THE ROYAL SOCIETY OF CHEMISTRY

ENVIRONMENTAL CHEMISTRY GROUP

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(from March 2003)

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News of the Environmental Chemistry Group Committee

The Environmental Chemistry Group Committee has undergone some changes recently and each committee member now has a particular responsibility. This will allow Group members access to the committee either for specific information concerning the ECG or to suggest future activities for the Group – for example ideas for future meetings. Please feel free to contact the appropriate Committee member if you have any suggestions to make.

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In terms of our activities, we are continuing to work closely with other groups within the Royal Society of Chemistry. For example, we have representation on the Environmental Health and Safety Committee (http://www.rsc.org/lap/rsccom/ehsc/ehsc.htm), and we are actively involved with the sub-group of EHSC that oversees RSC's membership of the UK Chemical Stakeholder Forum – a DEFRA body that advises Ministers (http://www.defra.gov.uk/environment/chemicals/csf/index.htm).

We are also strongly represented on the RSC's newly formed Environment, Sustainability and Energy Forum (ESEF), which aims to co-ordinate all RSC activities with respect to the environment. All members of the ECG are automatically members of ESEF at no extra charge. The opportunity for any member to 'opt out' of the Forum will be given on the registration form.

As you may already be aware, our main event is the **Distinguished Guest Lecture**, which is held on an afternoon in March every year at the Linnean Society and is free to all members of the Environmental Chemistry Group. The Group's Annual General Meeting is also held during the afternoon. The meeting in March this year was very well attended, and we hope that the topic for the 2004 meeting, **Environmental Chemistry from Space**, will prove as popular. This meeting will be held on **3rd March 2004**.

Other meetings to look out for are the **Young Environmental Chemists Meeting**, to be held on **10th September 2003** at the British Geological Survey in Nottingham, and **Ecotoxicology – monitoring and caring for the environment**, a joint meeting with Analytical Division, East Anglia Region. This will be held at the RSC's Thomas Graham House in Cambridge on **14th October 2003**. *See the RSC's Conferences Web pages for further details of these meetings*. Please do not hesitate to get in touch if you have an idea for a meeting or conference.

Finally, a reminder that the RSC is keen for members to submit their e-mail addresses. Please e-mail the RSC at subsrecords@rsc.org

Dr ANDREA JACKSON,
ECG Chairman,
June 2003

Does biology or chemistry determine the availability of toxic metals in soils and sediments?

Professor Bill Davison from Lancaster University, this year's ECG Distinguished Guest Lecturer, summarises the presentation he gave to the ECG at The Linnean Society of London in March 2003.

Environmental chemists and biologists have long known that they cannot study their subjects in isolation. The linkages between chemical and biological processes are key to a fundamental understanding of many environmental systems. This is particularly true in soils and sediments where chemical transformations are usually dependent on microbial activity and solute supply is easily limited.

Transport of solutes in soils and sediments is dominated by diffusion. When considering supply to plant roots or to microorganisms, the critical diffusional distance where gradients are steep is about 1 mm (Barber, 1995). Therefore to appreciate fully how the chemical supply operates measurements must be made on the same or smaller scale. The work of the groups at Aarhus and Bremen, led by Revsbech and Jorgensen, on the development and application of microelectrodes has led the way with respect to high-resolution measurements of oxygen and nutrients. During the 1990s we developed at Lancaster the technique of DGT (diffusive gradients in thin films) that can provide sub-mm scale information on trace metals (Davison and Zhang, 1994).

In DGT metals are trapped on a binding agent (Chelex resin) after they have diffused through a layer of gel of well-defined thickness. The simple, plastic devices are deployed for a known time (hours to days) and the accumulated metal is measured on retrieval. When they are deployed in sediments, or soils with high moisture content, the removal of metal by the Chelex causes a depletion of metal in the soil solution adjacent to the device. If the metal in soil solution is in dynamic equilibrium with the metal on the soil particles, it will be released into solution, counteracting the depletion. The balance between removal by DGT and resupply from the solid phase determines the extent of depletion in solution and the concentration, C, at the interface between the soil and the device. The well-defined geometry and properties of the diffusion layer allows calculation of the mean concentration of metal at the surface of the device during its deployment, C_{DGT}, from the measured accumulated mass.

A dynamic, numerical model of the DGT-soil system, DIFS (<u>D</u>GT <u>I</u>nduced <u>F</u>luxes in <u>S</u>oils), has shown how the concentrations of metals in solution, and in associated solid phases, change with time (Harper et al., 1998). This depends on the kinetics of release from solid phase to solution and the size of the solid phase pool. For most situations, depletion of metal, and therefore the effect on the soil, does not extend beyond 1 mm, even for deployments in excess of a day. DGT has been used for different times, to provide the first measurements of the solid phase pool size and the kinetics of release in relatively undisturbed soil.

The major way that a plant perturbs the metal chemistry of the soil system is by removing metal. DGT does exactly the same thing. Therefore, it can be used as a surrogate for this plant process. C_{DGT} is determined by both the concentration in soil solution and its resupply from the solid phase. The effective solution concentration, that DGT or a plant experiences, is enhanced by this solid phase supply. This effective concentration, C_E, can be calculated directly from C_{DGT} as measured by DGT. A series of studies from around the world have shown that C_E correlates extremely well with concentrations of metals in plants for a wide range of metals and soil types (Davison et al., 2000; Zhang et al., 2001). As DGT responds only to the chemical and physical processes in the soil, it follows that these are the major processes controlling plant uptake. Therefore, in this case, the chemistry of the 1 mm layer of soil adjacent to the uptake surface (the roots of the plant) controls the acquisition of metals by plants.

DGT can be configured into thin, plastic probes that may be inserted into sediments. On retrieval the binding layer can be sliced into thin strips prior to analysis, or it can be dried and analysed by laser ablation ICP-MS at any spatial resolution down to 30 microns. The resulting vertical profiles of metals in sediments show classic changes in concentration associated with redox zones, but additionally there is often fine structure on a scale of about mm (Zhang et al., 1995). Highly localised remobilisation of Zn and Mn has been observed at the surface of a microbial mat (Davison et al, 1997). Measurements in two dimensions in sediments have shown that the spiky signals are due to release of metals from highly localised, approximately spherical microniches (Davison et al., 1997; Fones et al., 2003). A combined probe that measures sulphide and metals simultaneously showed that metals could be released concomitantly with sulphide from the organic matter that fuels sulphate reduction or from iron oxides that are simultaneously reduced (Motelica-Heino et al., 2003). This suggests that within the microniche there is a consortial microbial community that facilitates the different chemical transformations. Outside the microniche chemical control takes over as metals and sulphide are removed according to the solubility of fresh sulphide phases.

Whether or not microniches involve sulphate reduction, organic matter must fuel them. Translocation of parcels of reactive organic matter to depth within the sediment can only be brought about by macrobenthos. Decomposition of the parcel of organic matter is then microbially mediated. Clearly then, in this case, the biology is controlling the chemistry.

The precise nature of chemical and biological interactions can only be appreciated if measurements are made on the correct scale. DGT is a good surrogate for plant uptake because both plants and DGT perturb the soil system on the same scale (ca. 1 mm) and consequently consider similar rates of supply. Information gleaned from DGT is then directly relevant to plant uptake. Metals released from microniches of presumably microbial colonies are only observed if measurements are able to detect their short range (ca. 1 mm diameter), near spherical distribution. To truly appreciate the details of chemical-biological interactions, it is necessary to study these highly localised environments. This new understanding can then be used to inform larger scale models and practical problems. For example the power of DGT as an assessment tool for potentially bioavailable metal is greatly enhanced by the firm base of underpinning scientific understanding.

References

Barber, S. A. *Soil Nutrient Bioavailability; a Mechanistic Approach*, Wiley, New York, 1995.

Davison, W.; Zhang, H. (1994) *In situ* speciation measurements of trace components in natural waters using thin-film gels. *Nature*, **367**, 546-548.

Davison, W.; Fones, G. R.; Grime, G. W. (1997) Dissolved metals in surface sediment and a microbial mat at 100 micron resolution. *Nature*, **387**, 885-888.

Davison, W.; Hooda, P. S.; Zhang, H.; Edwards, A. C. (2000) DGT measured fluxes as surrogates for uptake of metals by plants. *Adv. Environ. Res.*, **3**, 550-555.

Fones, G. R.; Davison, W.; Hamilton-Taylor, J. (2003) Fine scale remobilisation of metals in the surface sediments of the North East Atlantic. *Geochim. Cosmochim. Acta*, submitted

Harper, M.; Davison, W.; Zhang, H.; Tych, W. (1998) Solid phase to solution kinetics in sediments and soils interpreted from DGT measured fluxes. *Geochim. Cosmochim. Acta*, **62**, 2757-2770.

Motelica-Heino, M.; Naylor, C.; Davison, W. (2003) Simultaneous release of metals and sulphide in lacustrine sediment. *Environ. Sci. Technol.*, submitted.

Zhang, H.; Zhao, F.; Sun, B.; Davison, W.; McGrath, S. P. (2001) A new method to measure effective soil solution concentration predicts copper availability to plants. *Environ. Sci. Technol.* **35**, 2602-2607.

Zhang, H.; Davison, W.; Miller, S.; Tych, W. (1995) *In situ* high resolution measurements of fluxes of Ni, Cu, Fe and Mn and concentrations of Zn and Cd in porewaters by DGT. *Geochim. Cosmochim. Acta*, **59**, 4181-4193.

The EU's Water Framework Directive

In the first of two talks at the half-day symposium, which accompanied this year's ECG DGL, **Professor Brian Moss** from the School of Biological Sciences at University of Liverpool, spoke on the opportunities offered for improving the coastal and freshwater environments by the European Water Framework Directive.

Introduction

We are on the threshold of using some of the most revolutionary new legislation, the European Water Framework Directive, ever to improve our coastal and freshwater environments. Yet it may be undermined by government conservatism, commercial vested interests, civil service lack of flair, and the historic baggage of water management in the UK. It will involve much greater absolute involvement by both chemists and biologists, though the relative role of chemists will decrease a little. Natural waters are enormously complicated because of the pre-eminence of living organisms in modifying the chemical template provided by the underlying geology. They are by no means simple chemical systems. The Water Framework Directive recognises this: it requires major changes in the way we monitor and manage natural waters. At present in the UK we do not even do half a job, and the maps produced by Departments of the Environment over the past twenty years showing apparently steady improvements in water quality are grossly misleading at best when it comes to a comprehensive view of the state of our habitats.

