
How microbial processes in estuarine sediments can control the mobility of technetium-99

Ian Burke, Robert Mortimer and **Katherine Morris** at the School of Earth and Environment, University of Leeds, together with **Chris Boothman, Francis Livens** and **Jon Lloyd**, at the School of Earth and Atmospheric and

Results from anoxic microcosm experiments

In anoxic microcosms experiments, over 99% of Tc was removed from pore waters within approximately 20 days (Fig. 3). In sterile controls, however, Tc remained in solution as TcO_4^- indicating that Tc removal to sediments is a biologically mediated process. A classic cascade of terminal electron accepting processes (TEAPs) was observed and Tc removal occurred at the same time as active ingrowth of sediment bound Fe(II). At the concentrations used in these experiments, microbes are probably not able to directly utilise Tc as a TEAP (4), and Tc removal most likely occurs indirectly as a result of reaction with reduced species in

Estuary sediments were inoculated with pure microbial cultures capable of either nitrate, iron or sulphate reduction. In these experiments Tc reduction only occurred in those sediments where the active accumulation of Fe(II) was detected in sediments as a result of microbial Fe(III) reduction.

microbial incubations, species were present that were able to switch to each TEAP in turn as it became the most energetically favourable mode of respiration. In an attempt to isolate the microbes capable of Fe(III) reduction, potentially the most important in mediating Tc reduction, 10% sediment inoculums were incubated in Fe(III) containing media and repeatedly sub-

References

- (1) Morris, K.; Butterworth, J. C.; Livens, F. R., *Est. Coast. Shelf Sci.*, 2000, **51**, 613-625.
- (2) Keith-Roach, M.; Morris, K.; Dahlgaard, H., *Mar. Chem.*, 2003, **81**, 149-162.

Global warming: the physical chemistry

About 30% of this radiation is reflected, mainly by clouds, and the rest warms Earth so that it too radiates, approximately as a black body. The incoming and outgoing energy reach an equilibrium position, determined by our distance from the sun. (Partial black body curves for various temperatures are shown in Figures 1 and 2). (Note 1).

In the absence of any absorption of the outgoing energy, the average equilibrium temperature of our planet would be 255K. Thus nearly all the surface of the planet would be expected to be well below the melting point of ice, so that it is at least questionable whether or not life, dependent on liquid water, could have followed the path we know (Note 2), without the additional warming which gives us the current average temperature of about 288 K.

Much of this additional warming comes from absorption of the outgoing radiation by atmospheric water vapour. Although water has strong IR absorption in the “group vibration” region, the most significant energy absorption is from the very strong and complex *rotational* structure between *ca.* 1 cm^{-1} and *ca.* 700 cm^{-1} . The upper part of this region

spectrum contrasts with the sharp peak, due to the Q branch, which is shown in most textbook (absorption) spectra. This is the result of saturation: not only is the Q branch saturated, but so are most of the wings of the adjacent P and R branches, and everything in between; in this saturated region the emission matches the high-altitude black body curve at about 218K. This energy, originally emitted at the surface, has been absorbed and re-emitted several times through successively cooler regions. The “missing energy” between the 218K and 320K curves has been returned to the surface. The spectrum also shows the re-emission of radiation absorbed by ozone in the upper atmosphere, about 2-3 km altitude, and by methane (see below).

Figure 2 shows the converse situation – a ground-based spectrometer is “looking upwards” at the downward emitted radiation, but now with more normal humidity, so most of the water emission at wavenumbers below 550 cm^{-1} is at saturation, and this comes from a low altitude, temperature about 275K. Again the very intense emission between 650 cm^{-1} and 750 cm^{-1} is due to atmospheric CO_2 . CO_2 emission is therefore returning much of the radiation emitted from Earth over a fairly wide slice, close to the maximum of the spectrum of black body radiation (Note 8).

