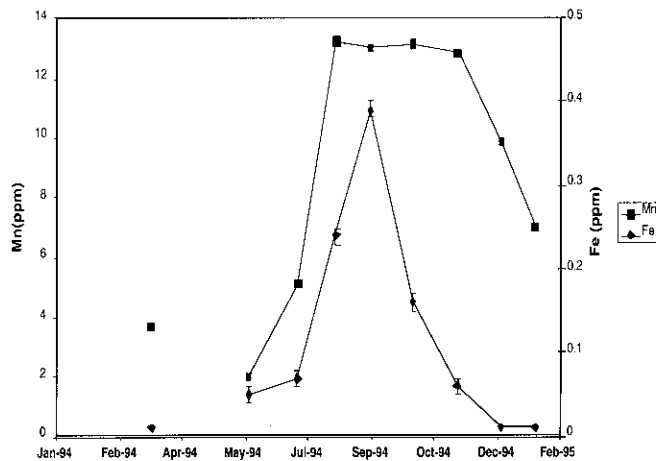
Email: [kath@lec.leeds.ac.uk](mailto:kath@lec.leeds.ac.uk)

## Plutonium Pharmacokinetics and Blood Biochemistry

Since its discovery in the early 1940's mankind has seen the element plutonium as both an opportunity and a threat. As a radioactive nuclide, plutonium presents health hazards in its handling and, if mankind is to make the most of this element's potential benefits, it is essential that these hazards be understood. Both overestimation and underestimation of these hazards are damaging to its proper utilisation.

Many studies have been carried out to determine the effects of plutonium exposure and a broad picture of the biological behaviour of plutonium has been built up. Radiological protection standards are based on such broad understanding and a central dogma has arisen *viz.* plutonium is bound avidly in liver and bone; clearance half-lives from these organs differ (by a factor of 2.5) but are very long – a minimum of 50 years for bone; this is why plutonium urinary excretion levels are very low.

Despite all the research work that has been carried out there are many important areas of plutonium behaviour which are not well understood or for which the central ideas adopted for radiological protection purposes are questionable. One such questionable area is extended half-life in the body. Two other different areas relate to the molecular binding



**Figure 2** Temporal variation in Fe and Mn concentrations in salt marsh pore waters.

interactions when plutonium enters body tissues, and to the transfer mechanisms from blood into cellular organelles. Very little is known about these processes and the speciation of plutonium in the body.

My thesis explores understanding of plutonium behaviour by application of pharmacokinetic theory to its **observed behaviour in humans**, following both occupational exposure and experimental injection. Occupational exposure data demonstrated behaviour consistent with pharmacokinetic expectations over periods of 25 years or more. Long-term half-lives were 10 to 30 years rather than 50 to 100 years or more. There was no evidence of differing half-lives between liver and bone. Very low renal clearance was seen in intravenous injection studies suggesting either very extensive plutonium binding to the protein transferrin in blood or pointing to reabsorption in the kidney tubule after glomerular filtration. This latter possibility might lead to a 'plutonium blood pressure' which effectively forces activity into tissues irrespective of the strength of binding forces. Experimental work indicated species differences in transferrin binding which may have relevance for extrapolation from animals to humans.

Abstract of a Thesis submitted by **Jennifer Woodhouse** for the degree of Doctor of Philosophy at the University of Central Lancashire, 1998.

Supervisors Professor Ian Shaw  
Dr. John Holder

Sponsor British Nuclear Fuels

## Obituary – Glenn T. Seaborg

To a young, aspiring nuclear scientist working at Harwell in the 1970's such as myself, Glenn T. Seaborg, who died in February this year, was a god and his text 'The Chemistry of the Actinide Elements', written with J.J. Katz in 1957 but still current, was the bible. Seaborg was uniquely qualified to write such a definitive text. He was the author of the 'Actinide' concept being the first to recognise this new rare earth series. He was also the creator with co-workers of all the elements from 94 (Plutonium) to 102 (Nobelium) and later 106 (appropriately named Seaborgium).

The archetypal tall, courteous American he was nevertheless immensely proud of his Swedish ancestry and the opening to his 1951 Nobel Prize address was in Swedish, the language he spoke as a child.

He was born in Ishpeming, Michigan of first and second generation immigrants and moved with his family at age 10 to

Los Angeles where he attended high school. He received his bachelor's degree in Chemistry from UCLA in 1934 and, determined to carry out nuclear research under Ernest Lawrence, moved to the University of California, Berkeley for his PhD which he received in 1937. He became Assistant Professor in 1940 lecturing and researching in the chemical and nuclear properties of the emerging transuranic elements.

During the war he headed a group which devised the chemical extraction processes in the production of plutonium for the Manhattan project. This was chemistry of extreme elegance and determination produced under the enormous pressure of war. His paper written with Edwin McMillan just before Pearl Harbour was withheld from publication for five years. As did many others involved, Seaborg had misgivings about the military application of his work and was prominent, with Leo Szilard and Charles Franck, in the group which in 1945 attempted to persuade President Truman's committee not to use atomic weapons in earnest before demonstrating

their power to the Japanese.

Returning to Berkeley in 1946 he became Head of Nuclear Chemical Research and a Director of the Lawrence Radiation Laboratory. He was appointed Chancellor of the University of California, Berkeley in 1958 and then, in 1961, Chairman of the US Atomic Energy Commission, which he guided for a decade. He was a driving force in the Atoms for Peace movement.

Further honours followed. In addition to the Nobel Prize, he was awarded the US AEC Enrico Fermi Award, the US National Medal of Science, appointment as Officier Légion d'honneur, the Order of the Polar Star (Sweden) and more than 50 honorary doctorates. He was president of the American Chemical Society in 1976 and the author of 12 books and over 200 scientific papers. Truly a giant upon whose shoulders we all stood.

### John Holder

Glenn Theodore Seaborg: born April 19, 1912; died February 18, 1999.

## Centre for Contaminated Land Remediation at the University of Greenwich

Dr Cecilia MacLeod, Senior Research Fellow and the Acting Director, previews the newly opened Centre for Contaminated Land Remediation at the University of Greenwich.

**The Centre for Contaminated Land Remediation** was established in March 1999 through an initiative begun by English Partnerships and sponsored by organisations including: The British Cement Association, British Lime Association, the British Urban Regeneration Association, Sir William Halcrow and Partners, WS Atkins, Kvaerner Technology and Shell Oil. The Centre will act as a focus for science and technology exchange and transfer. We have strong links with industry, involving collaborative research, consultancy and

input to the M.Sc. teaching programmes. The balance of both pure and applied research helps to ensure the quality and relevance of our work and enhances the employment prospects for postgraduates.

The Centre, located within the School of Earth & Environmental Sciences is based at the Medway Campus, adjacent to the Natural Resources Institute at Chatham Maritime. There are currently nine permanent staff within the Centre with expertise in water and soil chemistry, hydrology, geographical information system (GIS) modelling, geotechnical engineering, minerals processing, regulation and legislation, ecology and analysis with respect to contaminated land and its remediation. In-house remediation expertise includes the use of sorbant methods for treatment of water, soil washing techniques and solidification/stabilisation technology. The Centre has collaborative links with

experts in phytoremediation of soils, bioremedial methods of soils and ground water, contaminant transport and water quality modelling.

A primary objective of the Centre is to provide training to post-graduate students and practitioners in contaminated land remediation and on issues pertaining to remediation and redevelopment. A second objective of the Centre is to encourage international collaborative research and training efforts in contaminated land problems by providing a forum for such collaboration. In 2000, the Centre will initiate a series of 1-2 week speciality short courses and 1-day seminars to be held on specific areas of concern to practitioners dealing with contaminated land issues.

## Staff

Permanent Centre staff members include:

Professor Alistair Baxter, Head of School of Earth & Environmental Sciences, a mining geologist with over 20 years experience in research and consultancy in mining issues in South America and Africa.

Dr. Cecilia MacLeod, Senior Research Fellow and Acting Director of the Centre for Contaminated Land Remediation, a low temperature geo-chemist with research interests in contaminant transport and waste stabilisation and remediation.

Dr. Stephen LeHarne, Reader in Environmental Chemistry, research interests include DNAPL migration and use of surfactants and zero valent iron for treatment of wastes. MSc Course Director and Pathway Leader for MSc in Contaminated Land Remediation.

Dr. Colin Hills, a geologist with specialist expertise in waste stabilisation using cements and lime. Dr. Hills is a UK expert in this field and will be an important participant in the Remediation Hotline being set up by the Centre with sponsorship from the British Cement and Lime Associations.

Dr. Paula Carey, Reader in Geotechnical Engineering, a geological engineer with research interests and expertise in slope stabilisation and geomaterials engineering. Pathway Leader for MSc in Geomaterials.

Dr. Peter Graves, Lecturer in Environmental Science, an ecologist with specific research interests in risk assessment and regeneration of brownfield sites. Works closely with local authorities in developing remediation strategies.

Dr. Kath Harvey, Lecturer in Social and Economic Geography, interests include public consultation and re-valuation of brownfield land.

Dr. Bob Abraham, Lecturer in GIS, a computer scientist with special interests in the application of geographical information systems and neural network modelling to assessing water resource and management issues.

Dr. David Wray, Lecturer in Geochemistry, Laboratory Manager responsible for management of School laboratories. Specific interests in the analysis of trace metals in the environment.

The Centre is establishing a Help-line that will act as an information centre where the public, including local authorities, property developers *etc.*, may call for guidance and clarification on issues dealing with methods of assessing and cleaning up contaminated land, and will be active from 1 August 1999. The Help-line number will be 0181 331 7718.