The Water Framework Directive

The Water Framework Directive is long and apparently complicated but in principle it is simple. We must start to manage whole catchments (River Basins in the phraseology of the Directive), not just the water-filled rivers and lakes (for whatever happens in the catchments determines to a large extent what happens in the lakes and rivers); we must reduce the concentrations of a specified list of highly toxic substances to below the detection levels of the most sensitive methods available; and we must determine the ecological quality of all our aquatic habitats according to a scale from 'high' (virtually no human impact) through 'good' (slight deviation from 'high'), 'moderate', 'poor' and 'bad'. Then we must restore all our habitats (subject to some derogations) to good ecological status by 2015. In contrast, at present we have little legislation for regulating land use in catchments, we allow specified levels of toxic substances to persist on the basis of toxicological tests which, although repeatable in the laboratory, may have little relevance to what happens in complex ecosystems, and we monitor water quality, largely chemically, rather than ecological quality. Furthermore we monitor it essentially in respect of gross organic pollution, a problem of nineteenth century origin, now largely solved, and ignore several much larger modern problems.

The key to the Water Framework Directive is restoration of ecological quality. All other provisions ultimately lead to this. We have therefore to establish schemes which measure quality, within the detailed provisions stated in Annexes to the Directive, even though these lag somewhat behind current ecological understanding. The Directive says we must first establish a typology, a geographical pigeonholing of different sorts of habitats, and then for each of the categories we must define the conditions for high quality sites. These parameters must include, for example in rivers, invertebrates, aquatic plants and fish, the physical structure of the habitat, and water chemistry and we must then prescribe what is meant by lesser degrees of status using the same system. This will mean using perhaps twenty or thirty variables, mostly biological, compared with the current five or so, largely chemical. A major problem is that tangible high quality sites are extremely scarce and probably absent in the more populated parts of Europe, including the UK. However, we are allowed to use a variety of approaches, including expert judgement and historical records, to establish what we mean by high quality conditions.

What is a river of high ecological status like?

For rivers, for example, we can do this from studies of north-temperate systems that have not been so severely damaged by engineering operations in the interests of hydroelectric generation, flood control, agriculture and waste disposal as those in the UK. I will take such a generalised river to make the points. This pristine river will have a catchment covered with natural vegetation, mostly forest, which will retain and recycle soil nutrients so that even in soft rock areas, the phosphorus and nitrogen concentrations in the water will be very low (a few micrograms for phosphorus, a couple of hundred micrograms of nitrogen at most). The upper reaches of the river will be overhung with forest and even as the river widens, there will be a great deal of tree debris in the channel. The debris and the rocks will accumulate leaves and small branches in many small, and some large, temporary debris dams.

This material is the main source of energy for the ecosystem of the upstream river. It is poor in nutritional quality, however, because the forest, before shedding them, will have translocated valuable nutrients from the leaves into trunks and roots for re-use the following spring. However, the leaf debris in particular is colonised by a specialist group of fungi, the hyphomycetes, capable of absorbing nitrogen and phosphorus from low concentrations and converting the cellulose and lignin of the debris to fungal protein. The colonised leaves are then fed upon by invertebrates in a group called the shredders, which include freshwater shrimps and the larvae of crane flies (‘daddy long-legs’). These tear the leaves apart as they seek out the fungal protein. They are messy feeders and create a stream of fine particles, many of them faecal material, which passes downstream.

Downstream, as the river widens and more light penetrates the forest canopy, diatoms and other algae will grow on the bed rocks, again drawing on the scarce dissolved nutrients in the water. Such algal films are fed upon by another group of invertebrates, the scrapers, such as freshwater limpets and mayfly nymphs, which also dislodge particles to enter the flow. The fine particles from shredders and scrapers as well as material washed in from the catchment become colonised by micro-organisms, which again convert refractory into much more palatable material. They are subsequently either filtered from the current by invertebrate collectors with nets or filtering limbs – blackfly larvae or caddis nymphs, for example, or collect in the quieter nooks of the channel, where burrowing invertebrates like midge larvae and oligochaete worms feed on them. In turn these invertebrates are eaten by small fish or larger invertebrate predators so that there is a major link between the catchment forest and the production of the river community.

Salmon, bears and nutrients

However, there is a much more exciting twist to this otherwise mundane story of food webs. North-temperate rivers in their pristine state support populations of big salmonid fish. These fish are migratory. They are born in the rivers but migrate to the sea after a year or so, spending several years as predators on other fish in the Atlantic or Pacific Oceans, accumulating nutrients in their bodies. Later they move back to the river system where they themselves were born, recognising it from the subtly different water chemistry of every river, despite much dilution in the estuaries and coastal waters. They are unconsciously better chemists than we are. Once they enter the river systems, the salmon do not feed but use up a lot of stored energy on migration. Some die before reaching the spawning grounds and all from time to time congregate below waterfalls waiting for suitable conditions for the jump they must eventually make.

The carcasses and the vulnerable waiting fish are readily collected by brown bears, a major part of whose diet is made up of fresh (or slightly ‘off’) salmon. In turn, the bears, when they move through the forest in search of other components of their diet, such as berries or meat, excrete and defaecate and cycle nutrients ultimately derived from the sea to the forest. This we know from studies of the stable isotope signatures of nitrogen in the ocean, the fish, the bears’ faeces – and the trees. Close to the river, as much as 25% of tree nitrogen is ultimately brought from the sea by the salmon and the bears - a link now among the sea, the river and the forest. But there is more.

Salmon that reach the headwater spawning grounds have accomplished a long journey and they now will expend about half of their energy and materials in producing eggs or milt. They excavate depressions called redds in the gravel beds of the rivers and bury the fertilised eggs in coarse gravel, away from predators but where oxygen-rich water can flow freely around them through the interstices between the stones. Almost all the adults then die, their carcasses littering the bottom. In the debris-cluttered pristine channel, these nutrient-rich bodies are held by the tree debris to decompose *in situ*, providing the nutrients the fungi and algae will need to provide the protein-rich food for the invertebrates. In turn, these will be the food for the young salmon when they hatch and have used all of their yolk sac. In Pacific rivers where forestry operations have prevented accumulation of tree debris, salmon recruitment has failed for lack of such nutrients for the carcasses have been rapidly washed back to the sea. The pristine river thus shows a quite wonderfully efficient use and recycling of the resources of catchment, forest, river and ocean.

Floodplain rivers

The river system changes as it reaches lower ground and has become big with the extension of its catchment. Its channel must widen to accommodate the water that comes down in winter and it makes a wide bed called the floodplain. Its summer channel also meanders to accommodate even the summer water flow. It is a grave mistake to think of such a river as unfortunately flooding what should be dry land from time to time. The floodplain is a natural part of the river, necessary to accommodate the flows and providing some of the most diverse habitats on earth. The floodplain has a complicated structure because material is deposited in floods to form banks and islands and to cut off meanders as ox bow lakes. The silt deposited supports swamps and wet grasslands of great richness and productivity. The outer reaches of the pristine floodplain, as they dry down in summer, provide lush grass which attracts grazing animals and their predators. Fish species migrate up and down river and sideways into the floodplain to spawn in spring. Birds and invertebrates abound. Every great National Park has floodplain rivers at its heart.

These are the pristine systems, the models for 'high ecological status' under the Water Framework Directive. Under modest human impact they provide valuable goods and services – recreational fisheries, high quality water supply in the upper reaches, flood storage, which mitigates damage downstream, water treatment (through denitrification, for example) and even self-contained livelihoods for many traditional peoples, in the lower reaches. Natural habitats of all kinds provide goods and services annually which still amount to three times the combined gross products of all the World's economies put together. But they are easily damaged if their management does not recognise the continuous interlinking, or connectivity, of all of them, as illustrated by the rivers described above. Past management has been exceptionally myopic.

The damage

Upland rivers

Look at a typical upland river, for example in the Pennines, the Lake District or the Southern Uplands of Scotland. It may look fine to a lay eye, but usually it will be much damaged. Its water will be acidified from atmospheric pollution from industry or, increasingly, from vehicle exhausts. Its banks will have no woodland, indeed will have been seriously overgrazed so that the channel has widened and shallowed and the water will heat up in summer to temperatures too high to support even brown trout, let alone the more demanding salmon – that is if the salmon could get there. Most rivers are occluded by dams or weirs that are impassable. And even if the fish could get over or round those, spawning sites are scarce. Land erosion or accumulations of refractory needles from planted exotic conifers clog the spawning gravels.

Lowland rivers

In the lowlands, there are no rivers whose floodplains are intact. The presumption has been that the floodplains are land, to be protected from water in the interests of development or agriculture. The summer channels have been deepened and straightened to move water as fast as possible to the sea. There is little flood storage so heavy storms bring major damage downstream. Flood protection has to be increased downstream to protect property and is very expensive, ugly and, even if of use to man locally, is of no use at all to beast. Intensive agriculture pollutes the water with large supplies of nitrogen and phosphorus, destroying systems evolved to cope with small supplies of nutrients and replacing them with clogging filamentous algal growth and sometimes toxic blooms. We have almost no knowledge of the subtle effects of a huge number of chemicals liberally discharged into the water from a myriad of agricultural and urban activities.

'How to lie with maps'

Yet we pretend otherwise. We produce maps of water quality that actually measure only the degree of pollution by gross organic matter and allege that they represent river quality. Blue lines on them, indicating excellent status, merely mean that the oxygen concentrations and biological oxygen demand meet pre-determined arbitrary categories and support an invertebrate community that requires high oxygen concentrations. The yellow and orange lines of poor and bad quality decrease in length at every re-drawing and the improvement of the river system is lauded. But it is not improving overall at all! The maps are fiction if they are purported to represent river quality. Most of our upland rivers (whose streams are not included on the maps) are acidified or structurally impaired. All of our rivers are altered by increased nutrient loading, and almost all our lowland rivers are severely engineered.

In truth, the maps accurately represent the solution of the nineteenth century problem of discharge of raw sewage, tannery and food waste, and the like into our rivers. It was a major problem, but it is no longer the key problem for river management in the twenty-first century. Our present systems of monitoring and managing rivers are historical baggage. The Water Framework Directive is designed to face the twenty-first century problems. But the problem may be that the thinking which has pervaded water management so far will hamper the successful operation of the Directive.

Implementing the Directive: technical problems and 'Fifth Columns'

The Directive requires management of catchments. This means dealing with diffuse pollutants which are much more difficult to control than the point sources of industrial and waste water effluent pipes. Planning control of land use has been resisted by the land-owning community for decades. Control of listed toxic substances may appear less difficult but total removal of them from waste water poses major problems especially for chemical engineers. Removal from diffuse sources may mean banning of their use. Many are pesticides. But the major problems come in defining the 'good' ecological status required for restoration of rivers, lakes, estuaries and coastal waters by 2015.

'Good' is defined in the Directive as only *slightly* deviant from 'high' and could conceivably mean the reintroduction of the brown bear as a key component of a fully functioning upland river system. This is unlikely but a far more comprehensive approach to river restoration will be required. Floodplains that have been drained will, in many areas have to be reconnected to the summer channel. Even before contemplation of that will be considerable argument about how to define status categories. The Directive implies, and the current thinking of most water managers is, that there is a single set of conditions and a single collection of organisms that can be used to define ecological status in a given place. This is a reflection of previous chemically conditioned thinking. The reality is that ecosystems exist in multiple stable states and it is not possible to give a single set of conditions even for high status at a given site. Many species substitutions are likely and normal as a result of accidents of biogeography and natural random local extinction and re-colonisation. The statistical approaches that currently govern river classification on chemical bases will simply no longer work; ecological systems are much more complex than solution chemistry, though this nonetheless remains as a key component of the assessment.