The effects of increasing the CO_2 level are not simple. It might be thought that once there is enough of any “greenhouse gas” in the atmosphere for saturation to

have been reached, absorption of radiation is complete, so there could be no more warming, but this is not so. Firstly, the saturation only applies to the centre region. At the wings, increasing concentration increases the number of photons absorbed, and returned to earth. Furthermore, there is still a warming effect at the surface due to the centre of the band, because the first absorption now takes place at a lower altitude, where the temperature is higher. This energy is re-emitted, and more energy is returned to the surface. However, this is a very non-linear effect – the warming is not directly proportional to the number of molecules added, but rises more slowly. It needs to be emphasised, in view of certain media comments, that the warming effect from CO_2 , both natural and anthropogenic, is amplified by the water feedback mechanism, as the effect of water itself is (see above). Far from “ignoring water as a greenhouse gas” as some pundits proclaim, workers in climate modelling build this effect in to all their models. This amplification of the CO_2 warming effect by water is responsible for the predicted substantial

tottreasin79l]’s

Notes

- 1 These are plotted as energy density per wavenumber on a horizontal scale linear in wavenumbers. Many physics texts show curves linear in *wavelength*, and on these the maxima occur at different positions.
- 2 It is also of great importance to life that one part of the solar emission *is* absorbed significantly by the atmosphere, the hard UV radiation, which is removed by ozone.
- 3 In addition, there is a component from the “water bend” vibration, but there is not much of the total energy of the black body emission at these higher frequencies.
- 4 Unfortunately, the word “saturation” is used both for the SVP and for infrared absorption, though there is no necessary connection between these uses. In the rest of this note, the word refers to saturation of IR absorption.
- 5 See IPCC, referenced in “Further information”, Technical summary, D.1 Climate Processes and Feedbacks.
- 6 A more dramatic version of Figure 2, in which the “window” is emphasised by colouring various sections, can be found at: www.espere.net/Unitedkingdom/water/uk_watervapour.html#x3. Similar spectra, obtained under different conditions can be found at: <http://cimss.ssec.wisc.edu/aeri/science/aeriret/>
- 7 The rotational structure is very complex, and many of the apparent peaks in the figures consist of several components.
- 8 Since the intensities at saturation are controlled by temperature, the emission envelope follows a black body curve, and information about atmospheric temperature profiles can be extracted from such spectra; see the links in note 6.
- 9 “However, these deposits are enormous, about 10^7 TgC, and there is an indication of a catastrophic release of a gaseous carbon compound about 55 million years ago, which has been attributed to a large-scale perturbation of CH_4 hydrate deposits”; see IPCC Climate Change 2001: Working Group I: The Scientific Basis

4.2.1.1.

- 10 See IPCC: Climate Change 2001: Working Group I: The Scientific Basis 6.3.4

Further information

This article has to some extent followed the approach in A. P. Cox, “The Elements on Earth” (Oxford 1995), pp 14-19, with some amplification. IR spectra of the various molecules mentioned are available (at medium resolution) at <http://webbook.nist.gov/chemistry/>

Various other websites give some details on the stages by which the spectroscopic information is turned into models of the climate of the earth; one of the most detailed, which nevertheless is well-organised into links, so that particular interests can be followed through, is at <http://www.aip.org/history/climate/index.html>

As an introduction to this, there is a spectacular demonstration of the way in which global temperature and CO_2 levels have tracked each other over 160,000 years at <http://www.aip.org/history/climate/xVostokCO2.htm>

A site which attempts to answer individual problems is www.realclimate.org/index.php?p=1

There is a large, somewhat indigestible but authoritative collection of documents from the Intergovernmental Panel on Climate Change (IPCC) at http://www.grida.no/climate/ipcc_tar/index.htm

Within this the most directly relevant material to this note is the discussion of carbon species at http://www.grida.no/climate/ipcc_tar/wg1/095.htm and of the effects of the absorbed radiation at http://www.grida.no/climate/ipcc_tar/wg1/212.htm

Acknowledgements

I am particularly grateful to Professor Norman Sheppard, who provided advice at an earlier stage of this manuscript, and to Dr. Rob Jones of the Chemistry Department, University of Cambridge,

for a detailed discussion, and for making Figure 1 available. Any remaining errors are my responsibility. I would also like to note the contributions of two Skeptical Chymists, who in extensive correspondence have forced me to clarify my own ideas on this topic.

Biographical note

In 2000, **BOB LLOYD** retired from the Chair of General Chemistry at Trinity College, Dublin, where he had helped to set up a new course in Environmental Chemistry. His research, (after a start in solution kinetics) has been mainly in photoelectron spectroscopy and allied methods, initially in the gas phase (at the University of Birmingham, to 1978) and later in angle-resolved form on surfaces, particularly with adsorbed molecules.