The Centre currently has active links with the University of Sheffield (DNAPL migration); UCL, BGS and Environment Agency (soil washing); Surrey University (carbonation technology); Institute of Freshwater Ecology (mining wastes); and Imperial College (analytical methodology).

The Centre has also reached agreement for collaborative research programmes with the following overseas university departments:

Pennsylvania State University, U.S.A., Department of Geology,  
Swiss Federal Institute of Technology, Zurich, Institute for Land Improvement and Water Management,  
Princeton University, U.S.A., Departments of Chemistry, Civil Engineering and Geosciences,  
King Fahd University, Saudi Arabia, Departments of Civil Engineering and Geology,  
National University of Singapore, Department of Civil Engineering,  
University of Cape Town, R.S.A., Department of Geological Sciences,  
KuLeuven, Belgium, Laboratory of Soil Fertility and Soil Biology,  
India Institute of Technology, Kanpur, India, Department of Civil Engineering.

Thus the Centre has an expertise base which can examine all or almost all issues related to contaminated land and its remediation.

## Courses

The Centre currently offers two MSc degree courses which can be taken on a

part-time basis or for continuing professional development:

### **MSc Contaminated Land Remediation, Pathway Leader: Dr. Stephen LeHarne**

Through discussions with practitioners, ranging from borough councils, insurance industry, developers and environmental consultancy, the framework of the MSc course was developed. This framework, is designed to provide a background in contaminated land, from legal and planning considerations to scientific and technical detail. As most of the scientific and technological developments in the assessment, treatment, monitoring and re-development of contaminated land spring from policy and legal decisions, it is important that practitioners have an understanding of these basic tenets.

#### **Course Outline:**

- *Assessment Of Risk*
- *Site Investigation Techniques*
- *Regulatory Framework For The Cleanup Of Contaminated Land And Groundwater*
- *On-Site Pollutant Behaviour, Current And Developing Research On Pollutant Behaviour*
- *Remediation Techniques.*
- *Establishing New Landscapes and Post-Remediation Planning*

### **MSc Geomaterials, Pathway Leader: Dr. Paula Carey**

The course has recently transferred from Queen Mary and Westfield College, where it ran very successfully for 18 years. Staff teaching on the MSc course are internationally renowned for their research into concrete petrography and analytical methods of assessing the causes of damage by Alumina-Alkali Reaction (AAR) – a world-wide problem which has led to the need to replace major structures such as bridges and dams; rock joint mapping for quarry location; the testing and durability assessment of rock armouring for coastal structures; aggregates for highways and concrete. Research on rock weathering, clays, bricks, ceramics, slags and refractories has also been developed, benefiting from industrial links through a close association with Geomaterials Research Services Ltd.

#### **Course Outline:**

- *Site Investigation*
- *Rocks and Engineering Soils*

- *Aggregates and Construction Materials*
- *Research Techniques and Project Management*
- *Rock in Construction and Coastal Engineering*
- *Principles of Rock and Soil Mechanics*
- *Cement and Concretes*
- *Remote Sensing and Groundwater Studies*

## Research and Consultancy

As mentioned previously, the Centre has nine permanent staff who are all members of the School of Earth & Environmental Sciences. There are currently 2 EPSRC funded research projects, 1 EU project, 1 BURA project and 1 BCA project supporting 3 post-doctoral researchers and 7 PhD students. Areas of recent research and/or consulting include:

- *Site investigation for landfill sites and contaminated land*
- *DNAPL migration through aquifer sediments*
- *Development of soil washing techniques using surfactants for remobilising organic contaminants*
- *Use of zero valent iron in remediation of organic contaminants in soils and ground water*
- *Stabilisation of heavy metal wastes using cementitious systems*
- *Assessment of tailings and*

- *potential for acid mine drainage*
- *Mine monitoring and remediation*
- *GIS modelling for resource management*
- *Environmental risk assessment and monitoring*
- *Landscape assessment and management*
- *Habitat management and remediation*
- *Restoration ecology in urban and rural development programmes*
- *Hydrochemistry and contaminant transport*
- *Ground and surface water studies*
- *Analysis of structure and stability of landslips*
- *Geotechnical materials testing*

## Facilities

The Centre is supported by excellent laboratory and computational facilities in addition to a campus library and on-campus housing for out-of-town visitors or researchers. Computing facilities include powerful networks of PCs and SUN workstations supporting a range of leading-edge software packages for GIS/RS, environmental modelling and image processing. Peripheral devices include an ultra-high resolution digital camera, A0 and lower digitisers, scanners and plotters.

The laboratory facilities are extremely well supported giving the centre the

capability of analysing nearly all contaminants of concern in any matrix. These facilities include:

- *High resolution digital camera*
- *JEOL Scanning electron microscopy-electron probe microanalysis with low vacuum capability and a fully automated digital analysis programme*
- *Automated X-ray diffraction*
- *Inductively coupled plasma-emission spectrometry and -mass spectrometry*
- *Atomic absorption spectrometry (flame and graphite furnace)*
- *High performance liquid and ion chromatography*
- *Gas chromatography (ECD, FID and MS detection)*
- *X-ray fluorescence spectrometry*
- *Ion chromatography for anions and metal ion species in waters*
- *Ultra-trace mercury analysis*

**Dr. Cecilia MacLeod,**

*June 1999*

*Senior Research Fellow,*

*Centre for Contaminated Land*

*Remediation,*

*School of Earth & Environmental Sciences,*

*The University of Greenwich,*

*Medway Campus,*

*Pembroke,*

*Chatham Maritime,*

*Kent ME4 4TB*

E-mail [C.Macleod@greenwich.ac.uk](mailto:C.Macleod@greenwich.ac.uk)

## Memorandum

**To: All Members of the RSC's Environmental Chemistry Group**

**From: The ECG Committee, July 1999**

**Future ECG Symposia:** Have you any suggestions for future ECG symposia? Are there areas of environmental chemistry, or issues relating to the environment, which you think are inadequately covered at present by the ECG or by other sections of the Royal Society of Chemistry? Are there other ways by which the RSC should explain and illustrate current concerns on environmental topics? Please forward your ideas to the ECG committee members listed on the front cover of this Newsletter.

**ECG Newsletter:** Would you like to receive the ECG Newsletter electronically as an e-mail attachment instead of the hardcopy version? Please let Dr. Sarah Vallance at the RSC, Burlington House, know: [e-mailVallanceS@rsc.org](mailto:e-mailVallanceS@rsc.org)

## Further News of the Royal Society of Chemistry's Green Chemistry Network

As Environmental Chemistry Group members will be aware from the January Newsletter, the RSC has recently launched the Green Chemistry Network (GCN) with the aim of promoting Green Chemistry concepts in schools, universities and industry. In this article **Mike Lancaster**, the Network Manager and based at the University of York, discusses the concept of Green Chemistry and highlights some of the programmes in which the GCN is currently involved.

The term Green Chemistry is rather emotive, intentionally so, and conjures up different meanings to different people. Its origins are with the US Environmental Protection Agency, but the movement is rapidly spreading across Europe and is creating a great deal of interest elsewhere. At its core *Green Chemistry is the adoption of techniques and technology that reduce or eliminate the use or generation of hazardous substances in the design manufacture and application of chemical products.* Much of what Green Chemistry is about can be more readily expressed as waste minimisation at source.

A significant amount of Green Chemistry is targeted at R&D and Process Development Chemists; the following concepts are at the core of Green Chemistry:

- Preventing waste is better than treating it after it has been produced.
- Synthetic methods should be designed to maximise incorporation of all materials used in the process into the final product.
- Energy efficiency of processes should be considered when devising synthetic methods
- Chemicals should be designed to have minimum toxicity whilst maintaining their effect.

- Catalytic reagents are superior to stoichiometric reagents.
- Raw materials should be renewable whenever economically practicable.
- Products should be designed so that at the end of their function they break down into innocuous degradation products.

Whilst most, if not all, self-respecting chemists will surely agree with these principles many will comment – ‘easier said than done!’ The Green Chemistry Network aims to facilitate the process of education, technology transfer and sharing of best practice so that these concepts become part of the everyday thinking of chemists. There have been many developments in green, clean and sustainable chemistry; both in academia and industry during the last 10 years or so but the techniques have not gained widespread application.

The GCN is in the process of building a database of members' areas of expertise and of available methodologies and tools; chemists looking for Green solutions will then have easy access to the latest techniques. We are also actively encouraging technology transfer, both between academia and industry and within industry itself. Our first event in this area took place in May when in conjunction with the Sheffield Environmental Business Network, ETBPP (Engineering Technology Best Practice Programme) and Yorkshire & Humber Chemicals Sector we held a Swap Shop on the theme of ‘Waste Minimisation and Monitoring.’ This successful event attracted participants from both the chemical industry and monitoring equipment specialists, and included talks on legislation, examples of what industry has achieved as well as recent developments in monitoring. Encouraging industry to be more open and share best practice is never easy, no matter what the field. In the Green Chemistry area, industry has the dilemma of wishing to publicise the good things it is doing whilst wishing to preserve its hard gained competitive advantage. In order to try and encourage greater openness we are working with a number of potential partners to establish Green

Chemistry Awards both at the UK and European level. We hope to be able to give awards for excellence in Green Chemistry to small and medium-sized business enterprises as well as to the larger companies, together with an award for education. This idea has worked well in the US (Presidential Awards for Green Chemistry) and industry has now come to accept that there are benefits in publicising a certain amount of information.