These technical problems can be solved with the will to solve them. There is, alas, increasing evidence of a fifth column in Whitehall. The consultation documents issued by the Environment Agency and the Scottish Environmental Protection Agency have already suggested the re-writing of the Directive to change the meaning of 'high' status so that standards for 'good'' status can be reduced. This is undoubtedly illegal. There is strong resistance to the idea that floodplains are parts of rivers, ridiculous though this will seem to professional hydrologists and ecologists, and the most recent consultation paper from DEFRA reprints the water quality maps with the implication that these are a good basis for defining ecological status. This too is nonsense. There is opinion within the Environment Agency, reflected in the consultation documents, that what cannot be defined as precisely as a chemical concentration will simply be ignored. The upshot could therefore be merely derisory low standards, tightened point source pollution control, use of the derogation provisions to exclude many sites as too expensive to improve, concentration only on the sites designated under the European Habitats Directive as special areas of conservation and continued neglect of the wider countryside. In time there would then be prosecutions in the European Court of Justice, as there have been over the UK's failure to implement other Directives, that on Nitrates, for example, properly. But all that takes time.

Better, if the spirit of the legislation is respected, we could have a far more interesting, stimulating and valuable countryside than the present desperately damaged one. It would be a tragedy if major changes do not come about as a result. The Water Framework Directive has much wider implications than perhaps even Government presently realises. To manage river basins wisely to create ecological status in the waterways that will hold muster to standards elsewhere in Europe means an integration of policies on farming, housing, air pollution, industrial development, waste disposal, conservation and economics. The present administrative structure which separates these among different ministries and agencies is undoubtedly inadequate to cope. The future may lie in catchment-based organisations with a responsibility towards the whole catchment not some sectional use of it. These are potentially exciting times for chemists and biologists alike. It will be tragic if the dead hand of past attitudes gets in the way.

Web link: The Water Framework Directive http://www.defra.gov.uk/environment/water/wfd/

Biological monitoring *versus* chemical analysis in environmental monitoring

In the second talk at this year's DGL half-day symposium, **Professor Mike Depledge** from the UK's Environment Agency reviewed some techniques for monitoring the health of the environment.

For the Environment Agency (EA), the purposes of monitoring are to detect potential threats to humans and ecosystems and ensure that they are investigated. The monitoring should cover baseline and abnormal concentrations of materials in different media and should also observe the health of organisms and the health links to chemical species, speciation, toxicology and bioavailability.

Pollutants affect the health of organisms *via* molecular, biochemical, physiological, individual and ultimately population responses, and the quality of organism health can therefore be investigated by examining immunotoxicity, genotoxicity, neurotoxicity, endocrine disruption and metabolic toxicity. This can be achieved with biomarkers - responses which use tissue samples, body fluid samples or whole organisms to measure signals of exposure to, and/or the adverse effects of, chemicals or radiation. The best biomarker is one that offers a precise measure of Darwinian fitness.

One such example of a biomarker is the measurement of heart rate which can be performed using an infrared photo-transducer on species such as crabs. For the rock crab in Otago Harbour, New Zealand, the observed increase in median heart rate correlated with the (increasing) pollution gradient from the harbour mouth to the harbour interior. Other biomarkers include behavioural studies (the speed and frequency of directional changes of crabs increases with pollution exposure), success in habitat occupancy by marine crustaceans, the immuno-competence of *Mytilus edulis* (common mussel), and the Comet assay and/or micronucleus assay for work at the single cell level.

Some of these techniques are cheap, quick and robust and they are useful in helping the creation of monitoring systems in developing countries. The Rapid Assessment of Marine Pollution (RAMP) scheme is a UN supported technology transfer programme, which is assisting this process. But the EA also needs to develop effective techniques for continuous remote monitoring. Currently the EA pays £20 million for water sample collection each year but only £11 m for the analysis of the 3.8 million deteminants associated with the 268 00 samples collected. Although the EA has a £750 m budget, only 1.3% of this is currently allocated to R&D. Hence the research necessary for the introduction of changes in monitoring practice (particularly those related to the Water Framework Directive) will require some changes in funding priorities.

Web links for RAMP:

http://ioc.unesco.org/goos/RAMP_article.htm

http://coexploration.org/ramp/index.htm

Summary by **Dr LEO SALTER**,
Cornwall College,
Pool, Redruth, Cornwall

Arsenic hyperaccumulation in ferns: a review

The first report of a fern, which could accumulate arsenic, was published by Lena Ma *et al.* in *Nature* in 2001 (see *Environmental Chemistry Group Newsletter* No. 15, February 2002). This publication generated great interest, not only as the first report of a fern that showed hyperaccumulation characteristics, but also because the fern, *Pteris vittata*, was a highly efficient accumulator of arsenic. Publications reporting similar hyperaccumulation characteristics in other members of the Pteris family quickly followed. The Pteris family is not native to the British Isles, but it has now been shown that *Pteris cretica*, found naturalised in Cornwall, exhibits arsenic hyperaccumulation characteristics. In this review, **Carolyn Wilkins** and **Leo Salter** from Cornwall College describe some of the characteristics of ferns that distinguish them from the more familiar flowering plants and review the research that has recently been published on ferns as arsenic hyperaccumulators.

Fern biology

Ferns are ubiquitous in rain forests. However, ferns can be found in a wide range of terrestrial environments in every continent, and adaptation to these varied habitats means that ferns also have a large range of differing growth characteristics. For example, frond length can range from a few millimetres to several metres, fronds can manifest many different shapes and ferns can be epiphytic or can be waterborne as well as soil or rock based.

Ferns are not flowering plants. Reproduction is a two-part cycle with alternation of generations in which the sporophyte generation is prominent. Spores are produced, usually on the underside of the fertile fronds, in groups of sporangia (the sori) that show distinct patterns. The sori are often protected by a membrane, the indusa, in the early stages of spore development. As spores mature, the sporangium tends to darken in colour. The sporangium bursts, the spores are ejected into the environment and then germinate on damp surfaces to form a freestanding gametophyte in the form of a prothallus. Both male and female reproductive organs are contained in the prothallus and in wet conditions the male cells migrate to fertilise the female reproductive structure. The prothallus can be self-fertilising or cross fertilisation can take place. As a result of fertilisation, sporelings are formed that can develop into mature ferns.

A brief introduction and description of the life cycle of ferns can be found at www.amerfernsoc.org

Fern palaeobotany

Ferns and fern allies are very ancient. The fossil evidence shows that five classes of ferns and fern allies were present in the Devonian period and they dominated the vascular plants until the Mesozoic era when angiosperms proliferated. The true ferns or Pteropsida have been present since early in the Carboniferous period. The order Pteridales was first recorded from the Miocene period. In Cornwall the ancient ferns *Osmunda* and *Ophioglossum sp.* are represented, as are several of the ancient fern allies (e.g. *Equisetum, Selaginella, Botrychium* and club mosses).

Fern classification

In the past, fern classification has been based on fern morphology. Distinguishing characteristics such as spore shape and distribution were used to identify various ferns. Recently, extensive research on fern classification has been reported by Hassler and Swale (http://www.caverock.net.nz/~bj/fern) and Pryer *et al.* (1995) in which morphological characteristics and rbcl sequencing have been used to produce a phylogenetic classification. Linking these classifications to arsenic accumulation by ferns might lead to the identification of the evolutionary characteristics that produce arsenic accumulation (Meharg, 2002a,b) and this, in turn, would add to the repository of knowledge designed to help the optimisation of these properties. So far, two genera of fern have been found to accumulate arsenic (Pteris and Pityrogramma). These are both members of the Order Pteridales. However, as 10% of all ferns belong to this order it is, therefore, quite possible that other ferns that accumulate arsenic will be discovered in the future.

Metal hyperaccumulation

It has long been recognised (Baker, (1981); Baker, (1987); Baker and Whiting, (2002)) that some angiosperms growing on metalliferous substrates can accumulate large amounts (percentages) of heavy metals in the above ground biomass. The potential of these plants for phytoremediation (the removal of contaminants by plants) has generated much academic and some commercial interest (Raskin *et al.*, 1994).

Plants growing on metalliferous soils can either take up large amounts of the metal into the above ground biomass (accumulators), or can block the transport of metals between root and shoot (excluders). Accumulator plants have the facility to concentrate metals from soils that contain low as well as high concentrations of metals. Plants that show exceptional uptake of metals are known as hyperaccumulators, the term first being used to describe plants that were found to contain over 0.1% nickel in the dried tissue (Brooks *et al.*, 1977). The threshold of 0.1% does not apply to all metal hyperaccumulation, 'hyper-accumulator' is an arbitrary term used to describe plants with the ability to accumulate at least an order of magnitude more of a particular metal than 'normal' plants. In the case of zinc, 1% of zinc in the dry plant tissue would suggest hyperaccumulation whereas for gold, 1 mg/kg of gold would indicate hyperaccumulation (Baker and Brooks, 1989).

Hyperaccumulator plants are often indigenous to particular metalliferous substrates and this feature is used as the basis for geobotanical exploration. Within the last quarter century, there have been many hyperaccumulator genotypes recorded, especially zinc and cadmium hyperaccumulators from the calamine soils of Europe, nickel and chromium hyperaccumulators from serpentine soils worldwide (and especially New Caledonia) and copper hyperaccumulators from the Copper Belt of Central Africa. However, although ferns have been noted to be growing on metalliferous substrate, no ferns have been reported in the literature as metal hyperaccumulator plants.

Hyperaccumulation of arsenic

Metalloid hyperaccumulator plants (plants that take up metalloids such as mercury, arsenic, uranium and selenium) are not as well documented as metal hyperaccumulators with the exception of selenium hyperaccumulators that were related to the occurrence of 'loco' disease in horses in the USA (Rosenfeld and Beath, 1964). Arsenic accumulation has been reported in grasses (Porter and Peterson, (1975); Meharg and Hartley-Whitaker, (2002)). However, the first report of arsenic hyperaccumulation by a fern *(Pteris vittata*) (Ma *et al*., 2001) created much interest among scientists researching metal hyperaccumulation. *Pteridophytes* (or ferns and horsetails) are little known phyla of the plant kingdom. As mentioned above, they are ancient plants with a long fossil record and they are very diverse both in habitat and morphology. *Pteris*, one of the two genera that have been found, so far, to accumulate arsenic have been detected in rocks from the Miocene period (C. Page, private communication). However, it is not possible to say whether or not that the arsenic accumulation characteristic appeared in this period. It may be that it is a trait that has emerged and died out several times in the evolutionary history of the ferns. Recently, in addition to their arsenic hyperaccumulating properties there has been a resurgent interest in fern-based medicinal compounds.