Advances in surveying the soil chemistry of UK urban environments

Barry Rawlins and **Kirsten O'Donnell** from the British Geological Survey (Keyworth, Nottingham) describe their work on urban soil analysis.

Introduction



Figure 2: Contour map of Cr concentrations in the soils of Sheffield: a) including contaminant hotspots (•), and b) without contaminant hotspots (•) used for interpolation

Comparison between urban centres

The BGS has soil data covering rural areas, as well as seven urban centres across the Humber-Trent region. This is a unique soil geochemical dataset enabling comparison of closely distributed UK urban centres with the regional baseline. One of the main applications is improving our understanding of the nature of urban soil geochemistry, which may vary between urban areas as a result of differences in industrial history, transportation and underlying parent material types.

Figures 3a and 3b illustrate features of the distributions of arsenic (As) and lead (Pb) respectively in the seven Humber-Trent urban areas and in the non-urban

land (labelled Humber-Trent). The lower and upper ends of the boxes represent the 25th and 75th percentiles, the line is the median and the cross is the mean of the data. The dotted line in Figure 3a represents the soil guideline value (SGV) for As in soils of residential land use (20 mg/kg). The SGV for Pb (450 mg/kg) is outside of the range shown in the box and whisker plot (Figure 3b). Elevated levels of As in the urban soils of Scunthorpe and Sheffield, with respect to the regional distribution and the SGV can be attributed to the location of these urban areas over the Frodingham Ironstone and the Carboniferous Coal Measures, respectively, which are both enriched in a number of trace elements, including As. The exploitation of coal around Sheffield may also have contributed to elevated concentrations of trace elements in the urban soils.

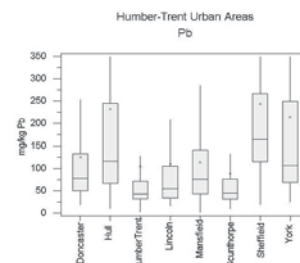


Figure 3: Box and whisker plots of soil a) arsenic (As) and b) lead (Pb) concentrations in the topsoil (0-15 cm depth) in various urban centres and the rural soils of the region (Humber-Trent)

Elevated levels of As and Pb occur in the soils of Kingston-upon-Hull relative to the regional baseline. The latter may in part be related to the former operation of a metal smelter to the west of the city. Although the levels of As in the other urban areas approach the SGV, exceeding it in some cases in the upper ranges, they are fairly consistent with the regional distribution. This suggests that As is naturally elevated in the soils of the Humber-Trent region as a whole. Although the concentrations of Pb in the Humber-Trent urban soils are predominantly below the SGV for residential areas involving plant uptake, the skewed distributions, with strong deviations of the mean values from the medians, are indicative of anthropogenic, point contamination.

Acknowledgement: We would like to thank **Dr Murray Lark** (Rothamsted Research) for his contribution to the geostatistical analysis of the Sheffield data.

Reference

Rawlins, B. G.; Lark, R. M.; O'Donnell, K. E.; Tye, A. M.; and Lister, T. R. in press. The assessment of point and diffuse soil pollution from an urban geochemical survey of Sheffield, England. *Soil Use and Management*, (2005).

British Geological Survey <http://www.bgs.ac.uk/>

Changes in soil metal content after addition of compost

Aten, 1993; Bucher and Schenk, 2000;
Keller and Hammer, 2004).

The power of the extracting method
depends on the soil characteristics.
DTPA was first developed for calcareous

The average total Zn content increased from 59 to 69 mg kg⁻¹ after the application of compost (Table 2), although individual values near 80 mg kg⁻¹ were also observed. The Zn DTPA-extractable fraction increased significantly from 1.3 to 4.9 mg/kg, which represents 2.1 and 7.1% of the total content, respectively. In soil, Zn is mainly bound as oxide (10.0%) and in the residual fraction (80%). From the sequential analysis, the percentage of the oxide bound fraction increased up to 16% in treated soils and the zinc fraction linked to organic matter increased in treated soils from 1.2% to 2.1%. The residual zinc fraction decreased. There is a significant linear correlation between the DTPA-extractable fraction and the Zn fraction linked to the organic matter ($r^2 = 0.68$) and the oxide fraction ($r^2 = 0.69$).

movement of these elements in soil is of concern due to potential impacts on the environment through surface water by runoff. There are a few examples in the literature of increased concentrations of metals in surface waters resulting from spreading organic wastes on farmland (Boy and Ramos, in press; Farsang *et al.*, 2005).