The other main area of interest for the GCN is education. We are currently in a vicious circle; much of the chemistry taught in schools and universities is still pre-war it is therefore not surprising that when chemists enter industry the processes they develop do not use the latest technology. Whilst we don't wish to change the curriculum we do wish to provide teachers, lecturers and students with up-to-date information on what is possible. In particular it is important that practical examples are given to the student. For example we no longer need to use aluminium chloride when demonstrating Friedel-Crafts reactions, there are many heterogeneous true catalysts available that can be filtered off and reused – avoiding all those gelatinous precipitates so hated by generations of chemists! The GCN is constantly on the look out for new material and examples we can use – if you know of any please get in touch.

I believe that the Green Chemistry Network and the Environmental Chemistry Group have a complementary role. The GCN is not primarily concerned with ‘end of pipe’ solutions or remediation, whilst the Environmental Chemistry Group is perhaps less concerned with the chemical process. Between the two groups we can truly cover the ‘cradle to grave’ scenario. In the middle there is obviously a little overlap; this provides an opportunity to work together in organising events and promotion. As good environmentalists we should endeavour to conserve resources – especially the scarce resources of the RSC!

**Mike Lancaster** *University of York*  
E-mail [greenet@york.ac.uk](mailto:greenet@york.ac.uk)

## The Hazards Forum

### Inauguration

The Hazards Forum, a registered Charity, was founded in 1989 by the Institutions of Chemical, Civil, Electrical and Mechanical Engineers to provide an interdisciplinary focus for:

- the study of disasters and the promulgation of lessons drawn from them;
- the promotion of risk reduction strategies;
- raising awareness in the professional community of the responsibility of the individual to improve safety.

Disasters arising from both natural and man-made hazards were within its remit, although it was UK examples of the latter that were the main incentive for the Institutions to inaugurate The Hazards Forum. The first Mission Statement stated "The Hazards Forum exists to provide a focal point in which engineering features in the mitigation and reduction of both man-made and natural hazards and disasters."

Forum membership was initially restricted to the engineering institutions and associated bodies, but in recent years membership has been extended beyond engineering. Other institutions and societies, including the Royal Society of Chemistry (RSC), Geological Society, Physics, IOSH, Hydrology, are now Associate Members. A range of companies, distinguished persons and others with an interest in hazards and risk are also included in the membership.

The Forum, under the successive Executive chairmanship of Sir Frederick Warner FREng, FRS, Sir Bernard Crossland FREng, FRS and Professor Phillip Bennett FREng, has pursued its aims and objectives via regular meetings, special keynote events and the publication of a Newsletter and books. The aim has been to provide a service to members and to bring important issues to a wider audience.

### Constitution and Membership

The Forum is constituted with an Executive Committee and an Activities Committee, both supported by a Secretariat based at the Institution of Civil Engineers. Membership of both committees is not limited to Engineers, but is by invitation only, with the minimum requirements of chartered status and formal approval of the Executive.

Stuart Luxon was the RSC Environment, Health & Safety representative on the Forum until he resigned from the EHSC a few years ago. I was nominated as his successor, (partly due to my background as Chief Chemist and Company Environmental Health Chemist with Rolls-Royce plc.). I was then invited to join the Forum's Activities Committee the following year. When Dr Darrol Stinton, a former test-pilot, and now an engineering consultant stepped down from the chairmanship due to overseas commitments in December 1998, I was offered and accepted the Chair of the Activities Committee.

Following the resignation of Professor Philip Bennett, also due to overseas commitments, Stuart Mustow CBE, a distinguished Fellow of the Royal Academy of Engineering, accepted the Executive Chairmanship in January 1999.

Both committees have a balanced representation from engineering, science, technology, safety and emergency planning.

### Recent Issues Addressed by The Hazards Forum

Seminars and meetings have included:

- The Successful Management of Safety
- Safety of Ships
- Flood Hazards in Bangladesh
- An Engineer's Response and Tasks in Disaster Preparedness
- Blowing the Whistle for Safety
- Risks to the Public – The Rules, The Rulers & The Ruled
- Gas-Rich Volcanic Lakes – A Major Natural Hazard

### Strategy for the Future

The Forum was initially conceived to ensure that lessons of the past learned from major disasters both natural and man-made should not be forgotten. It has been recognised that with its multidisciplinary composition, the Forum is ideally suited to address the whole spectrum of issues of Hazard and Risk. In order to address this spectrum however, a much greater degree of co-operation will be sought with other Institutions and major companies in organising attractive meetings that will offer a balanced perspective.

The British National Committee for the UN International Decade for Natural Disaster Reduction (IDNDR) is established under the auspices of the Royal Society and the Royal Academy of Engineering to co-ordinate British initiatives in support of the decade. It is interdisciplinary and reflects the involvement of many UK nationals; consultancies and NGOs in natural disaster-related work world-wide. The decade ends in December 1999 and the Committee will be disbanded, but there is an opportunity for The Hazards Forum to provide an on-going focus for the work and in particular to incorporate consideration of risks arising from British natural hazards.

The next seminar organised by The Hazards Forum and which will be of particular interest to the Environmental Chemistry Group, is *The Montreal Protocol – Twelve Years On*, chaired by **Sir John Krebs**, Chief Executive of the National Environmental Research Council. The invited speakers are from The Met. Office, Rolls-Royce plc, ICI, Environmental Investigation Agency and the HSE. Details of this meeting are given elsewhere in this Newsletter.

**Terry Farthing**  
EurChem, CChem, FRSC, MRAs  
*Chairman of The Hazards Forum Activities Committee*  
May 1999

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

John Holder, a Committee Member of the Environmental Chemistry Group, reports on the current activities of the Federation of European Chemical Societies Division for Chemistry and the Environment of which he is Secretary.

Details of the membership of the Divisional Committee and of FECS activities, including the 1998 Annual Report, are now posted on our website <http://www.ecomed.de/naturw/bereiche/titel/espr/welcome.htm>

The Committee met in Bayreuth, Bavaria on April 17 1999. The meeting was hosted by the University of Bayreuth and was held in conjunction with the First International Symposium on Atmospheric Reactive Substances (14-16 April), the proceedings of which will be published shortly. Significant points to emerge from the conference were the difficulties experienced in measuring the global abundance of precursors to reactive substances, the problems of differentiating between natural and man-made sources and the absence of the expected correlation between mutagenicity and the concentrations of benzo[a]pyrene and ozone.

The Committee was honoured to welcome as an observer to its meeting Prof. Valery Petrosyan from Moscow University who is Head of the Russian Ministry of the Environment's Federal Centre of Environmental Chemistry, Head of the Russian Seminar of Chemistry and Toxicology and a Member of the SETAC Europe Council. He expressed the wish that FECS and SETAC would work more closely together in future.

Two further symposia have been announced. The 17th International Symposium on Polycyclic Aromatic Hydrocarbons will be held at the University of Bordeaux, October 25-29, 1999 and an International Symposium on Filtration and Separation of Fine Particles

Suspensions in Vienna, November 10-12, 1999. Further information may be obtained from the website.

Guidelines on how to obtain FECS Sponsorship (non-financial) for events have been issued. If you are organising a major environmental conference or other event and would like it to be sponsored by and publicised through FECS you can obtain further information from Evelyn McEwan at the RSC.

The First Announcement and Call for Papers for the Seventh FECS International Conference on Chemistry and the Environment, subtitled Trace Metal Speciation in the Aquatic Environment has been issued. Anyone interested should visit the conference website <http://www.geocities.com/CapeCanaveral/Lab/8007/fecs2000.htm> or contact committee member Maria-Teresa Vasconcelos at the University of Porto.

The eighth FECS conference subtitled 'Chemistry for Maintaining Environmental Quality and Improving Human Life' will be held in Athens in 2002.

The European Environment Agency has asked FECS to be its partner in developing European Green Chemistry Awards by the year 2000. The awards will be similar to but broader than the American Presidential Green Chemistry Challenge Awards. The Division will form a sub-group of experts to develop the awards and seek funding. Meetings have taken place between the Division's Chairman, Allan Astrup Jensen and representatives of the British Green Chemistry Network. German industry has expressed concern over the use of Green in the title because of possible confusion with the Green Party. It is likely that the award title will be translated as 'Sustainable Chemistry' in countries where this is a sensitive issue.

Further Division sub-groups on Atmospheric Chemistry and Education will be formed. Anyone interested should contact committee members Hartmut

Frank and Toomas Tenno respectively.

The Division will shortly publish on its website a compilation of major textbooks on environmental chemistry.

The Committee now has members from thirty European countries including candidate states for EU membership, who would be willing to assist in partner searches for environmental projects seeking Framework 5 funding.

The next committee meeting will take place in Bordeaux in October 1999 and it is hoped to hold the following meeting in London to coincide with the ECG Distinguished Guest Lecture and AGM, on 1 March 2000.

**John V. Holder**  
*Faculty of Science*  
*University of Central Lancashire*  
E-mail [j.v.holder@uclan.ac.uk](mailto:j.v.holder@uclan.ac.uk)  
May 1999.

## Forthcoming Symposium

### The Montreal Protocol – 12 Years On

#### Organised by **The Hazards Forum**

Half-day seminar, October 13<sup>th</sup> 1999, at the Institution of Civil Engineers, 1, Great George Street, London

In 1987, the developed nations signed an agreement in Montreal, Canada to limit the general production and use of, and ultimately to ban, halons, chlorofluorocarbons (CFCs), carbon tetrachloride, and certain other solvents which had been shown to damage the ozone layer. Altogether, some 130 nations are committed to the **Montreal Protocol**, which does allow the very limited production of specific substances for mainly medical applications and drug preparations.