Research into arsenic accumulation by plants

Arsenic tolerant flora has been found in the South West of England on highly acidic mine waste containing 10,000 – 30,000 mg/kg arsenic in the surface horizons (Porter and Peterson*,* 1975). Plant cover was sparse but grasses with up to 0.7% arsenic were present. *Agrostis tenuis* samples from soils with 10 000 mg/kg arsenic showed extreme variability of uptake of arsenic ranging from 3 to 3000 mg/kg arsenic (Porter and Peterson, 1975). Arsenate, the dominant form of arsenic in well-drained soils, competes for uptake with phosphate in plants and alteration of the phosphate transport system is necessary if plants are to suppress arsenic uptake (Meharg and Macnair, 1992). Mycorrhizal associations are common on metal(loid) contaminated soils and these are known to increase phosphate transport to the host plants. However, the same mycorrhizal associations also appear to enhance arsenic resistance. A comprehensive review by Meharg and Hartley-Whitaker (2002) of arsenic uptake by plants suggests very complex interrelationships between mycorrhizal associations and between phosphate and arsenate transport within the plants. The mechanisms have yet to be fully understood.

Arsenic accumulation by ferns was investigated by Lombi *et al*. (2002). It was reported that 96% of the arsenic appeared to be held in the pinnae of the fern and less than 2% of this arsenic was present in the spores. Furthermore, the arsenic content of the pinnae increased with maturity with basal pinnae having up to 3 times as much arsenic as the newly formed pinnae. The majority of the arsenic was found as arsenite (As(III)) (75%) with the remainder as arsenate (As(V)). However, mature fronds appeared to have more As(V) than young fronds, suggesting that there is re-oxidation of As as fronds mature. The As(III)/As(V) partitioning found by Lombi *et al*., (2002) was similar to that reported by Ma *et al*. (2001) and Francesconi *et al.* (2002). It is suggested (Lombi *et al*., (2002)) that the arsenic is stored in cell vacuoles which would be analogous to the process of heavy metal storage in metal hyperaccumulator plants.

Ferns that hyperaccumulate arsenic

At present, *Pityrogramma calemelanos* (Francesconi *et al.*, (2002)) and several species of the *Pteris* family (Ma *et al.*, (2001); Meharg and Hartley-Whitaker, (2002); Zhao *et al.*, (2002)) have been reported to be arsenic hyperaccumulators. However, not all the *Pteris* family are hyperaccumulators and research is now starting on trying to identify the characteristics of the species that accumulate arsenic (McGrath, private communication). *Pityrogramma* is a close relative of the *Pteris* family.

So far, no British native ferns have been shown to accumulate arsenic but *Pteris cretica,* a fern that has naturalised in Cornwall, does hyperaccumulate arsenic. However, although two native ferns, *Athyrium filix-femina* (Lady Fern) and *Phyllitis scolopendrium* (Harts Tongue Fern), appear to be primary colonisers of arsenic rich mine waste in Cornwall, they do not accumulate arsenic (present study).

Possible uses of arsenic hyperaccumulating plants

Anthropogenic and natural concentrations of arsenic result in contaminated land and contaminated water supplies. Arsenic is present in some metallogenic provinces (e. g. Cornwall) and gives rise to elevated soil concentrations. In mining areas, spoil heaps can have arsenic concentrations of more than 1% while areas that have been polluted by arsenic calcining operations can have an order of magnitude greater arsenic concentration. The accepted standard for garden and parkland soils in the UK is 40 mg/kg; in West Cornwall, it is not unusual to have over 250 mg/kg arsenic in garden soil. Wood treatment plants and various agricultural operations also give rise to elevated arsenic in soil.

Arsenic is related to several serious medical conditions. It is, therefore, necessary to clean up areas in which the population is vulnerable to arsenic toxicity. Phytoremediation is a cost effective, low technology treatment that uses plants to decrease the concentrations of toxic materials in soils and waters. The ferns that hyperaccumulate arsenic are candidates for phytoremediation as they are fast growing, can be harvested several times a year and are capable of removing substantial amounts of arsenic from the surrounding soil. Francesconi *et al*. (2002) approximately calculated the reduction in arsenic concentration from a soil containing 500 mg/kg As that Pityrogramma calomelanos could achieve in one year in a field trial in Thailand as a 2% reduction.

The problem of disposal of arsenic rich vegetation has not yet been resolved. Francesconi *et al*. (2002) suggested disposal to a marine environment where any anionic arsenic would rapidly be altered to non-toxic organic arsenic compounds such as arsenobetaine $Me_3As^{(+)}CH_2CO_2^{(-)}$. Members of Rothamsted Research and RTZ are currently researching other mineral processing techniques that may be applied to recycling arsenic rich vegetation. Conventional incineration of Municipal Solid Waste may also be suitable for the disposal of arsenic rich vegetation.

References

Baker, A. J. M. (1981) Accumulators and excluders – strategies in the response of plants to heavy metals. *Journal of Plant Nutrition*, **3**, 643-654.

Baker, A. J. M. (1987) Metal tolerance. *New Phytologist*, **106**, 93-111.

Baker, A. J. M.; Brooks, R. R. (1989) Terrestrial higher plants which hyperaccumulate metallic elements – a review of their distribution, ecology and phytochemistry. *Biorecovery*, **1**, 81-126.

Baker, A. J. M.; Whiting, S. N. (2002) In search of the Holy Grail – a further step in understanding metal hyper-accumulation? *New Phytologist*, **155**, 1-4.

Brooks, R. R.; Lee, J.; Reeves, R. D.; Jaffre, T. (1977) Detection of nickeliferous rocks by analysis of herbarium specimens of indicator plants. *Journal of Geochemical Exploration*, **7**, 49-77.

Francesconi, K.; Visoottiviseth, P.; Sridokchan, W.; Goessler, W. (2002) Arsenic species in an arsenic hyperaccumulating fern, *Pityrogramma calomelanos*: a potential phyto-remediator of arsenic-contaminated soils. *Journal of the Science of the Total Environment*, **284**, 27-35.

Hassler, M.; Swaler, B. 'World of Ferns' Website http://www.caverock.net.nz/~bj/fern

Lombi, E.; Zhao, F. J.; Fuhrmann, M.; Ma, L. Q.; McGrath, S. P. (2002) Arsenic distribution and speciation in the fronds of the hyperaccumulator plant *Pteris vittata*. New Phytologist, **156**, 195-203.

Ma, L. Q.; Komar, K. M.; Tu, C.; Zhang, W. H.; Cai, Y.; Kennelley, E. D. (2001) A fern that hyperaccumulates arsenic: a hardy, versatile, fast-growing plant helps to remove arsenic from contaminated soils. *Nature*, **409**, 579.

Meharg, A. A. (2002a) Arsenic and old plants. *New Phytologist*, **156**, 1-8.

Meharg, A. A. (2002b) Variation in arsenic accumulation – hyper-accumulation in ferns and their allies. *New Phytologist*, **157**, 25-31.

Meharg, A. A.; Hartley-Whitaker, J. (2002) Arsenic uptake and metabolism in arsenic resistant and non-resistant plant species. *New Phytologist*, **154**, 29-43.

Meharg, A. A.; MacNair, M. R. (1992) Suppression of the high-affinity phosphate-uptake system – a mechanism of arsenate tolerance in *Holcus lanatus* L. *Journal of Experimental Botany,* **43**, 519-524.

McGrath, S. P.; Zhao, F. J.; Lombi, E. (2002) Phytoremediation of metals, metalloids, and radionuclides. *Advances in Agronomy*, **75**, 1-56.

Porter, E. K.; Peterson, P. J. (1975) Arsenic accumulation by plants on mine waste (United Kingdom). *Journal of the Science of the Total Environment*, **4**, 365-371.

Pryer, K. M.; Smith, A. R.; Skeg, J. (1995) Phylogenetic relationships of extant ferns based on evidence from morphology and rbcl sequences. *American Fern Journal*, **85**, 205-282

Raskin, I.; Kumar, P. B. A.; Dushenkov, S.; Salt, D. E. (1994) Bioconcentration of heavy metals by plants. *Current Opinion in Biotechnology*, **5**, 285-290.

Rosenfeld, I.; Beath, O. A. (1964) *Selenium – Geobotany, Biochemistry, Toxicity and Nutrition*. Academic Press, NY and London.

Tu, C.; Ma, L. Q. (2002) Effects of arsenic concentrations and forms on arsenic uptake by the hyperaccumulator ladder brake. *Journal of Environmental Quality*, **31**, 641-647.

Visoottiviseth, P.; Francesconi, K.; Sridokchan, W. (2002) The potential of Thai indigenous plant species for the phytoremediation of arsenic contaminated land. *Journal of Environmental Pollution*, **118**, 453-461

Wang, J.; Zhao, F. J.; Meharg, A. A.; Raab, A.; Feldmann, J.; McGrath, S. P. (2002) Mechanism of arsenic hyperaccumulation in *Pteris vittata*. Uptake kinetics, interactions with phosphate and arsenic speciation. *Plant Physiology*, **130**, 1552-1561.

Wilkins, C.; Salter, L. (2002) An arsenic accumulating fern in Cornwall. *Geo; Newsletter of the Royal Geological Society of Cornwall*, no 19, 4-5.

Zhao, F.J.; Dunham, S. J.; McGrath, S. P. (2002) Arsenic hyperaccumulation by different fern species. *New Phytologist*, **156**, 27-31

Web links: www.amerfernsoc.org www.caverock.net.nz/~bj/fern

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Arsenic in UK soils and the new intervention values

Guidance has recently been published by the UK government on the assessment of risks to human health from land contamination, including SGV's (soil guideline values) for a range of inorganic contaminants. The intervention value (SGV) for residential areas and allotments for arsenic (As) is 20 mg kg^{-1}. The tiered risk analysis approach advocated in UK guidance suggests that further site-specific studies should be undertaken when a statistically derived upper mean value at a site exceeds the guideline value for specific land use types. Recent chemical analysis of soils in one region of the UK (including the City of Sheffield) undertaken by the British Geological Survey (BGS) shows that natural soil arsenic concentrations above the SGV are widespread. **Barry Rawlins**, **Bob Lister** and **Mark Cave** from the BGS describe this survey and comment on the implications of the results.

Introduction

Trace metals and metalloid elements such as arsenic occur naturally in all soils, typically at low concentrations. Where soils have developed over mineralised rocks, or where human activities have caused contamination, their concentrations may be much higher, and may represent a hazard (Table 1). In April 2000, the Contaminated Land Regulations in England [1] came into force, and placed duties on local authorities to inspect their areas to identify sites which fall into its definition of 'contaminated land', and required its remediation in line with the 'suitable for use' approach. A risk-based approach is taken in the UK to defining contaminated land, which is in turn based on the linkage between a *source* (the contaminant), *a pathway* (such as the consumption of food) and a receptor (for example, a human being). In the case of human beings, the harm, which may be caused by a contaminant, is a human health effect, such as the development of cancer from a carcinogenic compound.