Therefore, metals applied to soil with compost or other wastes contribute not only to an increase in the total metal content of the soil, but also to an increase in the amount of metals that can be utilized by crops or can leach into the environment. This represents a potential hazard for the development of sustainable agriculture practice.

determination of the toxicity level. *Journal of American Society for Horticultural Science*, 2000, **125**, 765-770.

Brun, L.A.; Maillet, J.; Hinsiguer, P.; Pepin, M. Evaluation of copper availability to plants in copper-contaminated soils. *Environmental Pollution*

available on Science Direct

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determination of arsenic species (with detection limits of around 1 ng mL^{-1}), and the application of XAS (X-ray Absorption Spectroscopy) and

concern of the delegates about the significant costs involved in accessing the BGS mapping data and the detrimental impact this has on education and research.

More detailed accounts of the three presentations from the ECG DGL 2005 will appear in the January 2006 issue of the *ECG Bulletin*.

Dr LEO SALTER,
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*Examples of arsenic speciation

| Name | Abbreviation (Alternative Abbreviation ¹) | Chemical formula |
|-------------------------|---|--|
| Arsenite, Arsenous acid | As(III) | As(OH) ₃ |
| Arsenate, Arsenic acid | As(V) | AsO(OH) ₃ |
| Monomethylarsonic acid | MMA(V) (MA) | CH ₃ AsO(OH) ₂ |
| Monomethylarsonous acid | MMA(III) [MA(III)] | CH ₃ As(OH) ₂ |
| Dimethylarsinic acid | DMA(V) (DMA) | (CH ₃) ₂ AsO(OH) |
| Dimethylarsinous acid | DMA(III) | (CH ₃) ₂ AsOH |
| Trimethylarsine oxide | TMAO | (CH ₃) ₃ AsO |
| Trimethylarsine | TMA(III) | (CH ₃) ₃ As |
| Arsenobetaine | AsB (AB) | (CH ₃) ₃ As ⁺ CH ₂ COO ⁻ |
| Arsenocholine | AsC (AC) | (CH ₃) ₃ As ⁺ CH ₂ CH ₂ OH |
| Tetramethylarsonium ion | Me ₄ As ⁺ | (CH ₃) ₄ As ⁺ |
| Dimethylarsinoylethanol | DMAE | (CH ₃) ₂ AsOCH ₂ CH ₂ OH |

clouds were linked into the formation of OH *via* HONO chemistry. Donaldson (Toronto) gave a paper on the uptake and reaction of atmospheric organic vapours on organic films. This topic is relevant to oxidation reactions that occur on 'urban surfaces'.

Secondary organic aerosols (SOA) was the subject for the afternoon sessions. Baltensperger (Paul Scherrer Institut, Switzerland) examined the dependence of SOA growth rates on organic compound oligomerisation processes using α -pinene and trimethylbenzene in experimental systems. Herrmann (Leibniz Institut) discussed SOA formation from terpenes, and indicated that SOA yields depended on temperature, seed nuclei type, monomer molecular mass and monomer volatility. Using experimental and computational techniques, Donahue (Carnegie Mellon) examined the critical factors which determine the variation in SOA yields from terpene ozonolysis. The final

session of the second day focused on NMVOC (non-methyl volatile organic compounds) and their impact on oxidant and aerosol formation (Jenkin, Imperial College). Kolb (Aerodyne Research) described mobile ground level monitoring and the way in which it (as opposed to sparse fixed site air quality monitoring stations) could deal with the variable (temporal and spatial) emission sources which produce small area chemical gradients at ground level. McFiggans (Manchester) described the use of a Master Chemical Mechanism which was a simplified representation of the organic component of atmospheric particulates.

Burrows (Bremen), in the opening session on the final day, reviewed the remote sensing of atmospheric composition from space and gave a clear exposition of the difficulties and approximations involved. Jaegle (Washington) followed with a paper which illustrated how satellite

observations could be used to examine the relative roles of fossil fuel combustion, biomass burning and soil emissions as NO_x sources. There is a surprisingly large contribution (22%) from soil emissions to global surface NO_x emissions. Bloss (Leeds) examined the way in which the various measurements of the oxidative capacity of the troposphere (OH concentrations) could

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a presentation on 'Exposure measurements of indoor ultra fine particles: a pilot study on the night-time patterns'. Elevated ultrafine particle concentrations were observed during indoor activities such as cooking and vacuum cleaning, but the particulate level decreased during zero activity (sleep). Still indoors, Ivan Gee (Manchester) highlighted that carpets in houses with inhabitants who smoke were a source of endotoxins.