Many of these halogenated compounds had been developed as substitutes for compounds that were more harmful to

man, for use as refrigerants, aerosol propellants and non-flammable solvents.

This seminar has been arranged to discuss:

- the extent to which the Montreal Protocol has been successful in reducing damage to the ozone layer;
- the lessons learned by industry;
- the availability of alternative substances;
- and the problems experienced in identifying CFC smuggling from countries which are not signatories to the protocol.

The meeting will be particularly useful for small to medium sized business enterprises who are dealing with changes to their cleaning and refrigeration systems as a consequence of the Montreal Protocol.

Sir John Krebs, currently Chief Executive of the National Environmental Research Council, will chair the seminar, and the other speakers will be:

John Austin (The Meteorological Office)  
Ian Liddle (Rolls-Royce plc)  
Michael Walker (ICI)  
Steve Trent (The Environmental Investigation Agency)  
Bernard Robinson (The Health & Safety Executive)

The cost of the symposium is £56 for members of The Hazards Forum and Affiliates or £70 for non-members.

To register and for further details please contact The Hazards Forum Secretariat, 1 Great George Street, London SW1P 3AA,  
tel: 0171 665 2158;  
fax: 0171 233 1806;  
e-mail: [torey\\_d@ice.org.uk](mailto:torey_d@ice.org.uk)

## Forthcoming Symposium

### Chemical Contaminants in Estuaries and Coastal waters: Practical Applications of Models

We must apologise for the postponement of this meeting that was originally scheduled for 3<sup>rd</sup> February. Unfortunately, the unforeseen late distribution of the publicity material meant that there were not enough registrations a week before the date of the meeting. Of course, after having decided to rearrange the meeting more registrations arrived. The new date for the meeting is **Friday 19 November 1999**. This is the first day of "Chemistry Week" so we hope as many people as possible will attend what should be a particularly interesting meeting and get Chemistry Week off to a flying start!

There is an increasing reliance on models to forecast the distribution, movement and fate of chemicals, whether of natural

or anthropogenic origin. Environmental chemists and others who study estuaries and coastal waters need to appreciate the strengths and weaknesses of these models. Similarly, policy makers and enforcement agencies need to understand the capabilities of the models that are used to inform their activities.

The aim of this meeting is to provide a synopsis of the use of various modelling techniques in the study of the distribution and movement of contaminants in estuaries and coastal waters. The speakers will provide an informed picture of:

- where we are at present in modelling chemicals in estuarine and coastal waters;

- practical examples of models and the information that can be provided by them;
- some of the practical and theoretical problems in improving models.



**PROGRAMME**

10.15 - 10.45	Registration. Coffee/tea.
10.45 - 11.25	Use of models by the Environment Agency. Dr Neil Murdoch and Dr Peter Jonas (Environment Agency)
11.25 - 12.05	Contamination distribution in estuaries and the use of GIS. Dr Andy Tyler. (BMT)
12.05 - 12.45	Flexible modelling using ECOS. Dr John Harris. (CCMS, Plymouth)
12.45 - 13.55	Lunch
13.55 - 14.35	Modelling radionuclide transport in coastal waters. Dr Steve Bradley (Westlakes Research)
14.35 - 15.15	Modelling nutrient behaviour in estuaries and coastal waters. Dr David Hydes. (Southampton Oceanographic Centre)
15.15 - 15.55	Computer simulation of oil and chemical spills in estuaries and coastal waters. Professor Alan Elliott (University of Wales, Bangor)
15.55	Close of meeting

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

To register for this meeting, please use a photocopy of the application form printed below.

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

Scientific Societies' Lecture Theatre  
Friday, 19 November 1999

I wish to register for the Symposium on Friday, 19 November 1999

I enclose a cheque made payable to "RSC Environmental Chemistry Group" (Charge includes lunch and coffee/tea)

Members of the RSC Environmental Chemistry Group	£60.00
RSC retired members	£17.00
Other members of the RSC	£65.00
Non-members	£95.00
Students in full-time education. Indicate university/college	£17.00

**(BLOCK CAPITALS PLEASE)**

Name: ..... Title: .....

Address: .....

..... Post Code: .....

Tel: ..... Fax: .....

e-mail: .....

Special dietary requirements: .....

.....

**Please return to:** Dr P. O'Neill, Faculty of Science, University of Plymouth, Drake Circus, Plymouth PL4 8AA  
Tel: 01752 232984 Fax: 01752 233095

## Forthcoming Symposium

### Environmental Chemistry Group 2000 Distinguished Guest Lecture and Accompanying Symposium

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

At this meeting the **ECG 2000 Distinguished Guest Lecture** will be

given by **Sir John Houghton** CBE, FRS the co-chairman of the Science Assessment Working Group of the Intergovernmental Panel on Climate Change. The title of Sir John Houghton's lecture is "*Global Warming and Climate Change: the Latest science and the Likely Impacts.*"

The Distinguished Guest Lecture is part of a half-day symposium which starts at 13.30. Two supporting lectures will be given at the symposium: "*The Implications of Climate Change for Ecosystems*" (Dr Terry Parr, Co-

ordinator of the UK Environmental Change Network) and "*The Implications of Climate Change for Human Health*" (Professor Tony McMichael, London School of Hygiene and Tropical Medicine).

We are fortunate to have three such eminent speakers for a symposium that should provide an 'up-to-the-minute' assessment of the possible impacts of global warming. Booking forms for this symposium and the associated Annual General Meeting will be sent out at a later date. ECG members are entitled to free admission.

## Forthcoming Symposia

Details of many meetings related to the environmental sciences to be held in the second half of 1999 are given in the leaflet *Environmental Science and Technology Meetings* (No. 31, June 1999) which accompanies this issue of the ECG Newsletter.

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

### Living with Carcinogens

Organised by the RSC's Occupational and Environmental Toxicology Group, Tuesday 7<sup>th</sup> September 1999, Heriot-Watt University, Edinburgh. This half-day symposium is part of the Royal Society

of Chemistry's 1999 Annual Conference. The topics to be covered include: 'Why must we live with carcinogens; can't we just ban them?' How chemicals increase cancer incidence. The role of the chemist in identifying carcinogens. How far can we replace animal experiments in carcinogenicity testing? The regulation of carcinogens. For further details, please contact Mr. Paul Whitehead, tel: 01793 453639, e-mail [paul.whitehead@burmahcastrol.com](mailto:paul.whitehead@burmahcastrol.com)

### The Montreal Protocol – 12 Years On

Organised by The Hazards Forum, Wednesday 13<sup>th</sup> October 1999, Institution

of Civil Engineers, 1 Great George Street, London SW1P 3AA, tel: 0171 665 2158 (see elsewhere in this Newsletter for further details)

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

Organised by the RSC Environmental Chemistry Group, Friday 19<sup>th</sup> November 1999, Scientific Societies' Lecture Theatre, New Burlington Place, Savile Row, London (Dr. Peter O'Neill, tel: 01752 232984 for details – see also elsewhere in this Newsletter)

## Society for Environmental Geochemistry and Health (SEGH)

### Forthcoming SEGH Meetings

#### 2nd Asia Pacific Symposium on Environmental Geochemistry

Location: Seoul, South Korea  
Dates: 2-4th November 1999  
Contact: Prof. Hyo-Taek Chon  
Applied Geochemistry  
Research Unit  
School of Civil, Urban and  
Geosystem Engineering,

College of Engineering,  
Seoul National University  
Seoul 151-742, South Korea  
Tel: +82 (0)2 880 7725/7236  
Fax: +82 (0)2-871 7892/8938  
E-mail: [chon@plaza.snu.ac.kr](mailto:chon@plaza.snu.ac.kr)

#### GEOTROP-99 Third International Conference on Environmental Chemistry and Geochemistry in the Tropics

Location: Hong Kong University

Dates: 24-26th November 1999  
Contact: The Conference Secretariat  
Institute for Natural  
Resources and Waste  
Management  
Hong Kong Baptist University  
Kowloon Tong  
Hong Kong  
Tel: 852 23 397 054  
Fax: 852 23 361 400  
E-mail: [Geotrop@hkbu.edu.hk](mailto:Geotrop@hkbu.edu.hk)

#### 5th International Symposium on Environmental Geochemistry (ISEG)

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

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

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

#### **Fourth International Conference on Arsenic Exposure and Health**

This conference will focus on recent US EPA legislation on arsenic, the health effects of arsenic, exposure to arsenic, the treatment of patients, and water remediation.

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

#### **SEGH Conference on Environmental Chromium Contamination and Remediation**

This two-day conference will focus primarily on solutions to the problems

created by the historical dumping of chromium ore processing residue.

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

#### **5th International Symposium on Environmental Geochemistry (ISEG)**

Edinburgh, Scotland. September 2003

**For further information about SEGH, see our website, [www.segh.org](http://www.segh.org)**

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## **Meeting Report**

### **AIRMON '99: The Third International Symposium on Modern Principles of Air Monitoring**

(Geilo, Norway, February 10th to 14th 1999)

This Symposium was the third in the series of such meetings, the first at Geilo in 1993 and the second in Sälen, Sweden, in 1996 (see *Analyst*, 1994, **119**, pp1-107 and *Analyst* 1996, **121**, pp1155-1305). This latest meeting marked the return to the location of the first, and was organised jointly by the National Institute of Occupational Health of Norway (Oslo) and the National Institute for Working Life of Sweden (Umeå). It provided an auspicious launching for the Royal Society of Chemistry's new journal, the *Journal of Environmental Monitoring (JEM)*, key papers presented at this meeting will be published in the August issue of the journal.