The guidance on the definition of contaminated land refers to the use of 'relevant information', which is scientifically based, authoritative and relevant to the assessment of risks arising from the presence of contaminants in soil [2]. Guidance has recently been published on the assessment of risks to human health from land contamination [3], which includes Soil Guideline Values (SGV's) for inorganic contaminants such as arsenic [4]. Where the concentration is above the SGV, *there is a 'need to consider whether the presence of the contaminant justifies taking remedial action.'* Local authorities and other stakeholders use a tiered approach to assessing the risks from contaminated land [3]. Scientifically derived generic SGV's are used in the first tier of the risk-based approach to screen those sites which may pose a risk to human health and warrant further attention.

In the case of arsenic, the published SGV for residential areas and allotments is 20 mg kg^{-1} [4]. The risk associated with soil arsenic is principally via consumption of food and the ingestion of soil and dusts (or soil particles attached to food). In this paper we define soil as the natural, unconsolidated mineral and organic material occurring above bedrock and Quaternary deposits at the surface of the Earth. Soil ingestion by adults in the UK is generally inadvertent, although the frequent hand-to-mouth activity of children can lead to the ingestion of more significant quantities of soil. There is surprisingly little published data on the concentration of arsenic in UK soils at the regional scale. For example, the soil geochemical atlas of England and Wales [5], which summarises data from the National Soil Inventory, did not include arsenic in its list of elements. However, data recently released by the British Geological Survey [6] show that the natural arsenic content of soils in a region of north-east England (including the City of Sheffield) often exceed the SGV for residential areas and allotments.

Soil geochemical surveys

As part of its G-BASE (Geochemical Baseline Survey of the Environment) project in the UK, BGS (the British Geological Survey) collects and analyses soils regionally and in urban environments. A recent regional survey comprised 6,400 topsoil samples in rural areas in north-east England at an average density of 1 sample per 2 square kilometres. Soil sampling sites were selected on a systematic basis from every second kilometre square of the British National Grid. Site selection in each square was random, subject to the avoidance where possible of roads, tracks, railways, human habitation and other disturbed ground. The region has a variety of soil parent material types including lithologies ranging from the Carboniferous Limestone and Coal Measures rocks in the west to Cretaceous Chalk in the east, and several types of unconsolidated, Quaternary deposit.

An urban survey was also undertaken in the City of Sheffield at a higher density of 4 samples per square kilometre. In the urban survey, soil sampling is undertaken on the least disturbed, undeveloped area of ground closest to the centre of each 500 m square cell. Typical land use types are domestic gardens, allotments, parks or recreational ground.

At each survey site, five holes were augered at the corners and centre of a square with a side length of 20 metres using a hand auger. The soil samples were taken at depths of between 0 and 15 cm, after removal of any surface organic matter. The soil samples from each five holes were combined to form an aggregated sample. All soils were disaggregated following drying and sieved to 2 mm and this fraction was analysed by X-Ray Fluorescence to determine the total concentration of 24 major and trace elements (including arsenic). The analytical detection limit for arsenic was 1 mg kg^{-1}. An analysis of variance performed on data for arsenic in soil sub-samples showed that analytical error accounted for only 1.6% of the total variance in the dataset.

The regional survey

The sample locations were transferred to a geographical information system and the soil samples were classified by parent material type using combined versions of solid geology and Quaternary maps in digital form. The influence of parent material could be clearly seen in the spatial distribution of arsenic concentrations. Soils developed over Jurassic and Cretaceous ironstone deposits have the highest natural arsenic concentrations (maximum value 227 mg kg^{-1}), whilst those over the Carboniferous Coal Measures, Jurassic Limestone, and recent alluvial and peat deposits also have naturally elevated values. Despite soils over these deposits having the highest levels, they also have a broad range of concentrations, with the smallest values being typical of other parent material types. Arsenic in soils developed over the Carboniferous Coal Measures is likely to be derived from an association with the mineral pyrite, commonly found in coal-bearing rocks [7]. Consistently low arsenic values occur where soils have developed over the Permo-Triassic Sherwood Sandstone. Further north, where Quaternary deposits overlay the Sandstone, the arsenic values are more varied. Likewise along the coast of Lincolnshire, arsenic concentrations reflect the distributions of marine alluvium and glacial drift. By classifying each sample point by its underlying parent material, we have calculated that this accounts for 33% of the variation in total arsenic concentration.

Natural arsenic concentrations above the SGV of 20 mg kg^{-1} are common throughout the region, occurring at around 20% of sites. Appreciation of the typical concentrations of a range of potentially harmful compounds in soils that develop over different parent material types as shown here are useful as they put into context the results of site-specific investigations.

Urban survey of Sheffield

Although understanding the regional distribution of soil arsenic is useful in providing an overview, contaminated land investigations (for which SGV's are used) are far more common in the urban environment. Soils in Sheffield are largely derived from Coal Measures, although those in part of the west of the City overly Millstone Grit. Approximately two-thirds (63%) of the 569 samples had total arsenic concentrations above the 20 mg kg^{-1} SGV for residential areas and allotments. These data are presented as individual points because the uncertainty of interpolating values between sample locations in urban areas is much greater than the rural environment. Two further factors need to be considered in comparing the urban survey data with this SGV. First, contaminated land investigations typically involve the analysis of numerous soil samples across a site, whilst the urban survey data presented here are from a composite soil sample of five auger holes at an individual site. Second, the guidance [3] states that a mean value test should be applied to soil chemical data from potentially contaminated sites (based on the upper 95% confidence limit of the measured mean) to determine whether the SGV has been exceeded. Despite these qualifications, it is clear that results of site investigations across much of the City are likely exceed the threshold and require further, detailed risk assessments.

Improving human risk assessment using a bioaccessibility test

Where arsenic occurs naturally at high concentrations, site-specific risk assessments could include the use of a laboratory test to determine the bioaccessibility of soil arsenic. The SGV's are based on the assumption that 100% of the ingested arsenic is taken up by the systemic circulation. However, if arsenic is bound to the soil in a non-reactive form, which is not available for absorption in the human gut, the actual bioaccessibility, and therefore exposure, may be greatly reduced. To assess the fraction of arsenic in the soil that is likely to be 'bioaccessible', and hence improve human health risk assessment, extraction tests can be applied to soil samples that mimic the conditions in the human gastro-intestinal tract [8]. This *in vitro* method mimics the pH and oxidising/reducing conditions in the human stomach and small intestine, and the residence times of ingested material. The stomach phase of the test is acidic (pH 2.5), whilst the intestinal phase is neutral (pH 7). The concentration of arsenic in the test solution as a proportion of its concentration in the soil is used to estimate bioaccessibility (as operationally defined by the method). Such data, which include the total, bioaccessible fraction and form of arsenic, should then be used in conjunction with epidemiological and toxicological information to form the basis of a model that will provide a sensible prediction of the risk to human health from arsenic in soils.

Table 1 - Arsenic facts

General

- occurs naturally in rocks, soil, water, air, plants, and animals
- the 20th most common element in the earth's crust and the 12th most common element in the human body.
- typical arsenic minerals: arsenopyrite (FeSAs), realgar (AsS), arsenolite (As_2O_3)
- industrial uses: wood preservatives, paints, dyes, metals, drugs, soaps, semi-conductors, and pesticides.

Environmental Sources

Coal combustion, ore roasting and smelting, pig and poultry sewage, phosphate fertilisers

Health Risks

Long-term, chronic effects of exposure to low concentrations of arsenic include skin, bladder, lung, and prostate cancer. Non-cancer effects of ingesting low levels of arsenic include cardiovascular disease, diabetes, anaemia, reproductive problems, immunological disorders, and neurological ailments. Gastrointestinal irritations, convulsions, and death can occur at very high doses.

Soil Guideline values* for land-use types (published March 2002):

Residential and allotments – 20 mg kg^{-1}
Commercial / Industrial – 500 mg kg^{-1}
* based on total inorganic arsenic in soil and derived assuming a sandy soil type [9]

References

[1] DETR. *The Contaminated Land (England) Regulations 2000*. Department of the Environment, Transport and the Regions, London, 2000.

[2] DETR. *The Contaminated Land (England) Regulations 2000: Annex 3, Chapter A - Statutory Guidance on the Definition of Contaminated Land*. Department of the Environment, Transport and the Regions, London, 2000.

[3] DEFRA and Environment Agency (2002a) *Assessment of Risks to Human Health from Land Contamination: An Overview of the Development of Guideline Values and Related Research*, Report CLR7. Available from The R&D Dissemination Centre, WRC plc, Swindon, Wilts.

[4] DEFRA and Environment Agency (2002b) Soil Guideline Values for Arsenic Contamination (SGV1). http://www.defra.gov.uk/environment/landliability/pubs.htm#new. Accessed 08 August 2002.

[5] McGrath, S. P.; Loveland, P. J. *The Soil Geochemical Atlas of England and Wales*. 1992, Glasgow: Blackie Academic and Professional.

[6] Soil geochemical data available from the British Geological Survey can be found on the website at http://www.bgs.ac.uk/geoindex. Accessed 08 August 2002.

[7] Spears, D.A.; Manzanares-Papayanopoulos, L. I.; Booth, C. A. The distribution and origin of trace elements in a UK coal; the importance of pyrite. *Fuel*, 1999, **78,** 1671-1677.

[8] Ruby, M.V.; Davis, A.; Schoof, R.; Eberle, S.; Sellstone, C. M. Estimation of lead and arsenic bioavailability using a physiologically based extraction test. *Environmental Science & Technology,* 1996, **30,** 422-430

[9] DEFRA and Environment Agency (2002c). The Contaminated Land Exposure Assessment (CLEA) Model: Technical Basis and Algorithms. Report CLR10. Available from The R&D Dissemination Centre, WRC plc, Swindon, Wilts.

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Another mechanism for arsenic's carcinogenicity

Arsenic is a human carcinogen. However, the mechanisms of arsenic's induction of carcinogenic effects have not been identified clearly (*cf. ECG Newsletter* Issue No. 15, p. 19). It has previously been shown that monomethylarsonous acid (MMA(III)) and dimethylarsinous acid (DMA(III)) are genotoxic and can damage supercoiled phiX174 DNA and the DNA in peripheral human lymphocytes in culture. These trivalent arsenicals are biomethylated forms of inorganic arsenic and have been detected in the urine of subjects exposed to arsenite and arsenate.

New work now indicates that reactive oxygen species (ROS) are intermediates in the DNA-damaging activities of MMA(III) and DMA(III). Using the phiX174 DNA nicking assay it was found that the ROS inhibitors Tiron, melatonin, and the vitamin E analogue Trolox inhibited the DNA-nicking activities of both MMA(III) and DMA(III) at low micromolar concentrations. The spin trap agent 5,5-dimethyl-1-pyrroline-*N*-oxide (DMPO) also was effective at preventing the DNA nicking induced by MMA(III) and DMA(III.) Electron spin resonance studies using DMPO identified a radical as a ROS intermediate in the DNA incubations with DMA(III). This radical adduct was assigned to the DMPO-hydroxyl free radical adduct on the basis of comparison of the observed hyperfine splitting constants and line widths with those reported in the literature. The formation of the DMPO-hydroxyl free radical adduct was dependent on time and the presence of DMA(III), and was completely inhibited by Tiron and Trolox and partially inhibited by DMSO. Using electrospray mass spectrometry, micromolar concentrations of DMA(V) were detected in the DNA incubation mixtures with DMA(III). These data are consistent with the conclusions that the DNA-damaging activity of DMA(III) is an indirect genotoxic effect mediated by ROS-formed concomitantly with the oxidation of DMA(III) to DMA(V).