Alex Ledbrooke (Cornwall College) reviewed the 'Cornwall Air Quality Strategy: air quality issues in an isolated rural area'. A poor road infrastructure was of particular concern for its effect on localised air quality.

Session 3: Exposure measurement and modelling (2)

The exposure measurement and modelling session continued with Alison Tomlin (Leeds) who talked about 'Factors influencing exposure to traffic related pollutants in urban streets'. By monitoring traffic characteristics, correlations were found between CO₂ and vehicle occupancy. The results showed congestion to be a bigger contributing factor to elevated pollution concentrations than vehicle numbers. Tomlin also presented models of pollution in streets, and described the effects of topography, wind direction and traffic emissions.

Susan Hodgson (Imperial College, London) and Richard Mohan (Chemical Hazard and Poisons Division, London) both described dispersion modelling around a point source: a Chlor alkali plant in Runcorn and a landfill site respectively.

Session 3: Ultrafine seminar (1)

Roy Harrison (Birmingham): 'Formation and dispersion of ultrafine particles: composition, lifetime, monitoring and modelling'. Anthony Seaton (Institute of Occupational Medicine, Edinburgh), 'The ultrafine hypothesis after ten years'.

Session 4: Ultrafine seminar (2)

Ken Donaldson (Edinburgh): 'Reactions

Christina Yap reported an investigation into long term exposure to air pollution in Scotland. The study has lasted for 22 years and has involved 22,000 subjects in an area where detailed records of black smoke exist. The research found 'convincing evidence' of a link between exposure and cancer. There were,

however, missing data, and variables such as house and traffic density were not taken into consideration. This information will be added to the research, which will be reassessed to clarify the findings.

The final presentation of the conference

was by Roseanne McNamee (Manchester) who described an investigation into whether or not 'cardiopulmonary patients are more susceptible to pollutant-related mortality'.

A. LEDBROOKE, Air Quality Unit, Cornwall College

Comment: Fish stocks, endocrine disruptors, and global warming

Following an article on endocrine disruptors in the previous issue of the *ECG Bulletin*, **Alan Wiseman** comments on other environmental threats to fish stocks.

The laudable article in the January 2005 issue of the *Environmental Chemistry Group Bulletin* (pp 4-6) by E. M. Hill and C. M. Tyler, "Endocrine disruption and UK river fish stocks", emphasised the accumulation in the bile of oestrogens and mimics ($10^4 - 10^5$ fold). Using the YES bioassay (recombinant yeast containing oestrogen receptor) with reverse phase HPLC/MS techniques, a range of oestrogens were identified in the immature rainbow trout.

Nevertheless, especially where stocks of the gudgeon (*Gobio gobio*) are threatened by endocrine disruptors, other

factors may determine the survival outcome! These factors include the effects of water temperature on dissolved oxygen concentration (DOC). DOC is lower at higher temperatures, and biological oxygen demand (BOD) of the effluent waters will modulate the outcome (Lynch and Wiseman, 1998).

Furthermore, global warming, somewhere in the wide range of 2 – 11 °C in this century, has been predicted by a variety of models set up in computers worldwide (Stainforth, Alna, Christensen, Collins, Faull *et al.* 2005). Moreover, survival chances of individual species of fish, such as the river trout, should be extrapolated now to accommodate the ongoing global warming (from an anthropogenic cause or otherwise) associated with the rising atmospheric level of greenhouse gases, such as carbon dioxide and methane. In addition, presently pertinent data will be

replaced very soon by updated findings of further investigations of the pollution caused by endocrine disruptors such as oestrogens and mimics.

References

Lynch, J.M. and Wiseman, A. (eds.), *Environmental Biomonitoring: The Biotechnology Ecotoxicology Interface*, Cambridge University Press, Cambridge, 1998.

Stainforth, D.A., Alna, T., Christensen, C., Collins, M., Faull, N., *et al.* Uncertainty in predictions of climate response to rising levels of greenhouse gases. *Nature*, 2005, **433**, 403-406.