The rationale for the meeting was the increasing requirement for air monitoring within the preventive frameworks for

identifying and controlling airborne health hazards in workplaces and in the ambient and living environments. These in turn demand the characterisation of exposures of people to chemical and biological agents, involving the use of representative and valid sampling procedures and strategies, in addition to accurate and reliable quantitation techniques. With this in mind, the programme of plenary lectures was designed to provide comprehensive overviews of the latest developments in the multidisciplinary and interdisciplinary fields contained within this scenario. For this, the organisers brought together a strong international contingent of experts from nine countries. The attendees were drawn from a similarly wide international range. In addition to the formal scientific sessions, there was a large poster exhibition containing about 40 new scientific contributions, as well as an instrument exhibition, both of which ran for the duration of the symposium. In addition to the scheduled events, ample time was allowed for the 150 or so attendees to meet and talk informally. The net result was a very relaxed environment for the exchange of new ideas and information

relevant to air quality measurement in all its contexts.

Contributions on exposure assessment strategies identified the various motivations for exposure assessment, placing air monitoring firmly within the need to measure the exposures of people to airborne contaminants *via* the inhalation route in a way that relates to outcome (*e.g.*, to human health). So it was understood that air monitoring is an important component of environmental and occupational health in the wider context of public health. The needs of epidemiology were discussed, most notably from the point of view that sampling strategies provide a primary scientific basis for the development of standards and exposure limits for airborne contaminants. The role of variability in exposure assessment was articulated, where the importance was stressed of placing statistical considerations alongside the technical ones that have

dominated the subject for so many years. One contribution developed the new argument that self-assessment of exposure might be useful in the future. Overall, the new work which was presented suggested that the training of environmental and occupational hygienists and scientists needs to go beyond the technical disciplines – physics, chemistry and biology – which are frequently regarded as the cornerstones of graduate-level education in those fields. Meanwhile, the technical methods by which to carry out visualisation of exposures to aerosols, gases and vapours were highlighted as providing an important body of practical tools by which hygienists in the workplace setting may explore the nature and exposures for individual workers (and groups of workers). The information gained in this way may be used to improve working practices and educate workers about how to reduce their exposure/s.

The session on aerosols returned to themes developed at earlier AIRMON symposia; namely, that aerosol exposures need to be measured in a way that physically presents the way in which people are exposed. The question of the role of external factors such as particle size, windspeed (including moving versus calm air scenarios), sampling flowrate were therefore addressed, leading to suggestions for further updating the criteria which underpin current particle size-selective sampling and for the development of new – and more user-friendly – sampling instrumentation. The importance of micro-organisms as an important aerosol subgroup was identified, their measurement difficulties were discussed, and new measurement procedures were described. The special importance of very, very small particles was outlined, where it was noted that the very reactive properties of particles in the size range of just a few tens of nanometers which make them of great interest from an engineering point of view (*e.g.*, new materials) are also the same ones that might make them very toxic. One type of aerosol exposure that continues to provide significant measurement challenges concerns that from machining fluid aerosols experienced in the many industries where metal working is carried out. In this context, the special problems involved in measuring aerosol exposure associated with the use of the aqueous

class of machining fluids were discussed. Finally, the emergence of new techniques for the chemical analysis of individual particles was described, and the importance of the application of such techniques in “finger-printing” aerosols in the working and ambient environments was stressed.

The discussion about gases and vapours addressed concern about how air monitoring might deal with the difficult practical question of the measurement of airborne contaminants that may exist in both the aerosol and the gaseous form. Isocyanates continue to be an important airborne contaminant in many industrial settings, and still provide many measurement challenges. For these, emerging new methods were summarised and compared with the ones that were used some 20 or so years ago. It was described how complex isocyanate mixtures add to the difficulties that are currently faced, and significant progress is being achieved. New methods for the sampling of inorganic gases and vapours were outlined. The importance of aldehydes was also identified, and a range of analytical methods for their determination was described. Biosensors appear to have very high sensitivity for the measurement of gases and vapours, and it was suggested that these have great potential for measuring extremely low concentrations.

Many air quality issues have emerged in recent years. We are finding that health effects can occur at concentrations of airborne contaminants which – compared to most workplace and ambient air quality standards – are very low indeed. In this respect, the importance of hydrocarbons, ozone and other chemical species groups was discussed and new air monitoring challenges were identified. For many such situations, where – unlike for the assessment of workplace exposures – the culture (and practicality) of personal sampling for the determination of individual exposures has not yet been fully developed, dispersion modelling can provide important insights. In particular therefore, as was described in one contribution, such modelling can provide a means for determining the transport of airborne contaminants, and hence for assessment of their temporal and spatial distributions, in order to provide better estimates of the exposures of people in airsheds both large (*i.e.*, the atmosphere) and small (*i.e.*, indoor air situations).

Indoor air quality remains of considerable interest, especially since so-called “sick building syndrome” continues to be among the most commonly reported of workplace complaints. Here the role of microbe-generated volatile organic compounds (VOCs) was discussed. It is known that there is generally no relationship between SBS symptoms and levels of individual or total VOCs. However, it was suggested that a multivariate statistical approach on the measurement of VOCs might provide a means for the classification of “problem” and “non-problem” buildings. Overall, the development of more systematic scientific approaches to the understanding of this important problem was called for.

The last part of the symposium was devoted to discussion of questions concerning international regulations, standardisation and quality assurance. For most of the attendees, the European Union (EU) framework was clearly of primary interest, and this was addressed in relation to the new EU air quality directives, methods standardisation, reference procedures and proficiency testing schemes. The speakers described the various mechanisms that are in place or are being developed, and the extent to which harmonisation across the EU is being achieved. It would appear that much – but perhaps not all – of what was described is generic and so applicable to countries outside the EU.

The symposium followed in the same tradition as the first two, once again reflecting the commitment of its two Co-chairs, Yngvar Thomassen and Jan Olof Levin (of the mentioned Oslo and Umeå institutes, respectively), who have organised and hosted all three symposia in the series. Once again, the tone of the symposium owed much to the contributions of these two individuals. As before, the symposium was notable not only for its excellent and broad scientific content, but also for the congeniality of its organisation and surroundings. There are few scientific meetings most of us attend where the lunch break begins at noon and goes on until 4.00 pm, yet where it just so happens that some of the world’s best ski slopes and trails beckon just outside the door! And where, during the early evening sessions, freshened by our exposure to the clean winter air of Geilo, we could look ahead to the bountiful tables provided by the superb kitchens of

the Dr. Holms Hotel! I think I can speak for everyone who attended in thanking our hosts for yet another outstanding air monitoring symposium. We all look forward to AIRMON '02.

**Professor James H. Vincent,**  
University of Michigan,  
Department of Environmental and Industrial Health,  
School of Public Health  
Ann Arbor, MI 48109, U.S.A.

## Meeting Report

### Radiatively-Active and Ozone-Depleting Trace Gases in the Atmosphere

The Environmental Chemistry Group held a half-day symposium at the Royal Society, 6 Carlton House Terrace, London on March 3<sup>rd</sup> 1999. At the meeting the Nobel Laureate, **Professor Mario Molina** from the Massachusetts Institute of Technology, gave the Group's **1999 Distinguished Guest Lecture** on "Global Atmospheric Chemistry Challenges for the Coming Decade."

In two supporting talks, **Professor Peter Simmonds** from the University of Bristol spoke on "The History of Atmospheric Measurements at Mace Head, Ireland: Implications of the Changing Trends in Natural and Anthropogenic Trace Gases", and **Dr David Fisk**, Chief Scientist, Department of the Environment, Transport and the Regions, reviewed policy approaches to the control of radiatively-active and ozone-depleting trace gases.

### Global Atmospheric Chemistry Challenges for the Coming Decade

(Professor Mario Molina)

*Mario Molina was born in Mexico City in 1943. His interest in chemistry was an early development – before the age of eleven he had converted a bathroom at his home into a laboratory! In 1960 he enrolled in the National University of Mexico (UNAM) to study chemical engineering and subsequently started studies for a PhD in physical chemistry first at the University of Freiburg (polymerisation kinetics) for two years before joining UNAM as an Assistant Professor prior to enrolling in the graduate programme at Berkeley – completing a PhD in 1972 using chemical lasers to study chemical dynamics. In 1973 Professor Molina moved to Irvine to work with Professor Rowland as a postdoctoral fellow. The similarity between CFCs and species used for studies in chemical dynamics research plus a growing interest in atmospheric chemistry led Professor Molina to study these molecules and three months after his arrival in Irvine a "CFC-ozone depletion theory" was formulated. Conversations with Harold Johnston, Ralph Cicerone and Richard Stolarski led to the paper in Nature in June 1974. After several years at Irvine, Professor Molina joined the Molecular Physics and Chemistry Section at the Jet Propulsion Laboratory (1982) where he was offered an opportunity of doing laboratory work himself – particularly focusing on the role of Polar Stratospheric Clouds and ClO<sub>2</sub>. In 1989 he moved to MIT to continue research on global atmospheric chemistry issues. He was awarded the Nobel Prize in 1995.*

Professor Molina sketched the history of the development of the contemporary research interest in atmospheric chemistry; pointing out that although it had been known for centuries that there were anthropogenic effects on the local

environment it only became clear in the last decades that the 'very thin and fragile atmospheric layer' can also be affected by human activity.