DNA damage induced by methylated trivalent arsenicals is mediated by reactive oxygen species. Nesnow, S. *et al., Chemical Research in Toxicology*, 2002, **15**, 1627-1634.

The Loe Pool Management Forum

By Loe Pool

THE pool glitters, the fishes leap in the sun
With joyous fins, and dive in the pool again;
I see the corn in sheaves, and the harvestmen,
And the cows coming down to the water one by one.
Dragonflies mailed in lapis and malachite
Flash through the bending reeds and blaze on the pool;
Seaward, where trees cluster, the shadow is cool;
I hear a singing, where the sea is, out of sight;
It is noontide, and the fishes leap in the pool.

Arthur Symons
(1865-1945)

Introduction

Loe Pool (a site managed by the National Trust (NT)) is a shallow coastal lake in Cornwall, UK of maximum depth 10 m (mean 4 m) and surface area 0.56 km^2 (National Grid Reference SW 647250). The main inflow (River Cober) has a drainage area of 54 km^2. Loe Pool is the largest freshwater lake in Cornwall and has important amenity value (approx. 30 000 visitors p.a. (NT, 1998)) and conservation value (Site of Special Scientific Interest, (Nature Conservancy Council, 1986)). The lake is separated from the sea by a shingle bar which is the only British site of the Sandhill Rustic Moth (Spalding, 1988) and also holds rare plants and invertebrates, (Murphy, 1986; NT, 1996). The bar is a dynamic system and its ecology is influenced by landward movement and frequent breaking, (Coard, 1987). Fluctuations in Pool water levels and salinity are also linked to the breaching of the bar (last breached in 1984). Chief amongst the insults to the Pool is the phosphorus inputs from the Helston Sewage Treatment Works (STW) and the STW at the Royal Naval Air Station (RNAS) at Culdrose and nitrogen inputs from diffuse sources (chiefly agricultural). Since 1968 (and possibly earlier) elevated nutrient levels in the Pool have led to algal blooms – in particular the potentially toxic blue green algae *Microcystis aeruginosa* and Water Net *(Hydrodictyon reticulatum).* Consequent on this has been the elimination of submerged macrophytes, the existence of populations of coarse fish (perch, rudd) and a reduction of conservation interest, (Carvalho & Moss, 1995).

In June 1996 the Loe Pool Management Forum (LPMF) was established and four main objectives were identified (Wilson & Dinsdale, 1998):

1. To bring about a change from an algae-dominated turbid water state to a macrophyte-dominated clear water state characteristic of mesotrophy.
2. To establish more natural seasonal fluctuations in water levels and create conditions for a more diverse shoreline and submerged flora.
3. To maximise the nature conservation value of Loe Pool and its catchment.
4. To interest and involve the community in the management of Loe Pool and its catchment.

The management approaches used to achieve these objectives are discussed in this article.

Management

The Environment Agency via its system of LEAPs (Local Environment Agency Plans) is responsible for certain aspects (fisheries, flood defence, water quality, water abstraction) of Loe Pool and its catchment. Their funding (1997-1998) provided the catalyst to develop a Management Plan and they continue to contribute resources for its implementation. The Management Plan (Wilson & Dinsdale, 1998) classed the management issues into a number of linked but conceptually distinguishable topics; some of these (*agriculture*, *sewage*, *water-level*, *fish*) are discussed below.

Agriculture

Agricultural effects on the Pool (diffuse N and P inputs, contributions to river siltation and conservation decrements to wetland sites in the catchment) are being minimised by the designation of the catchment under the Countryside Stewardship Scheme (CSS). The introduction of 10 m buffer zones (and extension to 50 m) on arable field margins proximate to the Pool, the use of wetlands as nutrient traps and attempts by the NT to develop holistic management plans with their tenant farmers around the Pool are linked to CSS implementation. A recent report commissioned by the National Trust deals with some of these issues and identifies processes by which they can be resolved, (Haycock, 1999).

Sewage

Direct phosphorus inputs will (eventually) be reduced by the introduction (2004) of tertiary treatment (phosphate stripping) at the South-West Water (SWW) Helston STW via the implementation of the UWWT (Urban Waste Water Treatment) directive (Geatches, 1997). During the summer months close to 100% of the orthophosphate loading derives from the Helston STW (Wilson & Dinsdale, 1998) and modelling used to support its UWWT designation suggested that 90-100% removal of orthophosphate would meet the appropriate criteria. Implementation of phosphate stripping at the Helston STW is the most vital prerequisite for any attempts at remediation of the Pool. Questions exist concerning the amount of phosphate in the Pool sediment and the rate at which this will be released under a regime of reduced phosphorus input into the Pool and, inter alia, the rate at which the Pool chemistry and ecology will begin to reflect the reduced phosphorus input.

Pending the installation by SWW of phosphate stripping at the Helston STW the LPMF is now giving attention to the smaller RNAS Culdrose STW and to other, diffuse sources of phosphorus.

Water-level

Although Loe Pool was originally a mesotrophic lake with abundant underwater vegetation it is now an algae-dominated system with very limited plant growth. This has occurred principally because of nutrient enrichment but also because until recently, in order to improve dilution and inhibit algal growth, the water level in Loe Pool was manipulated in accordance with a water regime of high summer and low winter levels. Because this unnatural regime was singularly unsuccessful in inhibiting algal growth and was also detrimental to shoreline flora, it has been agreed to adjust the height of the adit weir under the bar to 3.5 m AOD in order to establish a mean water level in the Pool of 3.7-3.8 m AOD during autumn. Any threat of flooding to Helston would be dealt with by rapid lowering of the weir, (Haycock, 1999). A winter–high/summer–low regime is planned which would benefit the inundation/benthic plant communities partly because they are adapted to summer exposure and partly because they would not be submerged during periods of algal-induced stress in the Pool, (Stewart, 2000). A winter–high/summer–low regime would also benefit shoreline flora – though careful monitoring is planned to record the effect of this regime on communities on the seasonally exposed shore, (Wilson & Dinsdale, 1998).

Canalisation of the lower River Cober in 1988 (& 1946) compromised the ecology of Loe Pool and the surrounding area. First, it is thought to have initiated the drying out of one of Cornwall's largest remaining Willow (*Salix* spp.) carr areas (established during the early 20th century on the silts and clays from upriver mining activities). Secondly, continued dredging of the channel (1992, 1998) introduced Japanese Knotweed (*Fallopia japonica*) and Himalayan Balsam (*Impatiens glandulifera*) into the Willow and swamp area. Thirdly, dredging activity increased access to the Willow carr and this has damaged its conservation value. And fourthly, canalisation reduced the effectiveness of the carr as a pre-Pool nutrient trap.

Intra-agency discussions within the EA are taking place so that minimal dredging will occur in the future and the river is allowed to re-form its own meandering course through the carr. Discussions are also being held concerning the creation of settling ponds for silt from agriculture and from urban sources (run-off).

Fish

Loe Pool's role as a fishery not only has historical importance but also has relevance to its future amenity value. Native brown trout (*Salmo trutta L.*) are a feature of the Pool and although they are locally referred to as 'land-locked sea trout' they are most likely not unique sub-species. However, there does appear to be a migratory fraction and the use of the River Cober for spawning and as a refuge from the consequences of algal blooms in the Pool emphasises the need for a whole catchment management plan. Environmental insults to the Pool and the catchment have caused the trout population to decline (e.g. in 1976 the presence of algal blooms caused the suffocation of 2000 fish (mostly trout) (Turk, 1985)). Rudd (*Scardinus erythrophthalmus* L.) (introduced in the 1940s) and perch (*Perca fluviatilis* L.) (from an upstream commercial coarse fishery) are also present. Loe Pool is now dominated by perch and since colonisation the population has grown rapidly and is likely to continue to do so. The presence of large numbers of juvenile perch feeding on zooplankton aids the occurrence of algal blooms and this further exacerbates the effects of eutrophication. However, Loe Pool still contains the only trout population native to a Cornwall lake and appropriate management of this resource could provide high quality commercial angling opportunities, (Rule, 2000).

References

Carvalho, L.; Moss, B. (1995) *The Current Status of a Sample of English Sites of Special Scientific Interest Subject to Eutrophication*, Aquatic Conservation: Marine and Freshwater Ecosystems, **5**, 191-204.

Coard , M.A. (1989) *Palaeolimnological Study of the History of Loe Pool, Helston, and its Catchment,* Unpublished PhD Thesis, Plymouth Polytechnic.

Geatches, T. (1997) *Loe Pool Urban Waste Water Directive Sensitive Area (Eutrophic) Designation, Final draft,* Environment Agency, Bodmin.

Haycock, N.E. (1999) *The National Trust: Farm Buffer Zone Options. Report based on a survey of National Trust holdings in the Loe Pool Catchment*, National Trust, Penrose.

Murphy, R.J. (1986) *A Study of Loe Bar*, Cornish Studies, **14**, 23-33.

Nature Conservancy Council (1986) *Citation, Loe Pool Site of Special Scientific Interest,* Nature Conservancy Council, Peterborough.

National Trust (1996) *Biological Evaluation – Loe Bar,* Report to National Trust, National Trust, Penrose.

National Trust, (1998), *Penrose and Mounts Bay Estates Management Plan,* Report to National Trust, National Trust, Penrose.

Rule, M. (2000) *Loe Pool Catchment Management Project, First Annual Review, February 2000,* Environment Agency, Bodmin.

Spalding, A. (1988) *Luperina nickerlii leechi – Sandhill Rustic Moth at Loe Bar, Cornwall 1986-1988*, Report to English Nature.

Stewart, N.F. (2000) *Survey of the Botany and Vegetation of Loe Pool, Helston, 1999,* National Trust, Penrose.

Turk, S.M. (1985) *Pollution History in a Pool,* West Briton, 22 August.

Wilson, H.; Dinsdale, J. (1998) *Loe Pool Catchment Management Project, Final Report,* Environment Agency, Bodmin.

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

News of the Environment, Sustainability and Energy Forum

Since the last issue of the *ECG Bulletin*, planning for the RSC's new Environmental, Sustainability and Energy Forum (ESEF) has continued. A meeting to discuss future developments was held in February at Burlington House under the Chairmanship of Paul Whitehead. Representatives from the key subject groups, including **Dr Andrea Jackson** (ECG) attended the meeting. Paul Whitehead, currently chair of the Environmental, Health and Safety Committee has agreed to chair ESEF as an interim measure.