Dr ALAN WISEMAN

... Elizabeth Hill replies:

There are numerous stresses affecting fish population in UK rivers, and endocrine disrupting chemicals are one of them. The finding that intersex fish in effluent-contaminated waters have reduced fertility suggests the possibility of deleterious population changes in a number of UK fish species (Jobling *et al.*, *Biology of Reproduction*, 2002, **67**, 515-524). In addition, the impact of climate change, resulting in less dilution of effluents (some of which are barely diluted in receiving waters in summer) are likely to exacerbate this type of pollution unless additional wastewater treatment technologies are deployed.

Wiseman makes an important point that depletion of oxygen levels in rivers due

to climate change and BOD may also affect survival of sensitive fish species. In addition, the reports that sub-lethal levels of hypoxia can also impair fish reproduction and embryonic development raises further concern on the future health of fish populations in rivers (Wu *et al.*, *Environmental Science and Technology*, 2003, **37**, 1137-1141; Shang and Wu, *Environmental Science and Technology*, 2004, **38**, 4763-4767). These stresses combined with inputs of an array of effluent-associated xenobiotics – including some pharmaceuticals, the loss of habitat diversity, and the effects of damming (weirs) – which inhibit fish movement, all suggest that river environments are still amongst the most vulnerable

ecosystems in the world with regard to anthropogenic impacts.

E. M. HILL,
University of Sussex,
June 2005

Meeting report

Pharmaceuticals in the Environment

Organised by the SCI BioActive Sciences group in association with JPAG, RSC and SETAC-UK, this meeting was held in March 2005 at the Society of Chemical Industry, Belgrave Square, with an attendance of about 120.

The topic for the meeting was introduced by **Mark Cronin**, (Liverpool John Moores University), who noted that although there are data on the presence and distributions of some pharmaceuticals in the environment, relatively little is known of their biological effects on ecosystems.

Emma Pemberton (Environment Agency) explained how the types of pharmaceuticals that do enter the environment are related to their overall usage. Among the 5,500 active pharmaceutical ingredients approved for human use, the top 50 pharmaceuticals by usage include paracetamol, lactulose, ibuprofen, acetylsalicylic acid, and amoxicillin, which are all used at levels of around 100 tonnes/annum. The next level includes ranitidine, cimetidine, carbamazepine, and erythromycin which are used at levels of between 10-100 tonnes/annum. By contrast, only about 450 veterinary medicines are authorised. Usage of antimicrobial medicines is around 450 tonnes/annum (*ca.* 50% of which is accounted for by tetracycline), organophosphorus sheep dip (50.2 tonnes/annum), coccidiostats (214 tonnes/annum) and growth promoters (13 tonnes/annum).

For human pharmaceuticals, the primary route into the environment is through sewage treatment plants – the combined effect of excretion and improper disposal of unwanted drugs. Most sewage treatment works are likely to discharge low levels of pharmaceuticals, and in several cases measurable amounts are present in the receiving waters. In a UK study, twelve compounds were monitored in sewage works at low flow conditions. Ibuprofen levels were very much greater in effluent and in receiving waters than other compounds, reflecting

a low level of metabolism and relative persistence. Seven other pharmaceuticals were also found. The study concluded that most sewage works release pharmaceuticals in measurable amounts, with variations in individual sewage treatment works.

Alex Tait (Veterinary Medicines Directorate) outlined European Union environmental legislation for human and veterinary pharmaceutical products, which are covered by Directives 2001/83/EC (amended 2004/27/EC) and 2001/82/EC (amended 2004/28/EC), respectively. Some veterinary medicines have been refused Marketing Authorisation on the basis of environmental safety whereas many human medicines have been approved without an environmental assessment due to the absence, at present, of appropriate guidelines.

Len Levy (MRC Institute for Environment and Health, University of Leicester) reviewed the indirect effects of veterinary medicines on consumers. The main concerns are the long-term fate of these products in the environment and risks to health, which result from indirect exposure. Around 90 compounds were selected for their potential impact on human health using a priority scheme. Of these, 31 compounds were identified as being of particular concern. The range of compounds was expanded to 48 to include some that are not licensed for veterinary use but which find their way into the environment. Low or no effect levels for significant endpoints (*e.g.* neurological, developmental, mutagenic and carcinogenic effects) were estimated using literature data relevant to low-level, long-term exposure. The overall aim is to assess the likely exposure of humans to the priority veterinary medicines. Combining the exposure data with hazard information will allow assessment of risk. Refinements to the model will include additive effects of compounds with similar health effects and consideration of sensitive subgroups in the population.