As a case study of the manner in which technological change produced unforeseen impacts Professor Molina, focused (appropriately) on the advances in refrigerator technology which led from the use of ice-boxes through sulphur dioxide and ammonia based refrigerants (the use of which was encouraged by the widespread availability of electricity in the 1920s) to the development of CFCs ('miracle chemicals'). Interestingly the discovery of the 'safe' CFC refrigerants was by Thomas Midgley – who also developed the lead tetraethyl anti-knock agent. The use of CFCs as refrigerants, foam blowers and aerosol spray propellants led to their release into the atmosphere. The chemical stability of CFCs (the feature so desirable for their use as refrigerants) led to their persistence in the atmosphere and, subsequently, to their presence in the atmosphere being measured by Lovelock and co-workers (1973). Professors Rowland and Molina began their work on the atmospheric impact of CFCs around this time.

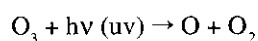
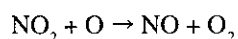
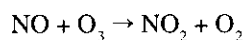
Professor Molina then gave a brief but wonderfully clear exposition of the features of the troposphere and stratosphere which led to the problems associated with the ground level release of CFCs. Slow vertical exchange (due to the temperature profile changes at the tropopause) means that (relatively) long (decades) vertical transport times to the stratosphere are expected for CFCs after their release – and, because of the inertness of CFCs, tropospheric removal processes are ineffective. In the stratosphere, although solar uv penetration does cause breakdown of the CFCs (with the release of chlorine atoms), the absence of the tropospheric removal processes (rain, oxidation etc.) means that the breakdown products (chlorine atoms) are available for reaction, particularly with ozone.

The chemistry of stratospheric ozone based around the Chapman Mechanism and developed by the addition of catalytic cycles (Crutzen) led to the following conceptual pathway:

CFCs (stratosphere) + solar uv (210 nm - 290 nm) → reactive chlorine (Cl, ClO) → catalytic cycles → ozone layer depletion

The reactive chlorine can be removed from active participation in the catalytic cycles by formation of HCl and ClNO<sub>3</sub> in the stratosphere where, (unlike the troposphere), removal by washout cannot occur.

An example of a catalytic cycle (for NO – but it applies analogously to other systems, e.g. chlorine atoms) was given:



Overall:  $2\text{O}_3 \rightarrow 3\text{O}_2$  (ozone removal & an unremoved NO chain carrier)

The experimentally detected presence of species such as ClO supported these ideas. But interest was moved into a more profound state of excitement by the publication of Farman's data (1985) showing significant ozone depletion in the spring months in the Antarctic atmosphere after the breakdown of the circumpolar vortex.

The elucidation of the heterogeneous chlorine formation mechanisms, which occur by the reaction of chlorine reservoir species (HCl, ClONO<sub>2</sub>) with uv/vis solar radiation on (mainly) ice crystals in Polar Stratospheric Clouds, and the recognition of the importance of these reactions in rationalising the rapid depletion of stratospheric ozone over the Antarctic, followed shortly afterwards.

The history of the response of the chemical industry to these findings was initially defensive, but the overwhelming force of the experimental data from Antarctica and from laboratory based experiments eventually led to the series of meetings (Montreal (1987), London (1990), Copenhagen (1992)) which effected global legislation relating to CFC usage.

Professor Molina pointed out the importance of bromine, a more effective ozone-depletor, and bromine-containing halons – the production and use of which still require legislative action.

The link between ozone depletion and global warming – through the global warming potential of CFCs (almost exactly balanced by the ozone they deplete!) – was developed by Professor Molina to indicate that the warming of the Earth's surface and the consequent cooling of the stratosphere would enhance ozone depletion by CFCs and halons. The monitoring of global warming *via* temperature measurement was discussed demonstrating that – like the reprogramming which was necessary to reveal the existence in satellite data of the low ozone measurements detected from the ground by Farman – satellite temperature data also needed to be modified to take into account the decline in orbital height of the satellites.

The importance of resolving the various views of the effects of climate change (reducing the range of predictions currently extant) was also mentioned with the comment that responses to global warming (economic and linked social effects) are not in the control of the scientific community – though some response is required! Professor Molina specifically suggested that research on aerosol effects (particularly in the tropics) on cloud formation was an item for more laboratory-based studies.

Additional areas of uncertainty in atmospheric chemistry were identified as the reactions involving particulate matter and health effects of tropospheric ozone (and effects on crops and forests) for which studies of the oxidising capacity of ozone will be important. Global budgets for NO<sub>x</sub>, VOCs and CO which are currently difficult to assess will need to be refined. These challenges are linked to major phenomena of global change – degradation of land, deforestation, loss of biodiversity, over-exploitation of fisheries, disposal of solid and hazardous waste, water pollution and the local and global changes in the atmosphere. Professor Molina ended by reiterating that over the next decades the complexities of global warming, ozone depletion and tropospheric ozone reactions need to be understood and clear information provided to government

decision-makers for action.

(Summary by Dr Leo Salter, Cornwall College)

During his visit to London in March, Professor Molina talked to the editor of *Chemistry in Britain*, Richard Stevenson. Their conversation is recorded in the June 1999 issue of *Chemistry in Britain*.

## The History of Atmospheric Measurements at Mace Head, Ireland: Implications of the Changing Trends in National and Anthropogenic Trace Gases

(Professor P.G. Simmonds)

'There is growing international concern over the unprecedented changes in our environment with sufficient scientific evidence to suggest that the combined activities of human beings may have serious consequences for the global climate system. It is therefore important to observe in detail the changing atmospheric composition and to present some of the long-term atmospheric measurements which have routinely monitored most of the radiatively important trace gases at remote atmospheric research stations and in particular the station at Mace Head in South West Ireland.'

Peter Simmond's talk highlighted the success of the Montreal Protocol in reducing the atmospheric abundance of the major ozone depleting halocarbons, and the rapid growth of their replacements, the HFCs and HCFCs. Observations were also reported which documented the changes in concentration of the radiatively important trace gases and the implications for future climate change.

Since Lovelock's seminal paper in *Nature* in 1973 recording high levels of atmospheric CFCs in South West Ireland using the election capture detector, which he invented, and Molina and Rowland's discovery the following year of the effects of CFCs on the ozone layer, there has

been growing concern over the impact of anthropogenic gases on ozone holes and climate change. This led to the development of the Montreal Protocol which required the phase-out of ozone depleting halocarbons in the developed countries by January 1996 and in the developing countries by 2010.

Monitoring under the current programme (ALE/GAGE/AGAGE) is carried out at stations which have either *in situ* continuous sampling or weekly flask sampling to provide temporal and spacial coverage respectively. Gases measured are  $\text{CFCl}_3$ ,  $\text{CF}_2\text{Cl}_2$ ,  $\text{CF}_2\text{ClCFCl}_2$ ,  $\text{CH}_3\text{CCl}_3$ ,  $\text{CCl}_4$ ,  $\text{CHCl}_3$ ,  $\text{CH}_4$ , and  $\text{N}_2\text{O}$ . Measurements are also carried out at some stations on  $\text{CO}_2$ ,  $\text{CO}$ ,  $\text{H}_2$  and  $\text{O}_3$ . The stations are located in Oregon and subsequently California, USA, Barbados, Samoa, Tasmania and Mace Head, Ireland.

$\text{CFCl}_3$  (CFC11) concentration has been found to have grown rapidly during the late 70's and 80's from around 150 parts per trillion (ppt) to a peak in 1991 of 270 ppt and is now declining at a rate of 1 ppt per year. In addition the amplitude of pollution events involving this gas in airflows from continental Europe has dropped dramatically since 1991.

$\text{CF}_2\text{Cl}_2$  (CFC12) showed similar growth in the 1980's and is still growing but the rate of accumulation has declined to 6 ppt per year. This continued growth might be due to releases from old refrigerators.

$\text{CH}_3\text{CCl}_3$  with its short atmospheric lifetime of 4.8 years has shown the most striking decline during the 1990's and has now returned to below the 1970's level. Other CFCs are also showing slow decline.

The result is that the atmospheric chlorine budget, which peaked at 2.9 parts per billion (ppb) total chlorine loading in 1992, is now dropping away much faster than predicted by the Montreal Protocol. Ozone-depleting chemicals with the possible exception of CFC12 are now declining globally. It is thus an excellent example of Governments and the chemical industry working together to reduce an identified potentially serious threat. If the developing countries also meet the target for CFC phase-out it has been estimated that ozone levels will return to their 1980 values by about the

year 2050.

A dispersion model 'NAME' has been developed by the Meteorological Office for pollutant flows from continental Europe to Mace Head which gives excellent agreement for CFC11 events. The model which was described fully in the talk, can be used to calculate actual emissions of a range of compounds from Europe. These may then be compared with chemical industry estimates of releases.

$\text{CO}_2$  measurements have been made since 1992 and have shown a growth of about 1.8 parts per million (ppm) per year, due mainly to agriculture and fossil fuel burning.  $\text{CH}_4$  has also been growing steadily since 1987 although the growth rate has slowed from around 10 ppb/year to around 1 ppb/year.

$\text{N}_2\text{O}$  is growing steadily in the atmosphere at 0.64 ppb/year from production of adipic and nitric acids. Positive trends in ozone levels have also been observed around the world although a slowdown in growth rate due to the Mt. Pinatubo eruption demonstrates that a long time series is needed to eliminate the effects of such events and to identify trends accurately.