- The RSC is committed to providing staff support for the ESEF, and it is expected that a new member of staff, who will also be responsible for the production of a regular Forum newsletter, will be recruited by the autumn.

- Membership of the ESEF will be free and members of the Environmental Chemistry Group, the OETG, the Water Science Forum, and other RSC Subject Groups will be invited to join.

- The RSC is currently searching for a permanent chair for the ESEF who will guide the Forum through its inauguration.

- The first tasks that the ESEF will tackle are its terms of reference, rules and publicity. ESEF web pages will be available by the autumn, and a publicity leaflet will be distributed.

- At least two conferences are planned for 2004 plus one or two workshops.

- The ESEF will have links to external organisations including the NERC and DEFRA.

Dr SEAN McWHINNIE,
Manager, Science Policy,
Royal Society of Chemistry,
Burlington House,
Piccadilly, London W1J 0BA.
June 2003

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

The Environment, Health and Safety Committee (EHSC) is producing the RSC's response to the current consultation on the EU Chemicals White Paper. Details are available at http://europa.eu.int/comm/enterprise/chemicals/chempol/whitepaper/consultation.htm. Other RSC groups, including the ECG have been invited to make an input to this submission. The current EHSC Note on the White Paper is being revised and updated.

The EHSC continues to oversee the RSC's involvement with the UK Chemical Stakeholder Forum (CSF) – see http://www.defra.gov.uk/environment/chemicals/csf. It met the Chairman of the CSF (Lord Selborne) to discuss concerns about the operation of CSF and the related Advisory Committee on Hazardous Substances. EHSC made comments to the DEFRA enquiry into the operation of CSF. EHSC is also in discussions with the CSF about the EU Chemicals White Paper.

EHSC has approved work plans for *Message Notes* and *Guidance Notes*. The former are intended to help improve public understanding of public risk. They will be aimed at opinion makers such as MPs and teachers rather than directly at the public. Two papers are in preparation with the provisional titles *What is a poison?* and *Are we right to worry about chemicals? Message Notes* will only be the start of a process of education and persuasion rather than an end in themselves. *Guidance Notes* will aim to provide essential professional guidance for RSC members. They will offer 'best practice' advice rather than simple factual information.

EHSC is producing a paper on 'substitution'. This will complement the existing position statement (see http://www.rsc.org/lap/rsccom/ehsc/substitution.htm). It will aim to provide solutions via risk-based substitution rather than re-state the problems with hazard-based substitution.

EHSC is continuing work on an update to the RSC booklet *COSHH in Laboratories* and to make it more compatible with HSE publication *COSHH Essentials.*

BOB HAZELL
Royal Society of Chemistry,
Burlington House,
Piccadilly,
London W1J 0BA
June 2003

Book review

Rowing the Eternal Sea – the Story of a Minamata Fisherman

Oiwa Keibo – narrated by Ogata Masato, translated by Karen Colligan-Taylor.
Rowman & Littlefield (www.rowmanlittlefield.com), Lanham, 2001.
ISBN 0-7425-0021-7 (pbk), 192 pp, £18,95.

In this book, Ogata Masato tells how methyl mercury affected his life, family, culture and identity and in a very personal way he then challenges assumptions that quality of life and material wealth are intrinsically linked. This is not new; but the voice is clear, universal and poignant and the situation in Minamata that created this voice epitomises the foolishness that bedevils the interactions between the chemical industry, human beings and the environment.

From 1932-1968 the Chisso Corporation was at,

“ . . . the vanguard of Japan’s chemical industry . . . . Releasing methyl mercury in its untreated effluent.”

and,

“Even before the discharge of mercury, however, pollution incidents had affected the local fishery. The earliest compensation payments by Chisso to fishing co-operatives for a fishery decline date from 1926.”

Post-war, the drivers for industrial production, employment and economic development in Japan became dominant,

“Concerns for human and environmental health did not enter the national policy-making process which had long sacrificed rural society and ecosystems for urban prosperity.”

Masato’s narrative focuses on his personal loss – his father, family, the fishing community on the Shiranui Sea – and how the events at Minamata unpicked the traditions and value systems of that community.

“ . . . Chisso easily dominated regional politics . . . . The company played the role of beneficent overlord, never allowing residents to forget that Minamata exists at the grace of Chisso.”

The life of the Ogata clan in the fishing village of Oki was shattered in 1959 when Masato was six years old and his father announced that his hands were numb. But it was not until the early 1970s that Masato “ . . . understood clearly that I was one of the many Minamata disease sufferers.”

The book has a strangeness (perhaps because of its setting in Japan), it is unsettling (because of the issues it leaves pendant) but it is certainly thought-producing and, for students, it offers a valuable introduction to Minamata.

Masato says,

“ . . . in order to avoid the pain, we turn the situation into a business negotiation.” “Just take this money and put up with your lot,” we say, dismissing the sufferers from our thoughts. Responsibility is exchanged for money, and something crucial is lost in the process.

And, consequently, he rejected compensation, withdrawing his application for it because,

“ . . . it gradually became clear to me that Chisso, the prefecture, and the national government could respond only from within the system, that it was impossible for any of them to accept fundamental responsibility.”

But he reflects,

“If I had worked for Chisso or within the government administration, is it possible that I would have behaved exactly as they did? I cannot deny the possibility.”

The book deserves a wide readership. For me it brought into clear focus the fact that when politicians and industrialists talk honestly about the benefits that their products have brought to the world they tend to neglect or, at best, neglect to emphasise, the attached environmental and human costs. And that when it comes to the sacrifice of the one for the many, it is best for all sorts of reasons (not the least financial) to offer choice and not to create collateral victims at the behest of any government, management, shareholders or accountants.

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

Forthcoming symposium

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

A discussion meeting organised by:

The Royal Society of Chemistry’s Occupational and Environmental Toxicology Group

at

Society of Chemical Industry
14/15 Belgrave Square,
London SW1X 8PS
Tel: +44 (0) 20 7598 1500
Fax: +44 (0) 20 7598 1545

on

5th September 2003

Registration approximately £80

Speakers include Professor Tim Zacharewski (Michigan)

For details, contact Dr Andy Smith, MRC Toxicology Unit,
Hodgkin Building, Leicester University
Lancaster Road, Leicester LE1 9HN
e-mail ags5@le.ac.uk
Tel: 0116 252 5617, Fax: 0116 252 5616

RS•C
ROYAL SOCIETY OF CHEMISTRY

Environmental
Chemistry Group

Young Environmental Chemists Meeting 2003

10th September 2003
@
British Geological Survey
Nottingham

Are you an Environmental Chemist just starting out on your career?

Would you like to present your research and meet fellow Environmental Chemists?

Well this is your chance!

For further information contact:

Dr Kim Cooke
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Phone: 020 8468 1720
Fax: 020 8467 7097
Email: kim.cooke@sira.co.uk

Environmental Chemistry Group

Young Environmental Chemists Meeting 2003

Wednesday 10th September 2003
At the British Geological Survey, Keyworth, Nottingham, UK

(http://www.bgs.ac.uk/contacts/sites/keyworth/kwhome.html)

The meeting is intended as a forum for young environmental chemists to present their research and discuss recent developments in the field. It will start at 9:30 am with coffee and registration and there will be talks, poster presentations and plenty of opportunities to mingle.

Professor Barry Smith of the British Geological Survey will be chairing the meeting and the day will include:

- A guest speaker from the Environment Agency giving a presentation on the future of environmental chemistry in the UK.
- Representatives from the RSC and other companies.
- A year's free subscription to the Journal of Environmental Monitoring for the winner best poster competition (kindly donated by the RSC).

Prospective authors should submit an abstract of 200-400 words by **18th July** and include the names of the authors and their affiliations, indicating the presenting author. This should be accompanied by the attached registration form and a cheque made payable to the "Environmental Chemistry Group" for £10 for RSC members or £15 for non-RSC members.

Young Environmental Chemists Meeting 2003
Wednesday 10th September 2003 @ British Geological Survey, Keyworth, Nottingham, UK

Registration Form

Name: ____________________

Affiliation: ____________________

Address: ____________________

E-mail: ____________________

Tel: ____________________

Fax: ____________________

Submitting Abstract: **YES / NO**

Abstract Title: ____________________

Special Dietary Requirements: ____________________

Will you be requiring transport from Nottingham Station: **YES / NO**

(A mini bus should be available for £5 return depending on interest)

Please send registration forms and abstracts to Dr Kim Cooke, Sira Ltd, South Hill, Chislehurst, Kent BR7 5EH. Tel: 020 8468 1720; Fax: 020 8467 7097; email: kim.cooke@sira.co.uk

Forthcoming symposium

Ecotoxicology: Monitoring and Caring For Our Environment

A one day meeting on Tuesday 14 October 2003 at The Royal Society of Chemistry Headquarters, Thomas Graham House, Cambridge Science Park, Milton Road, Cambridge, UK

Organised by the RSC's East Anglia Region Analytical Division and the Environmental Chemistry Group

Every year, thousands of tons of chemicals are discharged into our environment as waste products of either industrial or household use. Not so long ago, few people cared about what effects these chemicals were having on the environment, but that situation has changed as people have come to realise how fragile our ecosystems are and how this could affect all of us. Regulatory agencies, research institutions and responsible industrial companies are all working to develop and apply methodology to monitor, understand and prevent the decline of our environment. This meeting brings together these experts and covers many of the areas/ classes of compounds of current concern.

Programme

09.45 onwards	Registration and coffee.
10.25 – 10.30	Chairman's Welcome and Introduction.
10.30 – 11.15	**What is Ecotoxicology, and how are environmental standards set for things like endocrine disruptors?** Dr G. Brighty, The Environment Agency, Wallingford.
11.15 – 12.00	**The Fate and Effects of Veterinary Medicines in the Environment.** Dr A. Boxall, Centre for Ecochemistry, University of Cranfield.
12.00 – 12.45	**Pesticides in the Environment – Linking Fate & Effects, Methods and Data Interpretation.** Dr K. Barrett, Consultant.
12.45 – 14.00	Lunch
14.00 – 14.45	**The Biocidal Products Directive. Environmental Risk Assessment Strategies - where are we now and where are we going in the future?** Dr J. Chadwick, Health & Safety Executive, Bootle.
14.45 – 15.30	**Aquatic Ecotoxicology and the Marine Environment.** Dr J. Thain, Centre for Environment, Fisheries & Aquaculture Science, Burnham on Crouch.
15.30 – 16.15	**"Science in the box" – A Procter & Gamble Science Website to share Human & Environmental Risk Assessments & LCA to a wide range of the public.** Dr E. Saouter, Procter & Gamble Public Relations Dept, Geneva, Switzerland.
16.15 – 16.30	Final Questions and Answers – All Speakers.
16.30 – 16.35	Chairman's Closing Remarks.

For further details contact Brian Woodget, Tel/Fax + 44 (0) 1438 811903, Email bwoodget@aol.com.