Kevin Thomas (CEFAS) gave a talk on the occurrence of human pharmaceuticals in the UK aquatic

environment. Measurements (HPLC-ESI MS) were carried out in wastewater works, rivers and estuaries for the 500 most used pharmaceuticals. Of the five sewage works monitored, ten of the targeted pharmaceuticals were identified. Ibuprofen had the highest measured environmental concentration (MEC) at *ca.* 3 mg L⁻¹. Upstream samples were clean whereas discharge and downstream samples showed similar relative abundances. Eight of the targeted compounds were identified in receiving waters, with ibuprofen again at the highest MEC (1 mg L⁻¹). Analysis of six stations along the Tyne estuary revealed the presence of nine of the targeted compounds and showed that Howden water treatment works accounts for 80% of the effluent that goes into the Tyne.

Katherine Fenner (EAWAG, Switzerland) outlined the challenges in exposure modelling for pharmaceuticals. The main focus of modelling studies for pharmaceuticals in the environment is the transfer from soil/sediment/sludge to groundwater. There is little guidance on how to estimate elimination from sewage treatment plants and there is little detailed knowledge of the pathways of breakdown. The main uncertainty in exposure modelling is in the treatment of pharmaceutical release and transport into water systems from sludge or manure that has been applied to soils.

Most exposure models assume that sorption is dominated by adsorption to organic matter. However, pharmaceuticals associated with sludge and soil show little correlation between log K_{oc} and log K_{ow} , indicating that organic carbon content is not a good descriptor to model sorption. Thus, sorption is dominated by polar and charged interactions associated with the polar nature of the pharmaceuticals.

Liz Wellington (University of Warwick) discussed the impacts of clinical and non-clinical usage of antibiotics and biocides on environmental reservoirs and mobility of resistance genes. Bioavailability of pharmaceuticals in the environment has the potential to affect natural microbial populations through the development of resistance genes. The prevalence of

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 May 2005.

Asphalt (Bitumen)

(Concise International Chemical Assessment Document No. 59)

World Health Organization, Geneva, 2004, ISBN/ISSN: 9241530596

Chemical Science Priorities for Sustainable Energy Solutions

Royal Society of Chemistry, Cambridge, 2005

Chloroform

(Concise International Chemical Assessment Document No. 58)

World Health Organization, Geneva, 2004, ISBN/ISSN: 9241530588

1-Chloro-1,2,2,2-Tetrafluoroethane (HCFC 124), 2nd edition

(ECETOC Joint Assessment of Commodity Chemicals (JACC) No. 46)

European Centre for Ecotoxicology and Toxicology of Chemicals, Brussels 2004, ISBN/ISSN: 0773633946

Glyoxal

(Concise International Chemical Assessment Document No. 57)

World Health Organization, Geneva, 2004, ISBN/ISSN: 924153057X

IARC Monographs on the Evaluation of Carcinogenic Risks to Humans

(IARC Monographs Vol. 84)

World Health Organization, Geneva, 2004, ISBN/ISSN: 9283212843

Introduction to Environmental Analysis

R. Reeve, J. Wiley, Chichester, 2002, ISBN/ISSN: 0471492957

Local Authority Health and Safety Enforcement

C. N. Penn, Shaw & Sons Ltd., Crayford, 2005, ISBN/ISSN: 0721916503

Soil and Sediment Risk Assessment of

Organic Chemicals

(ECETOC Technical Report No. 92)

European Centre for Ecotoxicology and Toxicology of Chemicals, Brussels 2004, ISBN/ISSN: 0773807292

Targeted Risk Assessment

(ECETOC Technical Report No. 93)

European Centre for Ecotoxicology and Toxicology of Chemicals, Brussels 2004, ISBN/ISSN: 0773807293

The Toxicology of Glycol ethers and its Relevance to Man

(ECETOC Technical Report No. 95)

European Centre for Ecotoxicology and Toxicology of Chemicals, Brussels 2004, ISBN/ISSN: 0773807295

Whole Effluent Assessment

(ECETOC Technical Report No. 94)

European Centre for Ecotoxicology and Toxicology of Chemicals, Brussels 2004, ISBN/ISSN: 0773907294