$\text{CO}$  concentrations are declining and this is attributed to the introduction of catalytic converters in motor vehicle exhausts.

The HFCs and HCFCs which have been introduced as replacements for CFCs are all growing rapidly in concentration in the atmosphere with intense pollution episodes as air from Europe reaches Mace Head.

Atmospheric concentrations of the most important radiatively important trace gases are at their all time high and growing, and will have an impact on global climate. Relative contributions to radiative forcing, normalised to  $\text{CO}_2$  and changes per year, were given in the talk. These showed that  $\text{CH}_4$ ,  $\text{N}_2\text{O}$  and  $\text{O}_3$  now contribute 10% of the radiative forcing of  $\text{CO}_2$ . HFCs and HCFCs don't contribute much at present but are growing rapidly, and estimates indicate that they will reach 3% of the total radiative forcing from all gases by 2100.

(Summary by Dr John Holder,

University of Central Lancashire)

## Policy approaches to the control of radiatively-active and ozone-depleting trace gases

(Dr David Fisk)

Dr Fisk began his presentation with a sobering message about the dangers of being blind to science. He suggested that our present awareness of ozone depletion may be due only to accidents of fate, such as the presence of Dobson in the Arctic (to look for minerals) and satellites in the sky (originally intended for observation of space rather than the earth).

Dr Fisk talked of the need for politicians, research scientists and engineers to work together to identify, address, and hopefully solve the problems that face us, often in ways that can lead, for example, to technology transfer rather than technology sacrifice. A note of caution was introduced with the reminder that, whilst we may be approaching the peak for atmospheric levels of CFCs, this is not the case for greenhouse gases.

Concentrating on global warming, Dr Fisk stressed that our capacity to find and use new sources of fossil fuels grows ever stronger, thus increasing the theoretical maximum of atmospheric  $\text{CO}_2$ . Whilst emissions of greenhouse gases are presently decreasing, partly a result of increasing energy efficiency, predictions are that emissions will actually increase.

Politically, the global environment became a 'hot potato' in the years between the downfall of communism and the Rio Summit in 1992, leading to a period since Rio of tremendous media pressure for scientists. Dr Fisk talked of the problems for scientists of being asked for key scientific data which may then be 'cast in stone' in protocols and legislation before the science has been given a chance to prove itself 100% correct. Pressure can arise, for example, if countries spend vast sums of money to comply with regulations (possibly arranged hastily by scientific standards) which are later changed, based on new scientific findings.

The Kyoto Protocol, agreed in 1997 and signed in April 1998, has established legally binding targets for

2008-2012 for a basket of six greenhouse gases. Countries will act together in 'bubbles' (such as the EU bubble formed in 1998) and agree individual quotas which can be traded, a practice strongly advocated by Dr Fisk. There will also be investment in projects in developing countries. The

UK has made a strong effort to lead on this process and is actively consulting with various sectors (such as business, transport and agriculture) on meeting targets. Dr Fisk concluded with a brief discussion on 'prospects for the planet'. He stressed the need to be ready for surprises, ready to correctly negotiate

trade-offs between different sectors and finally, ready to explain scientific findings to the wider world.

(Summary by Dr John Rieuwerts, Geochemistry and Health Group, Imperial College, London)

## Meeting Report

### Rapid Detection Assays for Food and Water

Central Science Laboratory, York, 15 - 17<sup>th</sup>, March 1999. Organised jointly by the RSC's Water Chemistry Forum and the Environmental Chemistry Group

This international conference was attended by 162 delegates from 17 countries including New Zealand. The 54 oral presentations covered food microbiology, food chemistry, water microbiology, water chemistry and emerging technologies, and were held in two parallel sessions. There were also two workshops, 19 posters sessions and 21 exhibition stands.

PCR amplification of DNA for detecting bacteria, viruses, and parasites in matrices featured in many of the talks. PCR is also a key tool in methods for the authentication of food, *e.g.* the detection

of genetically modified food. However, the reliability and reproducibility of PCR-based techniques are causing problems and these were addressed by many of the speakers. For example, improvements in sample preparation for the PCR-detection of human enteric viruses in food were described, and it is hoped these will eventually allow the detection of 10 virus particles per sample.

Among other highlights, biosensors have been developed as better alternatives to hplc/gc for the rapid analysis of pesticide residues and marine toxins, and for enzyme assays indicative of food quality. Biosensors which use methods based on immunoassays, whole cell bioassays, receptor based assays, or transducer techniques were reviewed. An *in vitro* alternative to the mouse model was reported for the detection of botulinum toxins in food. This method is based on measuring the activity of zinc

endoproteases which are specific for this neurotoxin.

Some of the other techniques discussed at the meeting for rapidly detecting microbiological contamination of food and water included: solid-phase laser scanning cytometry; immunomagnetic separations; and hydrophobic interaction chromatography.

Despite three days of discussing what can lurk in food and water, the conference dinner was a truly memorable occasion. It was held in the York National Railway Museum with a genuine "Yorkshire Brass Band" in attendance.

The proceedings of 'Rapid Detection Assays for Food and Water' are to be published by the Royal Society of Chemistry in its 'Special Publication' series.

## 'Issues in Environmental Science and Technology' Goes Online

The *Issues in Environmental Science and Technology* series has long been recognised as a provider of concise, authoritative and up-to-date reviews of current environmental issues. It presents a multidisciplinary approach to pollution and environmental science, additionally focusing on broader issues such as economic, political and legal considerations.

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Issues can also be purchased individually, and an online pay-per-view option will be available for individual articles.

Two new titles were published in 1998, *Risk Assessment and Risk Management* and *Air Pollution and Health*, and the two titles planned for 1999 will be on *Environmental Impact of Power Generation* and *Endocrine Disrupting Chemicals*.

Further information can be obtained from

Sales and Customer Care, Royal Society of Chemistry, Thomas Graham House, Science Park, Milton Road, Cambridge CB4 0WF, UK, tel: 01223 420066



## Book Review

### Perspectives in Environmental Chemistry

Edited by Donald L. Macalady, (Professor in the Department of Chemistry and Geochemistry at the Colorado School of Mines), Oxford University Press, 1998, £35.00

In his preface Professor Donald Macalady writes that 'the complexity and diversity of environmental systems demands a concomitant diversity in the group of researchers who call themselves environmental scientists' and that this book is 'in many ways a reflection of this diversity.' As can be seen from the list of chapter titles there are certainly a variety of disciplines represented including aquatic scientists, atmospheric scientists, biologists, soil scientists, computer modellers, who are involved with a variety of environmental media.

The 512 pages are split into three sections and there is distinct improvement in terms of content, readability and interest as you progress through them, with Part III undoubtedly being the section that works best. This section provides a more applied and case-study approach to environmental chemistry. Chapter 17 gives a particularly good insight into sample collection and handling of environmental matrices, although it is based around volatile organic compounds (VOCs) which is not mentioned in the title. The only criticism of Part III is the distinct lack of an atmospheric chemical case study which would have added significantly to the overall outcome of this section.

#### Part I

##### Environmental Chemistry of Condensed Phases

The solid-water interface in natural systems

An overview of environmental colloids  
Environmental chemistry of trace metals  
Metal-catalysed hydrolysis of organic compounds in aquatic environments

The chemistry and geochemistry of natural organic matter (NOM)

Assessing the dynamic behaviour of

organic contaminants in natural waters  
Correlation analysis of environmental reactivity of organic substances  
Photolysis of organics in the environment  
Microbiologically mediated reactions in aquatic systems

#### Part II

##### Atmospheric Environmental Chemistry

Oxidant formation in the troposphere  
The tropospheric aerosol and its role in atmospheric chemistry  
Why carbon dioxide from fossil fuel burning won't go away  
Stratospheric chemistry – perspectives in environmental chemistry  
Laboratory studies of heterogeneous chemistry in the stratosphere  
The stratospheric aerosol and its impact on stratospheric chemistry  
Chemical-transport models of the atmosphere

#### Part III

##### Applied Environmental Chemistry

Sample collection and handling of environmental matrices  
Metal-phytoplankton interactions in marine systems  
Atmosphere-water-rock interactions; as observed in Alpine lakes  
Passive bioremediation of metals and inorganic contaminants

The preface states that the mixture of backgrounds of the authors 'provides a rather formidable challenge to editors who seek to provide a reference work/textbook in a consistent, readable format.'

This has obviously been too much of a challenge as the only constant is the consistently distracting layout. Even this cannot distract the reader from the disjointed structure of each of the three sections, inconsistency in the level at which material is presented, and the repetition of material between chapters (particularly in Part I).

For example, the book is reportedly a 'collection of chapters by some of the leading scientists in the field who present their research and their ideas about the

most important areas of future research'. These 'perspectives' have then been presented 'in a style and at a level that allows upper-level undergraduate and beginning graduate students in the environmental sciences to find the book helpful in their studies.' However, the chapters swing between those reporting current research, those which are extensive reviews and those that vaguely wash over the topic (fortunately there are few chapters in the latter category). One or two of the chapters offer minimal background information so that all but the brightest of undergraduate students would find it difficult to set the writers' research into the context of their studies.

The 'review-type' chapters are the clearest written and best structured and would be of good value to most undergraduate and graduate students. However, one or two of the chapters (*e.g.* chapter 8) appear to be probably based on rather old reference material and I am sure could have been more extensively researched.