Registration Fees:- RSC Members £60, Non-Members £80, Students & Unwaged Members £30. To register, please complete the form below and send with a cheque made out to "East Anglia Region AD Trust" to Mr B. Woodget, 5, Meadow Close, Datchworth, Herts, SG3 6TD, UK.

Delegate Name: ________________________________

Affiliation: ________________________________

Address: ________________________________

____

Telephone: ____________________ Fax: ____________________

Email: ________________________________

Registration Fee enclosed: £__________

Special dietary requirements: ________________________________

Meeting report: Coastal Futures 2003

Coastal Management for Sustainability organised its 10th Coastal Futures meeting on January 22nd and 23rd 2003 (‘Coastal Futures 2003: Review and Future Trends’) at the Brunei Gallery Lecture Theatre, School of Oriental and African Studies, University of London. **Leo Salter** reports on the meeting and its acronyms.

Attendance was by around 200 delegates comprised of a wide range of professionals working across many agencies and companies including statutory and non-statutory environment organisations, civil servants, industry (water, energy, resources) and local authorities with direct interests with coastal and marine issues.

The first day surveyed the developing policy context, the findings of the Marine Pollution Monitoring Management Group (MPMMG), the significance of the Strategic Environmental Assessment (SEA) Directive (2001/42/EC) (and the associated role of the Office of the Deputy Prime Minister) and the Port of London Authority’s view of its environmental responsibilities (in relation to the Habitats Directive, the Water Framework Directive, the CROW (Countryside and Rights of Way) Act and the Thames Estuary Partnership). One paper, referring to the Ministerial Declaration of the Fifth International Conference on the Protection of the North Sea and the development of an ‘ecosystem approach’ described the outcomes as ‘Great for consultants but c—p for the environment’. The theme of Offshore Wind Energy was also introduced and estimates are that the market for this will be worth £8b by 2007. Predictions are that 4-6 GW will be installed in the UK by 2010. Currently, although there are 18 developers at 18 sites, the planning and legislative process is hugely complex (e.g. 8 different consent procedures for the Solway Firth). The proposed strategic regions for development are the Wash Area, the Thames Estuary and Liverpool Bay. Other papers reviewed development in Marine and Coastal Waters (Department for Transport), spatial planning (the Crown Estate and industry representatives) and a paper “40 years of Conservation (?) of Strangford Lough, N. Ireland” was given by the CEO of the Ulster Wildlife Trust (“If, with the use of every UK conservation designation we cannot ensure the conservation of obvious marine species does not this position question other UK conservation activity in the marine environment?”).

The second day commenced with a paper “Archaeology in the coastal and marine environment” by the Head of Maritime Archaeology at English Heritage. This seemed to suggest that a similar process of designation was likely for Marine Heritage sites as for terrestrial sites. This was followed by presentations on the spatial designation of MEHRAs (Marine Environmental High Risk Areas) and the concept of regional fisheries management as an outcome of the reform of the CFP (Common Fisheries Policy) (Countryside Council for Wales and South Western Fish Producers Ltd.). A keynote presentation was given by Elliot Morley (Minister for Fisheries and Nature Conservation). The final afternoon looked at “The Irish Sea Pilot” as a regional scale framework for marine nature conservation and the also considered the implications of CFP reform on Irish fisheries. Ecosystem management approaches to the marine environment and the use of no-take zones to protect biodiversity and fisheries were also discussed.

In general these last papers focused on fisheries and the unresolved conflicts between short-term commercial interests and those of the fish and sustainable fishing. The minister had a good grasp of the detail of the issues but the negotiated outcomes in terms of EC fisheries policy were neither scientifically justified nor likely to achieve anything (in spite of the message from Canadian fishermen that they in retrospect wished they had listened to the scientific advice). Subsequent papers castigated the Minister’s stance but unfortunately he had left. Edward Fahy (Assistant Inspector-Inshore Fisheries, Marine Institute Fisheries Research Centre, Dublin) presented data concerning the development of Ireland’s inshore fisheries which were a devastating indictment of muddled thinking by the EC and the inability of national governments to enforce, monitor or direct fishing effort whilst simultaneously completely ignoring the impacts of industrial scale fishing on the marine environment. The final paper (No-take zones, NTZs) by Callum Roberts (University of York) presented the case for NTZs as a mode of fisheries management. This was so clearly argued and evidenced that it clearly exposed the crass inanity of political inaction.

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Pool, Redruth, Cornwall

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

The following books and monographs on environmental topics, toxicology, and health and safety have been acquired by the Royal Society of Chemistry library, Burlington House, during the period January to June 2003.

Acrolein

World Health Organization, Geneva, 2002, ISBN/ISSN: 924153043X, 46 pp., Accession No: 20030098, West Gallery 628.5

Advancing Sustainability through Green Chemistry and Engineering

Lankey, R.L. (ed.), American Chemical Society, Washington DC, 2002, ISBN/ISSN: 0841237786, 264 pp., Accession No: 20030219, West Gallery 628.5:54

Analysis of Environmental Endocrine Disruptors

Keith, L.H. (ed.), American Chemical Society, Washington, DC, 2000, ISBN/ISSN: 084123650X, 173 pp., Accession No: 20030130, West Gallery 628.5:615.9

Bromoethane

World Health Organization, Geneva, 2002, ISBN/ISSN: 9241530421, 26 pp., Accession No: 20030097, West Gallery 628.5

Chemicals in the Environment: Fate, Impacts, and Remediation

Lipnick, R.L. (ed.), American Chemical Society, Washington, DC, 2001, ISBN/ISSN: 084123776X, 508 pp., Accession No: 20030082, West Gallery 628.5:54

Control of Asbestos at Work Regulations 2002

Stationery Office, London, 2002, ISBN/ISSN: 0110429184, 25 pp., Accession No: 20030091, Reference Shelves REF 614.8 R

Control of Lead at Work Regulations 2002

Stationery Office, London, 2002, ISBN/ISSN: 0110429176, 20 pp., Accession No: 20030092, Reference Shelves REF 614.8 R

Control of Substances Hazardous to Health Regulations 2002

Stationery Office, London, 2002, ISBN/ISSN: 0110429192 44 pp., Accession No: 20030093, Reference Shelves REF 614.8 R

Derivation of Assessment Factors for Human Health Risk Assessment

ECETOC, Luxembourg, 2003, 86 pp., Accession No: 20030303, West Gallery 615.9

Environment Business Directory, 2003
9th edition

GEE, London, 2002, ISBN/ISSN: 1860899633, 219 pp., Accession No: 20030070, Reference Shelves REF 058.7:628.5 R

Health, Safety and Environment Legislation: A Pocket Guide

Day, R., Royal Society of Chemistry, Cambridge, 2003, ISBN/ISSN: 0854044973, 332 pp., Accession No: 20030141,
West Gallery 614.8:328.34

Nuclear Site Remediation: First Accomplishments of the Environmental Management Science Program

Eller, P.G. (ed.), American Chemical Society, Washington, DC, 2001, ISBN/ISSN: 0841237182, 464 pp., Accession No: 20030119, West Gallery 628.5

Persistent, Bioaccumulative, and Toxic Chemicals I: Fate and Exposure

Lipnick, R.L. (ed.), American Chemical Society, Washington DC, 2000, ISBN/ISSN: 0841236747, 308 pp., Accession No: 20030229, West Gallery 615.9

Persistent, Bioaccumulative, and Toxic Chemicals II: Assessment and New Chemicals

Lipnick, R.L. (ed.), American Chemical Society, Washington DC, 2000, ISBN/ISSN: 0841236755, 276 pp., Accession No: 20030216, West Gallery 615.9

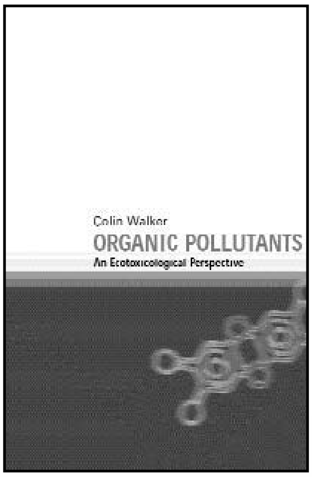
Recognition of, and Differentiation between, Adverse and Non-adverse Effects in Toxicology Studies

ECETOC, Luxembourg, 2002, 56 pp., Accession No: 20030302, West Gallery 615.9

Toxicological Chemistry and Biochemistry
3rd edition

Manahan, S.E., Lewis Publishers, Boca Raton, 2003, ISBN/ISSN:1566706181, 425 pp., Accession No.: 20030067,
West Gallery 615.9:54

Environmental Toxicology from Taylor & Francis



Organic Pollutants

An Ecotoxicological Perspective

Colin Walker, University of Reading, retired, UK

Taylor & Francis

246x174: 304pp:illus. 60 b+w line drawings

Hb: 0-7484-0961-0: £65.00
Pb: 0-7484-0962-9: £27.99

- **Written by an internationally respected lecturer and researcher of many years experience**
- **Can be used as part of undergraduate teaching, postgraduate research, or dipped into as a reference by professionals in the relevant fields**
- **No other single source gives such clear and concise information on these increasingly important compounds**

This much needed book is a companion to the highly praised *Principles of Ecotoxicology*. It covers organic pollutants in greater depth and detail than has been covered in a textbook before. The first part covers such issues as:

- Chemical warfare
- Metabolism of pollutants in animals and plants
- Environmental fate, and effects within ecosystems

This is followed by discussion of particular pollutants such as:

- Organochloride insecticides
- PCBs
- Dioxins
- Organometallic Compounds
- Polycyclic aromatic hydrocarbons
- Anticoagulent rodenticides

amongst others. The book concludes with coverage of ecotoxicity testing, biomarkers and bioassays and future prospects for improved assessment of the dangers these compounds pose.

It breaks new ground in offering a concise source of information on these compounds at a level suitable for senior undergraduates and postgraduates. Professionals working within the fields of environmental science will also find it a valuable reference.

'This publication is a valuable resource to all those studying environmental science'.
- Chemistry and Industry

Contents: 1. Chemical Warfare 2. Factors Determining the Toxicity of Organic Pollutants to Animals and Plants 3. Influence of the Properties of Chemicals on Their Environmental Fate 4. Distribution and Effect of Chemicals in Communities and Ecosystems 5. The Organochlorine Insecticides 6. Polychlorinated Biphenyls (PCBs) and Polybrominated Biphenyls (PBBs) 7. Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) 8. Organometallic Compounds 9. Polycyclic Aromatic Hydrocarbons (PAHs) 10. Organophosphorous and Carbamate Insecticides 11. The Anticoagulant Rodenticides 12. Pyrethroid Insecticides 13. The Ecotoxicological Effects of Herbicides 14. Dealing with Complexity - the Toxicity of Mixtures 15. The Environmental Impact of Organic Pollutants

To find out more on this, or any other toxicology book from Taylor & Francis,
visit our online resource centre at: **www.toxicologyarena.com**

or alternatively contact: **antonio.upali@tandf.co.uk** tel: +44 (0) 20 7842 2021
to request a free copy of our new 2003/4 Toxicology catalogue

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