Some of the chapters are rather short considering the scope of their titles. For example, chapter 3 reports on the 'Environmental chemistry of trace metals' in less than twenty pages. However, it does contain an extensive list of references for further material. Similarly, chapter 11 discusses 'The tropospheric aerosol and its role in atmospheric chemistry' at even shorter length than chapter 3 and with comparably fewer references. This chapter is particularly disappointing and could have been combined with the much more comprehensive chapter 15, which discusses the stratospheric aerosol, or aerosol as the header reads throughout the entire chapter. The only reason for the division appears to be position within the atmosphere with discussions on the troposphere and stratosphere being kept separate.

Other chapters are written in rather colloquial style, for example, the authors in chapter 5 describing natural organic matter as 'the kind of stuff you're likely to find as you dig in your garden.....'. Similar colloquial style is found in neighbouring chapter 6. This is obviously a question of personal taste but again it

does not help with the consistency for which the book was aiming.

On the whole this is an interesting book, although personally I do not feel that at £35 it is value for money. It is useful as a reference, not working text, as none of

the sections are comprehensive in their coverage of the field of environmental chemistry. However, the editor states that this was not his intention and although I agree that it would be difficult to comprehensively cover the field in a single volume, improved focus and

consistency of content and level of the chapters would have helped in achieving this.

**Dr Andrea Stroh**  
University of Leeds

## 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 January to June 1999. Recent additions on toxicology are also included in this list.

### **Advances in Occupational Medicine & Rehabilitation: Volatile Organic Compounds in the Environment: Risk Assessment and Neurotoxicity**

Manzo, L. *et al.* (eds.), (Le Collane della Fondazione Salvatore Maugeri, Vol. 3, No. 3), PI-ME Press, Italy, 1997, ISBN/ISSN: 8879630857, 282 pp., Accession No: 990143, West Gallery, 547:628.5

### **Chemical Speciation in the Environment**

Ure, A.M *et al.* (eds.), Blackie Academic & Professional, London, 1995, ISBN/ISSN: 0751400211, 408 pp., Accession No: 990109, West Gallery, 628.5:54

### **CHIP 98: Approved Supply List: Information Approved for the Classification and Labelling of Substances and Preparations Dangerous for Supply: Chemicals (Hazard Information and Packaging for Supply) (Amendment) Regulations 1998, 4th Edition**

Stationery Office, London, 1998, ISBN/ISSN: 071761641X, 329 pp., Accession No: 990220, Reference Shelves, REF 614.8 R

### **Clean Technology and the Environment**

Kirkwood, R.C. *et al.* (eds.), Blackie Academic & Professional, London, 1995, ISBN/ISSN: 0751400378,

350 pp., Accession No: 990088, West Gallery, 628.5

### **Digest of Environmental Statistics: No. 20, 1998**

Stationery Office, London, 1998, ISBN/ISSN: 0117534668, 338 pp., Accession No: 990060, Reference Shelves, REF 628.5:502.3 R

### **ECETOC Joint Assessment of Commodity Chemicals No. 37**

ECETOC, Brussels, 1998, ISBN/ISSN: 0773633937, 65 pp., Accession No: 990127, West Gallery, 615.9

### **ECETOC Technical Report No. 75: Organophosphorus Pesticides and Long-term Effects on the Nervous System**

ECETOC, Brussels, 1998, ISBN/ISSN: 0773807275, 110 pp., Accession No: 990128, West Gallery, 615.9

### **ECETOC: Technical Report No. 76: Monitoring and Modelling of Industrial Organic Chemicals, with Particular Reference to Aquatic Risk Assessment**

ECETOC, Brussels, 1999, ISBN/ISSN: 0773807276, 103 pp., Accession No: 990317, West Gallery, 615.9

### **Educating for OSHA Savvy Chemists: Developed from a Symposium Sponsored by the Divisions of Chemical Health and Safety and Chemical Education at the 213th National Meeting of the American Chemical Society, San Francisco, April 13-17, 1997**

American Chemical Society, Washington, DC, 1998, ISBN/ISSN: 0841235694, 191 pp., (ACS Symposium

Series No. 700), Accession No: 990300, Reading Room, 542.1:614.8:061.3

### **Environment Act 1995 (Commencement No. 14) Order 1999**

Stationery Office, London, 1999, ISBN/ISSN: 0110822358, 4 pp., Accession No: 990340, A 100, SI 1999/803 (C.25)

### **Environmental Soil and Water Chemistry: Principles and Applications**

Evangelou, V.P., John Wiley, New York, 1998, ISBN/ISSN: 0471165158, 564 pp., Accession No: 980837, West Gallery, 628.5:614.77

### **Environmental Audit Committee: Water Issues: Minutes of Evidence: Tuesday 7th July 1998**

Stationery Office, London, 1998, ISBN/ISSN: 22 pp., Accession No: 990039, West Gallery, 628.5:628.1

### **Environmental Chemistry of Selenium** Frankenberger, W.T *et al.* (eds.), Marcel Decker, New York, 1998, ISBN/ISSN: 0824701364, 713 pp., Accession No: 990289, Reading Room, 546.23:628.5:54

### **Environmental Protection Act 1990 (Extension of Section 140) Regulations 1999**

Stationery Office, London, 1999, ISBN/ISSN: 0110804945, 1 p., Accession No: 990342, A 100, SI 1999/396

### **Environmental Protection (Waste Recycling Payments) (Amendment) Regulations 1999**

Stationery Office, London, 1999, ISBN/ISSN: 0110821246, 4 pp., Accession No: 990341, A 100, SI 1999/546

**Environment in Your Pocket 1998**

Stationery Office, 1998, ISBN/ISSN: 61 pp., Accession No: 990062, Reference Shelves, REF 628.5:502.3 R

**Europe's Environment: The Second Assessment**

European Communities, Luxembourg, 1998, ISBN/ISSN: 9282833518, 293 pp., Accession No: 990073, Reference Shelves, REF 628.5(4) R

**Extraction Methods for Environmental Analysis**

Dean, J.R.,  
John Wiley, Chichester, 1998, ISBN/ISSN: 0471982873, 225 pp., Accession No: 980829, West Gallery, 628.5:543

**Financial Assistance for Environmental Purposes (No. 4) Order 1998**

Stationery Office, London, 1998, ISBN/ISSN: 0110802764, 1 p., Accession No: 990338, A 100, SI 1998/3234

**Handbook of Environmental Data on Organic Chemicals**

Vershueren, K.,  
John Wiley, Chichester, 1998, Accession No: 990135, Reference Shelves, REF 615.9:547 R

**Handbook of Occupational Safety and Health, 2nd Edition**

Diberardinis, L.J.(ed.),  
John Wiley & Sons, Inc, New York, 1999, ISBN/ISSN: 0471160172, 1232 pp., Accession No: 990238, West Gallery, 614.8

**Handbook of Industrial Toxicology and Hazardous Materials**

Cheremisinoff, N.P.,  
Marcel Dekker, New York, 1999, ISBN/ISSN: 0824719352, 914 pp., Accession No: 990269, Reference Shelves, REF 614.8 R

**Regulated Chemical Directory: 1995**

Van Nostrand Reinhold, New York, 1995, ISBN/ISSN: 0442021240, 1988 pp., Accession No: 990089, Reference Shelves, REF 614.8:661 R

**Review of the R&D programme 1997/98: For the Period April 1997 to March 1998**

Stationery Office, London, 1999, ISBN/ISSN: 0113101619, 120 pp., Accession No: 990351, West Gallery, 628.5:061.62

**Royal Commission on Environmental Pollution: Twenty-first Report: Setting Environmental Standards**

Stationery Office, London, 1998, ISBN/ISSN: 232 pp., (Cm 4053), Accession No: 990049, West Gallery, 628.512

**Selenium in the Environment**

Frankenberger, W.T. *et al.* (eds.),  
Marcel Dekker, New York, 1994, ISBN/ISSN: 0824789938, 456 pp., Accession No: 990288, Reading Room, 546.23:628.5

**Triazine Herbicides: Risk Assessment: Outgrowth of a Symposium held in March 1996, New Orleans**

American Chemical Society, Washington DC 1998, ISBN/ISSN: 0841235422, 480 pp., (ACS Symposium Series No. 683), Accession No: 990295, West Gallery, 632.954:615.9:061.3

**Understanding Our Environment: an Introduction to Environmental Chemistry and Pollution, 3rd Edition**

Harrison, R.M.,  
Royal Society of Chemistry, Cambridge, 1999, ISBN/ISSN: 0854045848, 445 pp., Accession No: 990282, West Gallery 628.5:57.02

**Use of Matrix Reference Materials in Environmental Analytical Processes**

Fajgelj, A. *et al* (eds.),  
Royal Society of Chemistry, Cambridge, 1999, ISBN/ISSN: 0854047395, 206 pp., (RSC Special Publication No. 238), Accession No: 990229, West Gallery

**Waste Management Licences (Consultation and Compensation) Regulations 1999**

Stationery Office, London, 1999, ISBN/ISSN: 0110820940, 6 pp., Accession No: 990343, A 100, SI 1999/481

# Environmental Awareness...

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Edited by Z.B. ALFASSI, Ben Gurion University of the Negev, Israel

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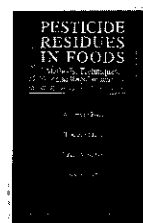
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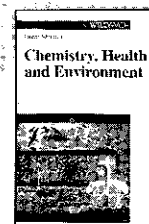
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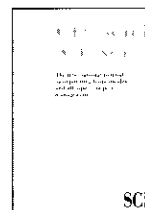
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